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**Abstract** - The global warming increasing daily and showing serious impact on earth environment due to Carbon dioxide (CO<sub>2</sub>) content in the atmosphere, and many other human activities. And it is very important to measure and analyse the concentration of Carbon dioxide before it became dangerous to humankind. In the present paper an optical signal is used to measure the level of Carbon dioxide in open space and in food Industry. So that, the engineers can take appropriate verdicts in advance before it become too late. CO<sub>2</sub> also plays vital role as output of industrial gas, helps in production of chemicals and also in preparation of food and food packaging. The ability to quantify gas concentrations with high sensitivity, excellent selectivity and rapid response by means of direct laser absorption spectroscopy is important.

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# Detection of Liquefied and Gaseous form of CO<sub>2</sub> Implementing New Method in Non-Dispersive Infrared Spectroscopy Sensor System

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## I. INTRODUCTION

Measurements of atmospheric concentrations of CO<sub>2</sub> will provide valuable information of the environmental conditions and intensities of carbon. Such studies will help the human being to analyse and control the global greenhouse warming. Now a days global warming becoming a serious issue which to control and reduce greenhouse gases. Atmospheric CO<sub>2</sub>, one of the major components in greenhouse gases which is a cause of large global warming on earth. The CO<sub>2</sub> absorbs the earths heat and warm up the atmosphere. The CO<sub>2</sub> largely induced due to chemical processes in oceans, earth and the usage of land and natural resources by human.

While practicing experiments with CO<sub>2</sub> some precautions need to be taken due to some hazards. Carbon Dioxide gas exists as colourless, cryogenic liquid. At low concentrations, both the gas and the liquid forms are odourless. At higher concentrations Carbon Dioxide will have a sharp, acidic odour. At concentrations between 2 and 10%, Carbon Dioxide can cause nausea, dizziness, headache, mental confusion, increased blood pressure and respiratory rate. If the gas concentration reaches 10% or more, suffocation and death can occur within minutes. Contact with the cold gas can cause freezing of exposed tissue. Moisture in

the air could lead to the development of carbonic acid which can be irritating to the eyes. All forms of Carbon Dioxide are non-combustible. Carbon Dioxide is heavier than air and should not be allowed to accumulate in low lying areas [4]. So the Carbon dioxide analysis is more important in all aspects of the life to protect ourselves, to protect the environment and to protect the earth from global warming.

CO<sub>2</sub> is an important industrial gas for many different uses that include production of chemicals for instance urea which is mostly used at farms, inert agent for food packaging which will help in increasing the expiry data of the content in the package, beverages, fire extinguishers, refrigeration systems, welding systems, water treatment processes, and many other smaller scale applications. And it is also revealing the importance of the Carbon dioxide gas in food processing industry to make the food in hygienic form.

There are already some existing methods actively involved in present scenario. A Surface Plasmon Resonance method is presented in [5], which is following a dispersive optical based sensor technique to measure the carbon dioxide concentration. This system produces high sensitive and accurate measurements when compared with traditional methods and chemical process methods. In dispersive measurement system, prisms are used and need to set a predefined wavelength from broad category of prism output wavelength. The selected light beam will pass through the sample chamber. It is all a complex process to select a particular wavelength of a prism. However, the dispersive systems are tending to be larger, complicated and more costly and hence they are less suitable for portable instrument measurement system [6]. In another method the carbon dioxide concentrations are analysed by fundamental chemical process [7]. Although this system produce accurate measurement readings the control process is little tedious job and achieving sensitivity is difficult when compared with optical system.

In the present paper working principles of NDIR sensors and operations are discussed to find the concentration of Gaseous Carbon dioxide. And

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Liquefied Carbon dioxide measurement techniques also discussed in the present paper to measure the concentration of required Carbon dioxide in food processing Industry.

## II. MOTIVATION

The active gases are transparent to incoming short-wave solar radiation, but they absorb and re-radiate outgoing long-wave terrestrial radiation, thus heating the atmosphere. This energy absorption is measured in Watts/m<sup>2</sup> and is called "radiative forcing". Gases which exhibit this property are called "greenhouse gases"[1]. The main greenhouse gas is CO<sub>2</sub>. The CO<sub>2</sub> emissions are seriously affecting the environment. The CO<sub>2</sub> emissions cause the increase in the global warming and indirectly involved in the change of climate conditions. The CO<sub>2</sub> also have some advantages beside its disadvantages. The CO<sub>2</sub> is used in some food preparations, food packaging and in preparation beverages. But few percentage of CO<sub>2</sub> is allowed in food processing industry. Beyond the allowed percentage it may contaminate the food which is not allowed to have by corporeal. So it is highly essential to measure the CO<sub>2</sub> concentration in food processing industry and also to analyse the percentage of CO<sub>2</sub> in

the environment. On the earth atmosphere the sun radiates infrared waves with high intensity. The same waves again reflected from earth surface back to space. But while reflecting, the intensity of these waves will be reduced due to the earth atmospheric weather. Based on this principle a light source can be used to analyse the concentration of the gases. In the present paper IR waves are used to analyse the CO<sub>2</sub> gas in open air and also discussed to analyse the CO<sub>2</sub> concentration in food processing industries.

## III. EXISTING METHODS

In the present section some existing and actively involved methods are discussed to understand the Gas sensor measurement system.

### 3.1 Refractometric fiber optic sensors Measurement :

The Refractometric fiber probe was immersed in the solution and fixed in rigid. In each case, refractive index was measured after some minutes of bubbling with the corresponding gas. The results showed a consistent visibility difference of 1% between the two states, meaning that there was a refractive index decrease of approximately 0.005 refractive index unit induced by the increase in CO<sub>2</sub> concentration [8].

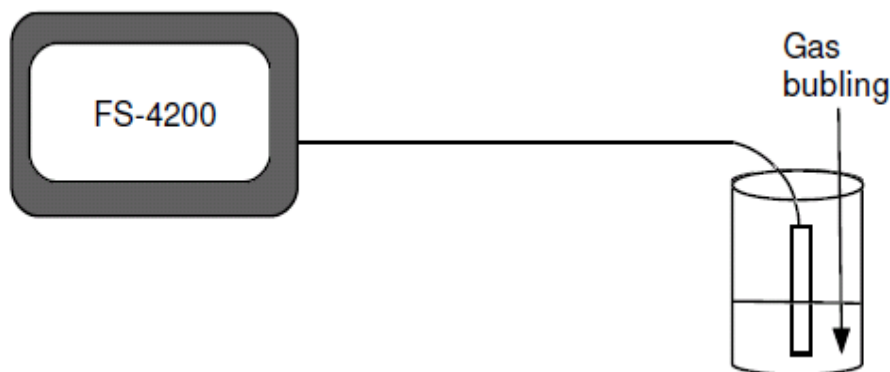


Figure 1 : Setup used to evaluate refractive index changes of the polymer precursor solution.

1.2 **LED-LED Portable CO<sub>2</sub> gas sensor :** In this system a test rig was constructed to ensure the accurate alignment of the two LED pair channels, the secure placement of the chemical sensing membrane and to investigate the effect of the distance between the emitter and detector LEDs. The membrane housing contained two sensing chambers wherein each was fitted with one LED emitter/detector pair. Furthermore, the chambers were designed with hollow through-hole sections to allow for a flow of gas to react with the sensing membrane. The LEDs were polished and flattened down, and placed within threaded housings, so that the rotation of the housing inside the tapped holder varied the distance between the emitter and the detector. The

distance was adjusted by inserting different sized washers, each of a pre-set designed thickness. Finally, the membrane holder allows the sensing surface to be directly aligned with both the emitter and detector LEDs.

1.3 **NDIR Sensor Design :** The figure 2 is showing a top view of the overall NDIR sensor design. The gas sample diffuses through a metal which on the top. Polychromatic light from the incandescent bulb passes through the gas sample and is absorbed in proportion to the amount of CO<sub>2</sub> present. Reflection of light off the internal walls increases the path length and hence it increases the sensitivity. The filter in front of the detector removes all the light except that at 4.26μm, corresponding to CO<sub>2</sub>[6].

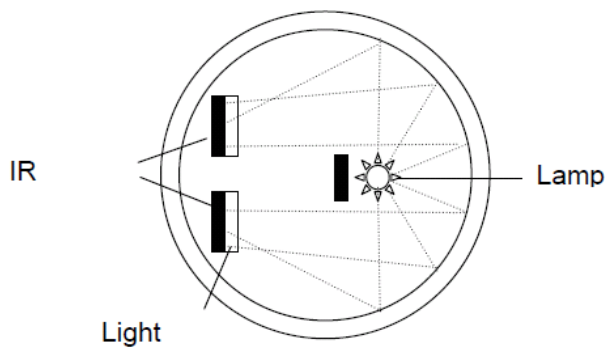


Figure 2 : Top View of NDIR sensor

- 1.4 **Chemical Gas Sensor** : Chemical CO<sub>2</sub> gas sensors with sensitive layers depend on polymer or heteropolysiloxane have the principal advantage of very low energy consumption and can be condensed in size to fit into microelectronic-based schemes. The short- and long term drift effects and low lifetime are major drawbacks when compared with the NDIR measurement principle [3].
- 3.5 **Surface Plasmon Resonance sensor** : Surface Plasmon Resonance (SPR) is a charge density wave which takes place at the interface of two media with dielectric constants of opposite signs. This charge density wave is associated with a TM electromagnetic wave and whose field vector is at maximum[9]. This wave can be optically excited by using a coupling prism coated with a thin metal layer, where a TM-polarized light beam is imposing on the metallized face of the prism through the prism itself under total internal reflection conditions which is shown in figure 3 [5]. The resonance linewidth strongly depends on the excitation wavelength, the metallayer structure and the refractive index of the dielectric medium. This refractive index variations modify significantly the SPR conditions, varying the resonance angle value and hence the resonance angular position. Therefore the refractive index variations are incidental by the spatial displacement of the resonance peak. These features allow SPR-based devices to be used as high sensitivity optical sensors [5].

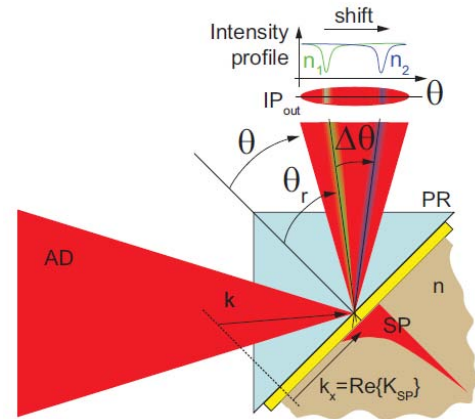


Figure 3 : Surface Plasmon Resonance Sensor

#### IV. EXPERIMENTAL SETUP

**4.1 Detection of Gaseous Carbon Dioxide** : NDIR sensors are most often used for measuring carbon dioxide in gaseous environment [1] and have sensitivities of 20–50 PPM [2]. The main components in the present Non-Dispersive Infrared sensor device are an infrared source (lamp), a sample chamber, Reference chamber, a Light detector chamber. Before starting the process the sample chamber is fed with carbon dioxide to measure the actual concentration, and the reference chamber fed with Nitrogen as referenced gas to compare with the sample chamber. Then the Infrared light is directed from source lamp with high intensity through the sample chamber. Then some of the infrared rays absorbed by gas and partially the IR waves transmitted towards the detector. In parallel, the reference chamber which is enclosed with the nitrogen gas is incident with the Infrared light. The infrared light is transmitted with same intensity levels through the reference chamber. In the reference chamber the infrared rays scattered in to nitrogen gas. The nitrogen gas absorbs some of the infrared radiation and partial radiations will be transmitted towards the detector. The detector has an optical filter in front of it that eliminates all light except the wavelength that the selected gas molecules can absorb. Ideally other gas molecules do not absorb light at this wavelength, and do not affect the amount of light reaching the detector[1] to compensate for interfering components. If the concentration of the carbon dioxide is high the absorption ratio in chambers increases. Similarly the radiations in detector chamber also increases. When a detector chamber absorbs some of the infrared radiation, it heats up and expands. This causes a rise in pressure within the sealed vessel that can be detected either with a pressure transducer. This pressure can be measured with low pressure diaphragms. These diaphragms will convert pressure in the detector chamber into displacement. Finally the displacement can be converted into analog signal with

the help of Linear Variable Differential Transformer as shown in figure 4. The combination of these output voltages from the detector chambers from the sample gas can then be compared to the output voltages from the reference chamber. The analog signals are further need to convert into digital signals to process and analysis the signals through microcontroller. The analog

signals generated from NDIR sensors are amplified and further converted into digital signals by passing them through Analog to Digital Converter as shown in figure5. The digital signals are fed to microcontroller through input ports for consideration to analysis and display the output on LCD screen

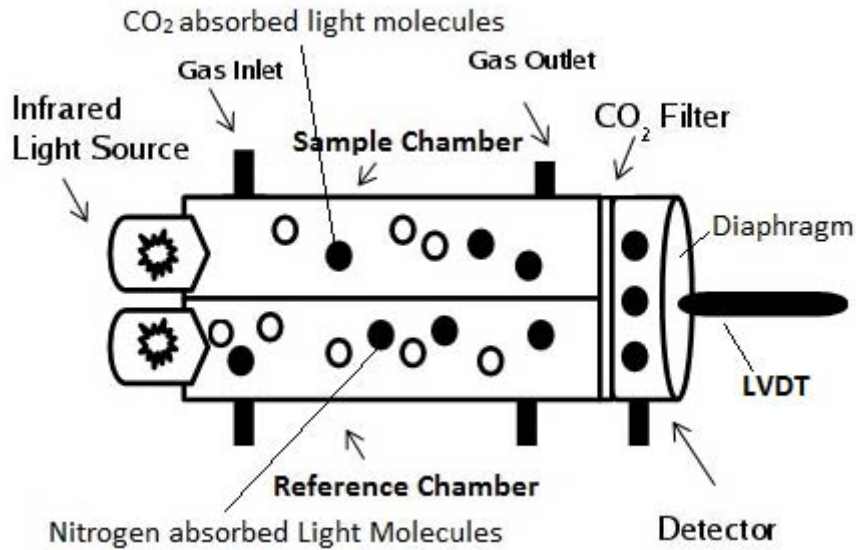


Figure 4 : NDIR Spectroscopic Sensor

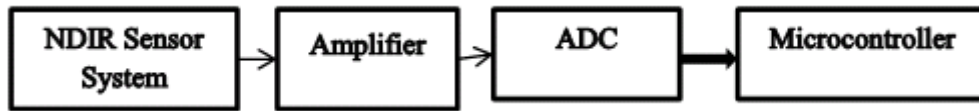


Figure 5 : Block diagram of CO<sub>2</sub> Measurement System

**1.5 Detection of Liquid Carbon Dioxide :** The first step in measuring Liquefied carbon dioxide, compress the carbon dioxide gas until it liquefies, at the same time removing the excess heat. The CO<sub>2</sub> gas will liquefy at a pressure of approximately 870 pounds per square inch at room temperature. Next, the pressure is reduced over the liquid carbon dioxide by sending it through an expansion valve into an empty chamber. The liquid will blaze, with some turning into gas causing the remainder to cool. As the temperature drops to -109.3°F, the temperature of frozen CO<sub>2</sub>, some of it will freeze into snow. Connect liquid carbon dioxide to the inlet of the chamber, which is fixed with LIGHT on one side and Light detector on other side. When the liquid CO<sub>2</sub> flushes in to the chamber some of the cold CO<sub>2</sub> freeze in to snow. Firstly note the time to propagate the Light to

the detector. Then note the time at the detector by emitting the liquefied CO<sub>2</sub> in to the chamber. The timing of detector excitement pulses are counted by external timer. If the sensing device is connected with 3<sup>rd</sup> generation microcontroller, it is not required to interface any external timer. The internal Direct Memory Access (DMA) control can be used to measure the time at detector. The DMA can also be used as counter [10][11]. The number of pulses at DMA represents the propagation delay between LED emitter and detector. Indirectly it is representing the concentration of CO<sub>2</sub> in the chamber. As the concentration of CO<sub>2</sub> goes on increasing the travelling period of the light waves also increases and further it increases the count at DMA terminal count register.

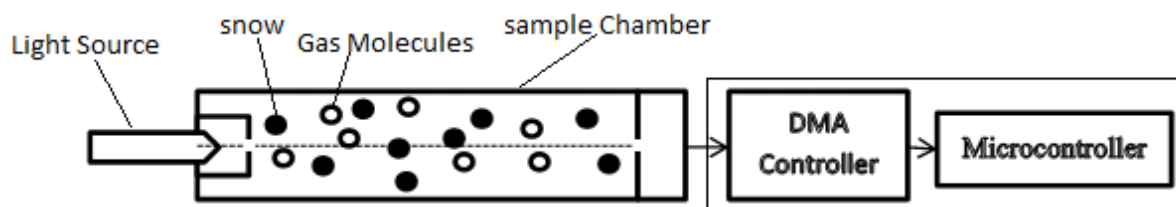


Figure 6 : Interfacing Diagram of Liquid gas sensor with DMA Controller

## V. CONCLUSION

High sensitivity is achieved with Diaphragm attached in detector chamber of gas analyser. In liquid gas analyser DMA controller is used to measure the time taken to change the status of detector. The DMA controller is used to read pulses from the detector while microcontroller is busy with some other task. That is for instance, while microcontroller accessing the memory device, the DMA controller can fetch pulses from the light detector. The instrument is very capable of measuring low concentrations of CO<sub>2</sub> and it can also measure wide range of CO<sub>2</sub> with high sensitivity. In liquefied gas sensor system, power consumption is minimized since, without the intervention of the microcontroller the DMA controller is able to read the data waves from detector chamber. At the same time microcontroller can concentrate other tasks.

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