| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 9, Issue 8, August 2020||

Handheld Evidential Breath Analyser Design

Mokhtar Shouran[1,2], Ibrahim Elhedmi[3]

Lecturer, Department of Control Engineering, College of Electronic Technology, Bani-Walid, Libya[1]

PhD Student, Wolfson Centre for Magnetics, Cardiff University,Cardiff, United Kingdom[2]

Lecturer, Department of Electronic Engineering, Higher Institute of Sciences and Technology, Azizia, Libya[3]

ABSTRACT:Breath analyser is a device that is used in order to estimate the concentration of the alcohol from a breath sample. This device can be in various sorts and forms; it depends on the goal that it is designed for.The main objective of this research work is to design an evidential breath analyser that is handheld and truly portable which guarantees the minimum requirements establishedby the International Evidential Standard (OIML R 126) with an estimation of its final cost.Besides, different absorption-based technologies such as, tunable diode laser spectroscopy, nondispersive infrared sensor, and spectrophotometry are assessed in order to select the best one for the design to meet the requirements.In this paper, Ze-max optic studio alongside with MATLABsoftware have been used to reach the goals of this design.

KEYWORDS: Breath Analyser,Laser Diode,Ze-max Optic Studio,MATLAB.

I.INTRODUCTION

A breathanalyser or breathalyser is a device for estimating blood alcohol content (BAC) from a breath sample. The name is a genericized trademark of the Breathalyzer brand name of instruments developed by inventor Robert Frank Borkenstein in the 1950s [1,2].Two breathanalyser technologies are most prevalent,the portable ones which is widely used to test whether a person is drunk or not. The other shape which is the desktop format that commonly uses infrared spectrometer technology. Moreover, they can be categorised depending on the technology that they use so they can be Semiconductor oxide breath analysers, Fuel cell breath analysers, or Spectrophotometer breath analysers. Importantly, in order to design an internationally standard alcohol breath analyser the certification requirements of the International Evidential Standard (OIML R 126) should be met[1].One of the first steps in this field was produced by Emil Bogen, who collected air in a football bladder and then tested this air for traces of alcohol, discovered that the alcohol content of 2 litres of expired air was a little greater than that of 1 cc of urine[3]. However, research into the possibilities of using breath to test for alcohol in a person's body dates as far back as 1874, when Francis E. Anstie made the observation that small amounts of alcohol were excreted in breath[4].

II.THE INTERNATIONAL EVIDENTIAL STANDARDS

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States. The main categories of OIML publications are:

1- International Recommendations (OIML R), which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity OIML Member States shall implement these Recommendations to the greatest possible extent.

2- International Documents (OIML D), which are informative in nature and which are intended to harmonize and improve work in the field of legal metrology.

3- International Guides (OIML G), which are also informative in nature and which are intended to give guidelines for the application of certain requirements to legal metrology.

4- International Basic Publications (OIML B), which define the operating rules of the various OIML structures and systems.

This publication - reference OIML R 126, edition 2012 (E) - was developed by the OIML Technical Subcommittee TC 17/SC 7 Breath testers. It was approved for final publication by the International Committee of Legal Metrology at its

47th meeting in Bucharest, Romania, in October 2012 and supersedes the previous edition dated 1998. It was sanctioned by the Fourteenth International Conference on Legal Metrology in 2012. This reference provides the full details of the steps and recommendations that should be understood and followed to design the Breath Analyser [5].

III.ASSESSMENT OF DIFFERENT ABSORPTION BASED TECHNOLOGIES

3.1 SPECTROPHOTOMETRY

Generally, Spectrophotometry is a scientific method based on the absorption of light by a substanceand takes advantage of the two laws of light absorption. From a similar angle, spectrophotometry can be defined as the measurement of the absorption or transmission characteristics of a material as a function of wavelength.This technique mainly uses the visible light and infrared, as well as ultraviolet regions. Therefore, Spectrophotometry is used to identify a substance by measuring the absorbances at various wavelengths. This method is applicable to identification tests, purity tests, and assays, in which the absorbance of a solution with a certain concentration is usually measured at the wavelength of the maximum absorption (λ max.) or the minimum absorption (λ min.) [6].
Spectrophotometry is based on the light and perception of the colour. Light is a form of electromagnetic radiation, when it falls on a substance, three things occurs:

- It be reflected by the material
- It can be absorbed by the material
- Certain wavelength might be absorbed, and the rest can be transmitted or reflected.

The instrument shown in fig 1 operates by passing the light from a light source through a monochromator which diffracts light into a rainbow of wavelengths, then a narrow bandwidth of diffracted spectrum is passed through a mechanical to the output side of monochromator. These bandwidths are transmitted through the test sample. The transmitted light from the test sample is then measured with a photodiode or a light sensor. The transmittance or reflectance at each wavelength is then compared to the transmittance from the reference sample. Most of the times the absorbance is found out by taking the negative logarithm of the transmittance [6].

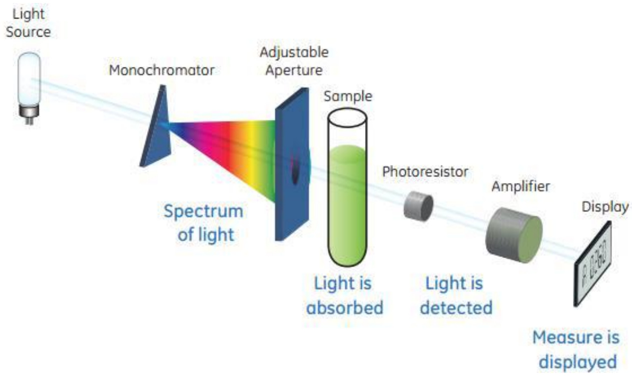

Fig. 1Spectrophotometry.

3.2 NONDISPERSIVE INFRARED SENSOR (NDIR)

A nondispersive infrared sensor (NDIR sensor) shown in fig 2 is a simple spectroscopic sensor often used as a gas detector. It consists of a simple spectroscopic sensor which is used as a gas species detector. It uses the infrared radiations for the detection of the gas. Since infrared energy is allowed to pass through a sample without deformation it is non-dispersive in sense. NDIR can also be defined as an industry term for "nondispersive infrared" and is the most common type of sensor used to measure CO_2. The benefits of NDIR sensors are they Could be low cost and the relatively basic components required to construct the device. However, the selectivity is not good enough and the sensitivity is considered lower than laser-based sensor.
An infrared lamp directs waves of light through a tube filled with air toward an IR light detector, which measures the amount of IR light that hits it. As the light passes through the tube, any gas molecules that are the same size as the wavelength of the IR light absorb the IR light only, while letting other wavelengths of light pass through.Next, the remaining light hits an optical filter that absorbs every wavelength of light except the exact wavelength absorbed by CO_2.Finally, an IR detector reads the amount of light that was not absorbed by the CO_2 molecules or the optical filter [7].

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 9, Issue 8, August 2020||

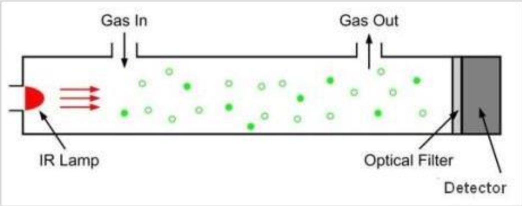

Fig. 2 A simple block diagram of NDIR sensor.

3.3 TUNABLE DIODE LASER SPECTROSCOPY (TDLS)

The development of semiconductor diode lasers in the near infrared has been spurred by thedevelopment of CD players and optical fiber communication. As technology has improved,lasers have been developed for new applications such as pumping of solid state and fiber lasers.In addition to wavelength, other important laser parameters are mode stability, currenttunability frequency drift, and Long-term frequency stability.

The most important application of tunable diode lasers to atmospheric measurements has turned out to be their use in conjunction with a long-path cell to provide high sensitivity local measurements. This technique is commonly referred to as tunable diode laser absorption spectroscopy (TDLAS), a general technique for monitoring most atmospheric trace species. The requirement is that the molecule should have an infrared line spectrum, which is resolvable at the Doppler limit.TDLAS is an effective technique to measure the concentration of certain types such as methane, water vapour, in a gaseous mixture using tunable diode lasers and laser absorption spectrometry.

The principle of TDLAS is absorption spectroscopy using a single isolated absorption line of the species. TDLAS has now established itself as one of the leading techniques for atmospheric analysis of trace gas constituents. Operating at infrared wavelengths, most trace gases except nitrogen and oxygen to be monitored via their characteristic vibrational spectra and the high spectral resolution reduces the possibility of interferences from other species. Fig 3 shows the schematic of tuneable diode spectroscopy [8].

The benefit of TDLAS over other methods for concentration measurement is it is able to achieve very low detection levels. However, the main drawback of this method is that it relies on the measurement of small variation of a signal on top of a large background. Any noise made via the light source will have a crucial affect which may lead to change the detectability of this technique.What should be mentioned is TDLAS can determine the temperature, pressure, velocity and mass flux of the gas under observation.

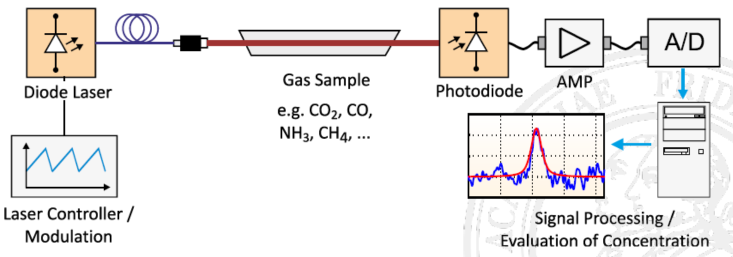

Fig.3Tuneable diode spectroscopy.

IV.METHODOLOGY

In this research paper, two different programs have been used to reach the goals.

4.1 ZE-MAX OPTIC STUDIO

Optics Studio is an advance level optical system designing software, engineered by Ze-max. Its unique features and functions make it one of the best optics studios around the world. Ze-max optics studio is an ideal software for creating models and designing optical systems. Designing of any optical system or illumination system is possible through Optic Studio including, projection, free from lenses, coherent lasers, LEDs, backlight, display, fiber optics systems and much more.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 9, Issue 8, August 2020||

4.2 MATLAB

The name MATLAB stands for Matrix Laboratory. MATLAB was written originally to provide easy access to matrix software developed by the LINPACK (linear system package) and EISPACK (Eigen system package) projects. It is a high-performance language for technical computing. It integrates computation, visualization, andprogramming environment. Furthermore, it is a modern programming language environment: it has sophisticated data structures, contains built-in editing and debugging tools, and supports object-oriented programming. These factors make MATLAB an excellent tool for research.

V.EXPERMINAL RESULTS AND DISSCUSTION

5.1 ANALYSING THE SPECTRUM INFORMATION

This step is done to select absorption windows of operation based on the accuracy and selectivity requirement and calculating the absorbance within the line/window based on the linewidth/bandwidth of a laser/filter.

Different spectrums are analysed such as Ethanol spectrum, Carbon Monoxide to get the best possible window lines for the alcohol breath analyser. The window lines can be selected from range 2.7 µm to 2.74µm, other windows can be chosen which use other filters with different specifications. A filter should be designed based on the assumption that the gas chamber or the gas cell of the breath analyser will detect, gas contains five types of Molecules or substances which are Acetone, Isopropyl alcohol, methyl alcohol, ethyl alcohol, and Carbon Monoxide. This filter should allow a certain wavelength to pass through it. The centre of filter is at 2.72µm. The range of the filter is from 2.70µm to 2.74µm. When the spectrum of gaseous mixture is pass through the filter only wavelengths from 2.70µm to 2.74µm are allowed to pass and reach the detector. Selecting this range of the filter due to the wavelengths of the desired spectrum is at this range. Therefore, to investigate the range of wavelengths that the absorbance of alcohol is maximum at, the absorption coefficient of each of these five substances should be got.

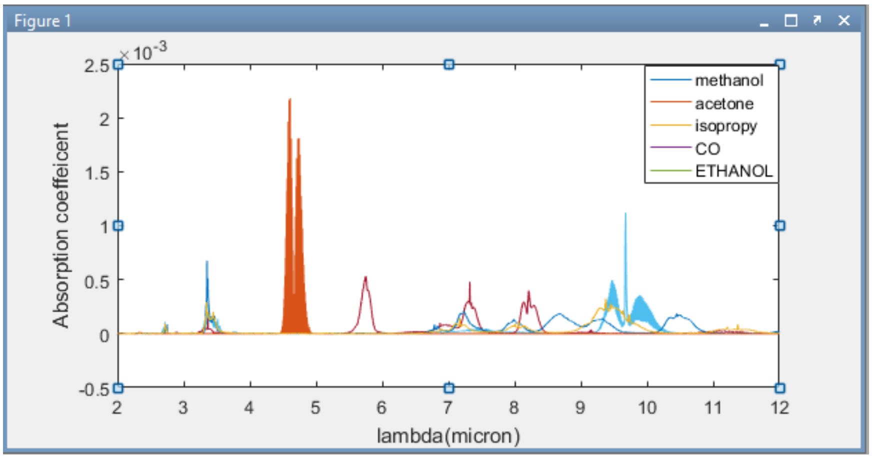

Fig. 4 The absorbance coefficient of all spectrums.

Fig 4 displays the absorption spectrum of Ethanol Alcohol, Acetone, Isopropyl, Methanol and Corban monoxide in terms of wavelengths in microns. By analysing these spectrums, after filtering, it can be seen that in the range from 2.3µm to 3µm the absorption of ethanol is highest one. The first shape or window of the filter that can be selected to pass a certain wavelength is shown in fig 5. Also, the centre and the range of the filter can be clearly shown.

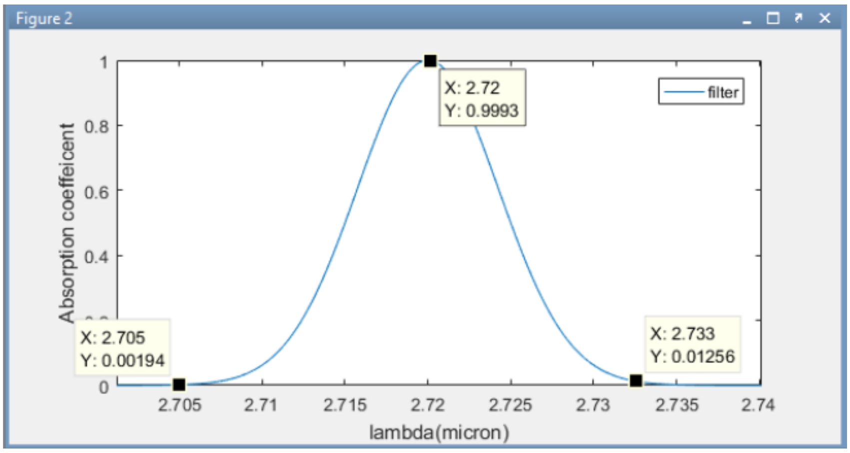

Fig.5 The shape of the filter that has been selected

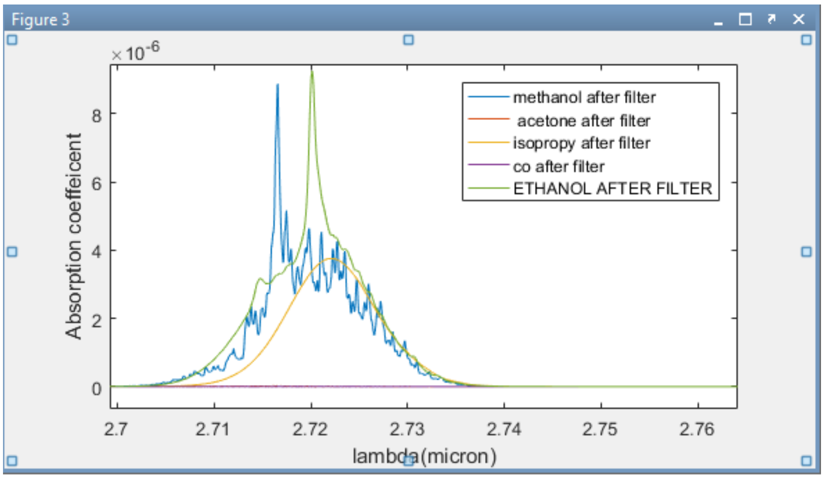

Fig.6 The absorbance coefficient of all gaseous when the filter is used

From fig 6, it can be observed that after applying the filter the highest absorption coefficient at this range is the absorption coefficient of ethanol.

Note, there is also a higher absorption coefficient for the alcohol at another range which is from 6µm to10.5µm but it cannot be selected due to it requires a source and a detector that operate at this higher wavelengths which leads to make the cost of the system higher.As the results demonstrate, after filtering, the absorbance of ethanol is greater than the others. This is the purpose why this line width has been selected to achieve the desired result. The absorbance of these spectrums as they have been calculated by the Matlab code can be listed as follows: $\text{Methanol} = 3.8 * 10^{-6}$, $\text{Aceton} = 7.5 * 10^{-9}$, $\text{Isopropanol} = 3.1 * 10^{-6}$, $\text{Carbon monoxide} = 1.49 * 10^{-10}$, and$\text{Ethanol} = 4.8 * 10^{-6}$.

It might worth menthioning that another range of wavelength shown in fig 7 can be used as it covers all the gaseous which is the range from 3.34µm to 3.513µm as the filter below provides and the center of the filter is 3.43µm. Importantly, this range covers all the spectrums that mentioned above. Also, the absorption spectrum of the alcohol is the highest.

```
b=3.432;          %center wavelength in micron of filter
FWHM=0.0830;      %FWHM of filter
```

This part from the Matlab code which can be used shows how the filter adjusted and as fig 7 explains the center is at 3.43µm. So, the range is from (3.432-0.083 to 3.432+0.083) which means from 3.34µm to 3.513µm.

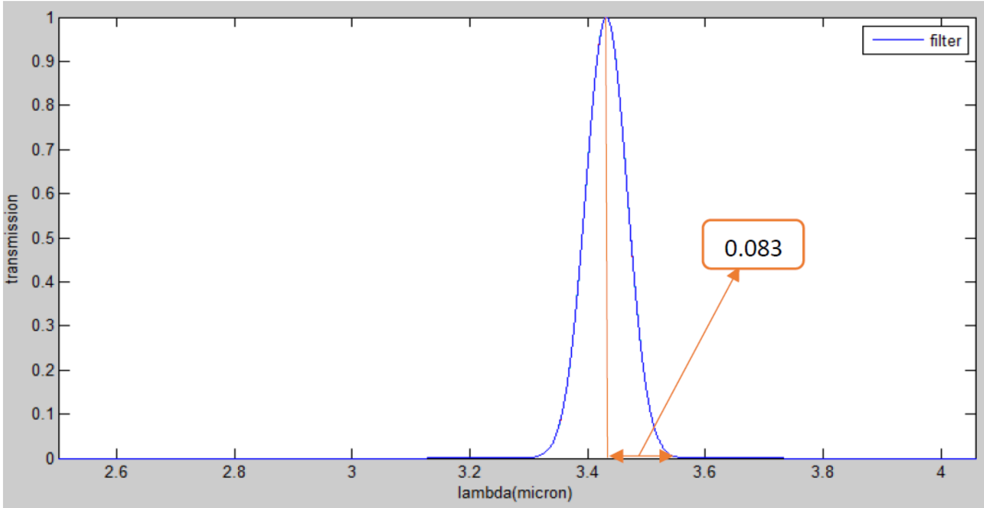

Fig.7 The second window filter that can be used.

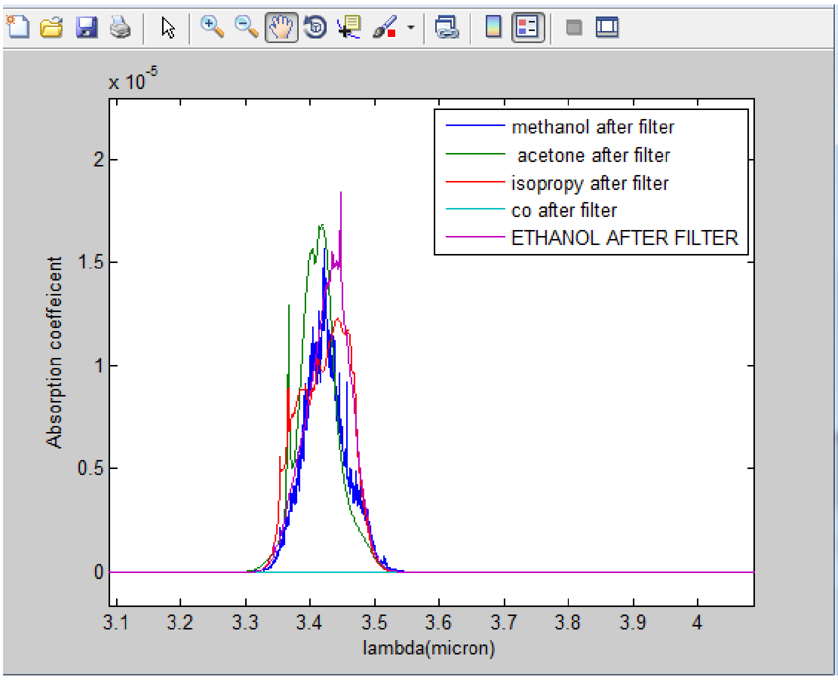

Fig.8The spectrums after filtering.

Fig 8 illustrates how the absorption spectrum of these gaseous will be after filtering. This window or this range can be considred for the design of the proposed analyser.

5.2 SELECTING THE SOURCE, THE DETECTOR, AND CALCULATING THE OPTICAL PATH

Meeting the requirement standers and keeping the cost in a reasonable value is essential in this section. Therefore, in order to reach this aim, special procedures should be taken as follows:

5.2.1 DETECTOR (PbSe PHOTOCONDUCTOR)

This detector can detect light that varies from 1.5µm to 4.8 µm. This type of detect is the best choice to meet the requirements and the cost of the project. The active area of this detector is 2*2 mm. The detector is selected which has been chosen it based on the absorption of Alcohol, Isopropyl, Acetone, Methyl and Co which the detector needs to be sensitive at 2.71µm.The specification of this element is summarized in table 1. This detector is available on thorlabs under the number FDPSE2X2.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 9, Issue 8, August 2020||

Table 1 The specification of the selected detector.

Electrical Specifications	
Wavelength range	1.5 to 4.8 um
Peak Wavelength	4μm
Peak Sensitivity	1.5k V/W(min) 3k V/W(min)
Rise time^2(0 to 63%)	10 us (max)
Detectivity^3(λ_p, 600,1)	$2.5 * 10^{-9} \frac{cm*\sqrt{Hz}}{W}$(typ)
Dark Resistance	0.1 to 0. 3MΩ
Bias Voltage	100V
General	
Package	TO-5
Operating Temperature	-30 to 50 ℃
Storage Temperature	-55 to 60 ℃

5.2.2 LIGHT SOURCE (LED34H-PRW MID INFRARED LIGHT EMITTING DIODE)

The light source is one of the most essential part of the optical system design. The light source that is used in this design is LED34H-PRW which is mid infrared LED. It emits infrared IR radiation with centre wavelength at 3400nm as shown in the figure below. This LED has a high response time and high modulation around 100 MHz. The other specifications of this Light source are described in table 2.

Table 2 The specification of the selected light source.

Optical and Electrical Characteristics

LED34H-PRW - Standard LED chip with circular or ring top contact					
Parameters	**Units**	**Conditions**	**Ratings**		
			Min	**Typ**	**Max**
Peak emission wavelength	μm	T=300 K, I = 150 mA qCW	3.30	3.40	3.49
FWHM of the emission band	nm	I = 150 mA qCW	400	450	500
Quasi-CW Optical Power	μW	I = 200 mA qCW	45.0	65.0	80.0
Pulsed Peak Optical Power	μW	I=1 A, f=1 kHz, duty cycle 0.1%	480	600	720
Voltage	V	T=300 K, I=200 mA	0.2	-	0.5
Switching time	ns	T=300 K	10	20	30
Operating temperature range	°C	-200 ~ +50			
Soldering temperature	°C	180			

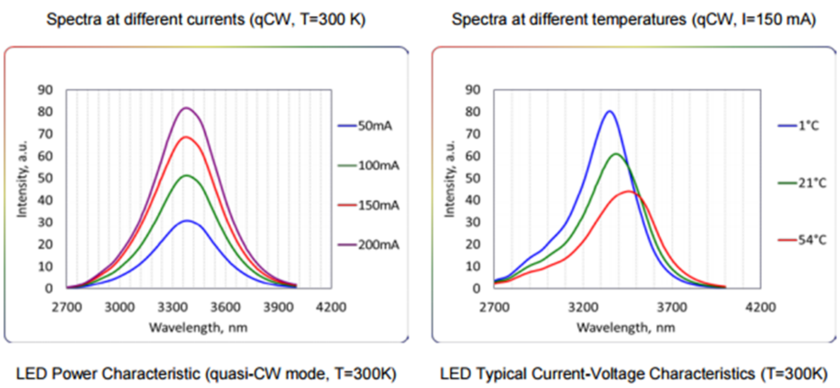

Fig.9 Emission wavelength for LED34H-PRW.

5.2.3 CALCULATING THE OPTICAL PATH LENGTH AND THE ACCURACY

After selecting the source and the detector, the optical path length can be determined as follows:

Noise Equivalent Power (NEP) = $2.5 * 10^{-9} \frac{\mathrm{cm}*\sqrt{\mathrm{Hz}}}{\mathrm{W}}$, Area = 4mm2, Bandwidth 1 Hz, $\mathrm{NEP} = 8 * 10^{-10}$

The absorption coefficient for the Alcohol at 3.44um is about 1.89µ ($\propto = 1.89 * 10^{-5}$)

$$\Delta \mathrm{I} = \mathrm{I}_0 * \mathrm{effeciency} * \alpha * 0.1\mathrm{ppm} * 1\mathrm{meter}$$

When the concentration is 0.1 ppm so the intensity change for 1m path length would be:

$$\Delta \mathrm{I} = \mathrm{I}_0 \times \mathrm{efficiency} \times \mathrm{absorbtion\ coeffecient} \times 0.1\mathrm{ppm} \times \mathrm{distance}$$
$$\Delta \mathrm{I} = 6.5 \times 40\% \times 1.89 \times 10^{-5} \times 0.1\mathrm{ppm} \times 1\mathrm{mm} = 0.49 * 10^{-5}\mathrm{w}$$
$$\mathrm{L} = \frac{\mathrm{NEP}}{\Delta \mathrm{I}} \times 1\mathrm{m} = \frac{8*10^{-10}}{0.49*10^{-5}} * 1\mathrm{m} = 16.3 * 10^{-5}\mathrm{m}.$$

This is the minimum path length which can be set for a detector. This length can be changed to achieve the desired accuracy. These results are obtained by assuming the efficiency is 40%.For 1 ppm concentration, the intensity change will be:

$$\Delta \mathrm{I} = \mathrm{I}_0 \times \mathrm{efficiency} \times \mathrm{absorbtion\ coeffecient} \times 1\mathrm{ppm} \times \mathrm{distance}$$
$$\Delta \mathrm{I} = 6.5 \times 40\% \times 1.89 \times 10^{-5} \times 1\mathrm{ppm} \times 16.3 * 10^{-5} = 8\mathrm{n}$$
$$\mathrm{Accuracy} = \frac{\mathrm{NEP}}{\Delta \mathrm{I}} \times 1\mathrm{ppm} = \frac{8 * 10^{-10}}{8 * 10^{-9}} * 1\mathrm{ppm} = 0.1$$

This calculation is theoretical, the real efficiency will be calculated after designing the Ze-max system when the total output power and the input can be practically set.

5.3 DESIGNING THE SYSTEM USING ZE-MAX

Designing the optical system in Ze-max optics studio using the light source and detector that have been mentioned above; considering the cost of the design of the light source and detector and all the requirements provided.

The idea behind the design is the light that is generated from a light source will travel a certain path length L and will fall on the detector. During passing through the path length the light will interact with gases present in the path and certain part of the light will be absorbed by the gases present in the path. The light transmitted to the detector will determine how much of the light has been absorbed. Therefore, in order to design an optical system for Alcohol breath analyser essential components are needed such as light source and detector.

Before starting in the design one point should be taken into consideration which is the higher path length L means more the light is expected to interact with the gas present in the path which brings about the accuracy of the system increase. Therefore, to achieve higher accuracy the path length should be long within the certain limits of design that meets the requirements.

5.3.1 THE LIGHT SOURCE

As it is provided the Light source (LED34H-PRW Mid infrared light Emitting Diode) is considered. The allowance angle for the light source is from 0 to 10 for LED with a parabolic reflector. This source as shown in fig 11produces a light with power around 65uw as it is adjusted in Ze-max program. The point behind selecting this light source is that when the spectrums of many gaseous were analysed, they all have spectrum in this range.

	Object Type	Comment	Ref	Ins	X Positio	Y Position	Z Position
1	Source Radial	LED34H-PRW	0	0	0.0	-10.0	-15.0
2	Standard Surface	concave mirror	0	0	0.0	-10.0	40.0
3	Standard Surface	concave mirror	0	0	0.0	28.0	-5.0
4	Standard Surface	concave mirror	0	0	0.0	62.0	40.0
5	Detector Rectangle	PbSe	0	0	0.0	81.0	0.0

Fig. 10 Parameters of the source from Ze-max.

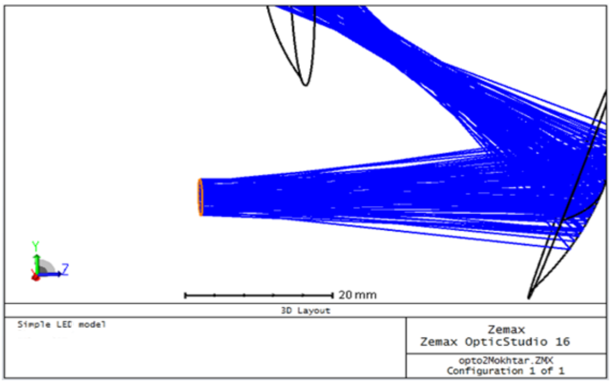

Fig.11 The source from the Ze-max design.

5.3.2 CONCAVE MIRRORS

In case the path length wants to be increased which consequences the accuracy of the optical system for alcohol breath analyser increases, mirrors are used to reflect the light that is generated by the source several times before reaching the detector. There are three reflecting mirrors, they are arranged in a way that it catches all the light from the light source and reflect it to the detector surface. To achieve high accuracy the mirrors should be able to receive and reflect all the incident light. The distance between the mirrors should be extended in a way that meet the requirements and that make the system portable. In other words, the distance that the light travels through from the source to the detector should be as far as possible. The higher path length the more accurate the measurement would be.

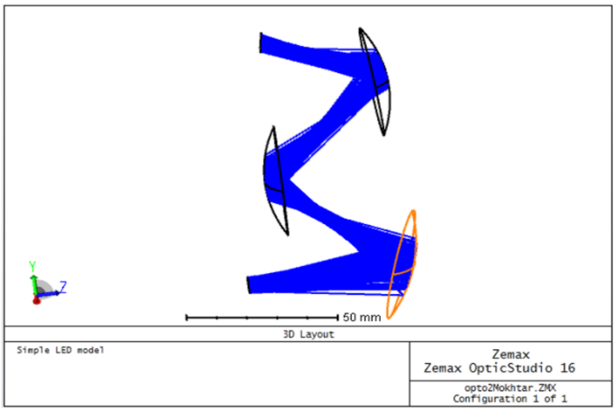

Fig. 13 3D layout of the design shows how the reflective concave mirrors are arranged.

5.3.3 THE DETECTOR

The detector PbSe Photoconductor has the capabilities to detect light varying from wavelength 1.5um to 4.8 um. In order to meet the requirements and the cost of the system, this detector was the best choice. The light is directed from the third and concentrated on the detector. The detector should be placed in a way that allows to receive as much light as possible. The resolution of the detector is kept 100 pixels to achieve better response.

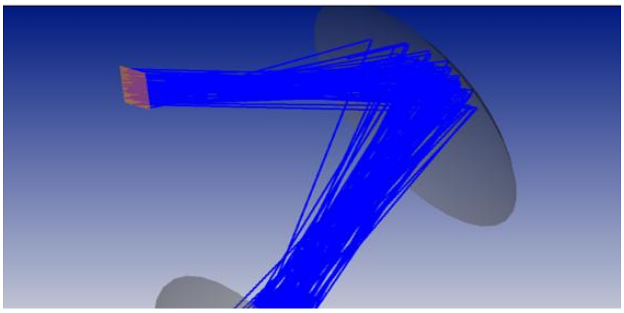
Fig.14The detector of the system.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 9, Issue 8, August 2020||

The way of working of this system is simple and it can be described as the figure below demonstrates, the light that is sent from light source is directed towards the first mirror which typically reflects all the light that incident on it. The reflected light is directed again towards the second mirror which reflects the light falling on it without any loss if it is possible, then redirected it towards the third mirror which reflects all the light to the detector. Typically, due to the area of the detector should be 2*2mm the light reflected from 3rd mirror cannot fall on the detector and there must be some loss of light and energy.

5.3.4 THE EFFICIENCY OF THE SYSTEM

To calculate the efficiency of the system light was sent through the system and the results were taken from the detector. Figures 15 shows the output of the system.

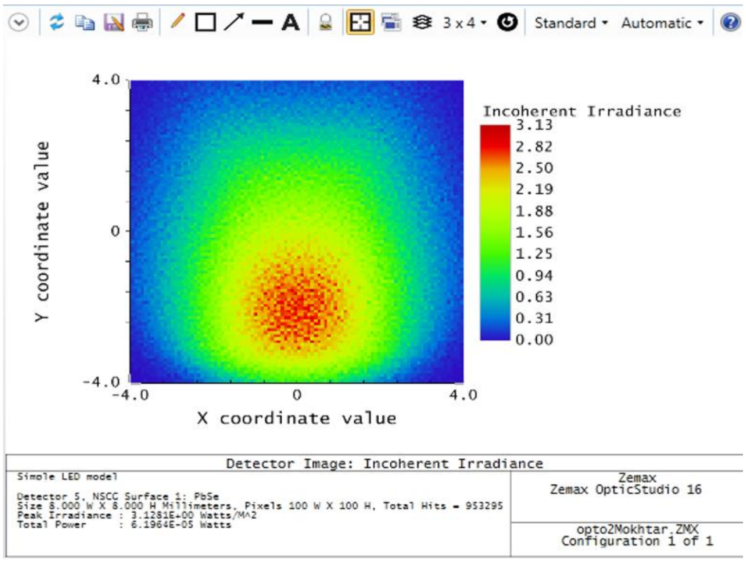

Fig. 15The detector image for incoherent irradiance.

Radiant intensity is defined as the incoherent intensity of the ray in cosine space.The efficiency is the ratio of output power to the input power. So, the value of the input power from the light source as it has been adjusted is 65 W. The output power as it can be seen from the pictures of the detector above is 61.964 μW.

$$Efficiency = \left(\frac{output\ power}{input\ power}\right) x\ 100 = \frac{61.964}{65} * 100$$

Efficiency = 95.5%

What is importantly must be mentioned is this efficiency will be considered as a reference percentage to determine how much of the light has been absorbed when the gas is tested.

5.3.5 PATH LENGTH

The path length of this design is calculated using this formula:

$$L = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

Firstly, the distance between the source and the first mirror

$$d_1 = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

$$d_1 = \sqrt{(0-0)^2 + ((-10) - (-10))^2 + (40 - (-15))^2}$$ = 55mm.

Secondly, the distance between the first mirror and the second mirror.

$$d_2 = \sqrt{(0-0)^2 + ((28) - (-10))^2 + ((-5) - (40))^2}$$ = 58.89mm.

Thirdly, the distance between the second mirror and the third mirror.

$d_3 = \sqrt{(0-0)^2 + ((62)-(28))^2 + ((40)-(-5))^2}$ = 56.4mm.

Fourthly, the distance between the third mirror and the detector.

$d_3 = \sqrt{(0-0)^2 + ((81)-(62))^2 + ((0)-(-40))^2}$ = 44.28mm.

L = 55mm + 58.89mm + 56.4mm+ 44.28mm = 214.57mm

Regarding to the physical size of the system,From the data which is put in Ze-max optics studio the physical size of the optical system can be determine. The height of the system is 81+10=91mm, the width of the system is 55mm, and the length is 20mm.

5.3.6 THE ESTIMATION COST OF THE SYSTEM

The estimation cost of the proposed system can be summarised as in table 3.

Table 3 The estimation cost of the system.

Component	Model	Cost of the components
Photoconductor / Detector	FDPSE2X2 (1.5-4.8µm)	£154.35
Light source	LED34H-PRW(2.7um-4.2µm)	Roughly £132
Concave lenses	LC4573-µV(245 - 400 nm)	£66.89*3=£200.67
Power supply	2 v battery	£20
Total		£507.02

VI.CONCLUSION

In this research paper, the design of Alcohol Breath Analyser has been achieved after finishing number of stages, Starting from deep understanding of the requirements of international evidential standard (OIML R126).Then a research about different absorption based technologies was done before finishing theoretical calculations and selection of components, the price of the system has been taken into consideration during designing the system. Also, the selectivity of the light source and the light detector is based on the range of spectrum that has been selected. The optical system is designed using Ze-max OpticStudio using concave mirrors to increase the path length which lead to increase the accuracy. The optical path length of the system was pushed to be extended and as the calculation says it is 214.57mm. The efficiency was around 95 %. The physical size of the design allows the system to be portable.

REFERENCES

[1] Martin D (August 17, 2002). "Robert F. Borkenstein, 89, Inventor of the Breathalyzer". The New York Times. Retrieved 2013-12-23. Robert F. Borkenstein, who revolutionized enforcement of drunken driving laws by inventing the Breathalyzer to measure alcohol in the blood, died last Saturday at his home in Bloomington, Ind. He was 89....born in Fort Wayne, Ind., on Aug. 31, 1912.

[2] "Breathalyzer". US Patent & Trademark Office. May 13, 1958. Retrieved 2014-01-03.

[3] Bogen E (June 1927). "The Diagnosis of Drunkenness-A Quantitative Study of Acute Alcoholic Intoxication". California and Western Medicine. 26 (6): 778–83. PMC 1655515. PMID 18740360.

[4] "Professor Robert F. Borkenstein — An Appreciation of his Life and Work" (PDF). Borkensteincourse.org. Archived from the original (PDF) on 2009-02-25. Retrieved 2012-11-19.

[5] OIML R 126 (2012) International Organization of Legal Metrology– Evidential breath analyzers.

[6] L. M. Bachmann and W. G. Miller, "Spectrophotometry," in *Contemporary Practice in Clinical Chemistry*, 4th ed., Richmond, VA, United States Learning: INC, 2020, pp. 119–133.

[7] "How does an NDIR CO2 Sensor Work?," 2020. [Online]. Available: https://www.co2meter.com/blogs/news/6010192-how-does-an-ndir-co2-sensor-work. [Accessed: 07-Sep-2020].

[8] Lackner, M. Tunable diode laser absorption spectroscopy (TDLAS) in the process industries - a review. Rev. Chem. Eng. 23, 65–147 (2007).