

Anti-Ground Crashing Instrument Landing System

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Abstract-The aviation industry is the world biggest industry in transportation the rapid increase in short time in aviation industry requires parallel effective plans, programs and designs of systems and facilities nationwide to fulfil the increasing needs for safe air transportation. Aircraft landing remains a problem for a long time all over the world. Systems that aircraft rely on in landing are unreliable to perform a precise guidance due to many limitations of them such as inaccuracy, unreliability and no system have to solve the bad landing like when aircraft lands on the half of the runway or in case of the short runway. The aim to development of this system is to solve such limitations. According to a survey the inaccuracy in distance measurement from aircraft to the runway is a big problem which is faced by the aircraft during the landing .most of the distance measuring instrument work on the Doppler effect the parameters of this type of systems can be subjected to the environment conditions .other problem is the presence of two aircrafts on the runway at the same time this condition can solve by using ground radar but in case when A.C.T controller miss to inform to the pilot about this condition or error in communication system or error in radar signal this problem becomes more danger. In low visibility conditions, when pilots are unable to see the runway; the aircrafts are diverted to another airport. However, low visibility can also affect all airports in the vicinity, forcing aircrafts to land in low visibility conditions depending on Instrument Flight Rules (IFR). Aircraft approach and landing are the most hazardous portions of flight; accidents records indicate that approximately 50 per cent of the accidents occur during aircraft landing Currently, Global Positioning System (GPS) is the main navigation system used all over the world for aircraft navigation, approach and landing. However, in aircraft approach and landing phase, the accuracy of GPS is not sufficient to perform a perfect landing due to the possibility of aircraft to be drifted out of the runway. This system provides the particular guidance to solve these situations by using some advance technical support

Keywords- wireless transmitter, receiver, microprocessor light sensors, laser diodes, LCD monitor, yagi-uda antenna, anti-ground crashing ILS, GPS.

I. INTRODUCTION

*1.1. Background-*The aviation industry is the world biggest industry in transportation the rapid increase in short time in aviation industry requires parallel effective plans, programs and designs of systems and facilities nationwide to fulfil the increasing needs for safe air transportation. Aircraft landing remains a problem for a long time all over the world. Systems that aircraft rely on in landing are unreliable to perform a precise guidance due to many limitations of them such as inaccuracy, unreliability and no system have to solve the bad landing like when aircraft lands on the half of the runway or in case of the short runway. The aim to development of this system is to solve such limitations. According to a survey the inaccuracy in distance measurement from aircraft to the runway is a big problem which is faced by the aircraft during the landing .most of the distance measuring instrument work on the Doppler effect the parameters of this type of systems can be subjected to the environment conditions .other problem is the presence of two aircrafts on the runway at the same time this condition can solve by using ground radar but in case when A.C.T controller miss to inform to the pilot about this condition or error in communication system or error in radar signal this problem becomes more danger. In low visibility conditions, when pilots are unable to see the runway; the aircrafts are diverted to another airport. However, low visibility can also affect all airports in the vicinity, forcing aircrafts to land in low visibility conditions depending on Instrument Flight Rules (IFR). Aircraft approach and landing are the most hazardous portions of flight; accidents records indicate that approximately 50 per cent of the accidents occur during aircraft landing Currently, Global Positioning System (GPS) is the main navigation system used all over the world for aircraft navigation, approach and landing. However, in aircraft approach and landing phase, the accuracy of GPS is not sufficient to perform a perfect landing due to the possibility of aircraft to be drifted out of the runway.

As it approach runway more accuracy is required since the limit for mismatching the touch point should not exceed meter level. International Civil Aviation Organization (ICAO) has divided landing systems into three categories according to decision height, visibility and runway visual range. Category III C is not in operation yet anywhere in the world because of systematic limitations of landing systems in service. It requires landing with no visibility or runway visual range. Currently, the limits of integrity and accuracy of ground equipment's have not been able to match ICAO standards and recommended practices. Nevertheless, they are still in use due to the lack of better alternatives. The main current equipment's limitations are: inaccuracy, unreliability, vulnerability to multipath, obstruction in signal broadcasting, cause ground service cognition, lack of integrity and high cost.

In this paper, a ground-based system based on concept of optical measurement, controlling of system parameters via radio signals has been designed in order to provide accurate distance from aircraft to runway and reduce or even to eliminate landing systems errors and to solve the problem of bad landing of aircraft system specifications have been calculated, designed and simulated using Proteus simulation suite v8 and Keil uvision3 programing environment for microcontroller

1.2. Problem statement-in present whole aviation industry demanding a system which is helpful in case of short runway and can protect aircraft after the problem which arises from the band landing and more other reasons some systems has been introduced which are only show the indications and The level of accuracy of these indications for aircraft positioning has been achieved has not been able to match ICAO standard for CAT III C and it is not sufficient to fulfil aircraft automatic landing. ICAO favoured GPS over MLS; however, GPS is not highly accurate and has many limitations make such system not feasible to be used for aircraft automatic landing. GPS accuracy could be improved by receiving differential correction messages (DGPS) to 3-5 meters. Hence, this error may lead to drift aircraft out of runway and crash. Beside the lack of high accuracy, the other GPS limitations are: Satellite unavailability, Satellite Geometry, Low vertical accuracy Satellite signal broadcasting travel time is longer than signals transmitted from ground surface, GPS receiver update rate is low, Signal weakening and degradation, Ionosphere effects, GPS lack of high accuracy.

In order to overcome GPS limitations, even though many systems have been designed to augment GPS and improve the accuracy, no system can be relied on to achieve a high accuracy in a range of less than 1 m for high speed applications with high integrity and reliability.at that movement a system which protects the aircraft to crash. Will require that stop the aircraft before goes down to crash this system will able to stop the air craft when it land on the half of the runway This system provide a facility of the pilot when he does not put down aircraft on the desired part of the runway To solve the band landing much system has stabilised but these systems only show the indication for safe landing but no system have. Which can solve the mistake of pilot or the mistake which have raised due to the some situations

II. LITERATURE REVIEW

A detailed literature survey on "*Instrument landing system and other system of landing and runway safety*" has been carried out to know the current status of research in this field.

Aircraft landing and runway overrun mostly in case of short runway remain problems for a long time all over the world. Systems that aircraft rely on in landing are unreliable to perform complete automatic landing due to many limitations. As flying aircraft approaches runway, more accuracy is required since the limit for mismatching the touch point on the runway should not exceed meter level. Commonly, aircrafts are diverted to alternate airport in low visibility conditions when the visibility is below the allowable limit and in case when the aircraft cannot be diverted to other runway or if all of the runways of the particular area bear the same problem and in case when aircraft has limited fuel.in that case Pilot has last option to land his aircraft on short or current runway. In such cases 50 per cent chance to crash. We have many cases to show this reality of aviation industry such as

1) According to the report of "**National Transportation Safety Board. 2011.Crash During Approach to Landing, Empire Airlines Flight 8284, Avions de Transport Regional Aerospatiale Alenia ATR, N902FX, Lubbock, Texas, January 27, 2009. Aircraft Accident Report NTSB/AAR-11/02. Washington, DC**". This accident report discusses the January 27, 2009, accident involving Empire Airlines flight 8284, an Avions de Transport Regional Aerospatiale Alenia ATR 42-320, N902FX, which crashed short of the runway at Lubbock Preston Smith International Airport, Lubbock, Texas.

The captain sustained serious injuries, and the first officer sustained minor injuries. The airplane was substantially damaged. The airplane was registered to FedEx Corporation and operated by Empire Airlines, Inc., as a 14 Code of Federal Regulations Part 121 supplemental cargo flight. Instrument meteorological conditions prevailed, and an instrument flight rules flight plan was filed. The safety issues discussed in this report include the flight crew's actions in response to the flap anomaly, the continuation of the unsterilized approach, the dispatch of the flight into freezing drizzle conditions, the efficiency of the emergency response, and simulator-based training for pilots who fly in icing conditions. Nine safety recommendations are addressed to the Federal Aviation Administration.[1]

(2) According to the report of **National Transportation Safety Board. 2011. Crash During Attempted Go-Around After Landing, East Coast Jets Flight 81, Hawker Beechcraft Corporation 125-800A, N818MV, Owatonna, Minnesota, July 31, 2008. Aircraft Accident Report NTSB/AAR-11/01. Washington, DC.** This accident report discusses the July 31, 2008, accident involving East Coast Jets flight 81, a Hawker Beechcraft Corporation 125-800A, N818MV, which crashed while attempting to go around after landing on runway 30 at Owatonna Degner Regional Airport, Owatonna, Minnesota. The two pilots and six passengers were killed, and the airplane was destroyed by impact forces. The non-scheduled, domestic passenger flight was operating under the provisions of 14 Code of Federal Regulations (CFR) Part 135. An instrument flight rules flight plan had been filed and activated; however, it was cancelled before the landing. Visual meteorological conditions prevailed at the time of the accident. The safety issues discussed in this report relate to flight crew actions; lack of standard operating procedures requirements for 14 CFR Part 135 operators, including crew resource management training and checklist usage; go-around guidance for turbine-powered aircraft; Part 135 pre-flight weather briefings; pilot fatigue and sleep disorders; inadequate arrival landing distance assessment guidance and requirements; Part 135 on-demand, pilot-in-command line checks; and cockpit image recording systems[2] Until the mid-1950's, only visual landing procedures were possible. In 1958 the first Instrument Flight Rule (IFR) landing system developed. Currently, the standard radio landing guidance system used worldwide is the ILS it was selected by (ICAO) in 1946 as the international all-weather aircraft landing aid [3].

In order to overcome the operational and technical problems of ILS, ICAO has formulated guidelines for futuristic system that will replace ILS After evaluation the various systems; ICAO has accepted Microwave Landing System (MLS) for world-wide use [4]. Both ILS and MLS have many limitations and they are not highly accurate relatively they are unable to provide navigation service for aircraft flying in conditions of low visibility [5]. Hence, this is where a GPS-based landing system has the potential to complement landing systems, or even replacing them completely. Earlier, several papers described about GPS-based precision approach and landing [6–8]. The studies indicated that GPS was a revolution never dreamed possible that has many advantages over other navigation and landing systems. Since the introduction of GPS, most existing MLS systems have been turned off in North America. FAA favoured GPS over MLS [9].

III. AIRCRAFT LANDING SYSTEM

The civil aviation industry is developing rapidly to occupy the increasing needs for faster, comfortable and safe transportation. Aircraft landing is a critical phase and high accuracy in required especially when flying under low visibility conditions for that a system will require that provides some facilities to prevent runway overrun, accuracy in speed, more accurate distance from runway and some other parameters The zero accident policy announced by FAA requires airliners to have essentially perfect navigation from take-off to landing (Aviation Safety Action Plan, 1995). ICAO has divided landing systems into three categories according to decision height, visibility and runway visual range [10]. Category IIC operation requires precision instrument approach and landing with no decision height and no runway visual range limitations.

3.1 Anti Ground Crashing Instrument landing system- Landing is the difficult process and for safe landing all navigational data like altitude, speed, distance etc. should be accurate. Currently, no system has the capability to achieve aircraft landing CAT III C which enables the aircraft to land in all weather conditions and when the visibility level is low, runway is short

In this paper anti-ground crashing instrument landing system specifications will be designed to overcome the limitations of previous aircraft landing systems and to achieve high accurate guidance for aircrafts with improved capabilities and to solve the problems generated due to some weather conditions and human mistakes.

We introduce a system for aircraft landing in which the pilot is guided by showing some indications like speed, time, length, distance from aircraft to the runway and high beam light to make runway visible. This system helps to the pilot to prevent crash during the bad landing by providing some control. This system will start apart from the runway by providing distance from few kilometres. If pilot cannot see the runway due to great fog or rain then he can turn on the runway high beam light to make runway visible and after that if due to some mistakes or conditions the pilot has unable to stop the aircraft on runway this system will provide a facility to stop the aircraft or prevent to the crash by allowing in area or tank which will be filled by liquid. The liquid level has adjustable and it can be adjusted by the pilot.

3.2 System theory of operation-In this system the number of points (unit of TX and RX) which will be located apart from the runway each point contain a fixed distance from the runway during the landing process pilot will start the system and the system will continuously send a signal toward the ground when the aircraft will flying over the first point it receive the signal and send the distance to the aircraft from it to the runway each point send their position will get signal from the aircraft. After that when aircraft will reach near to the runway and if runway is not properly seeing to the pilot then he can use the high beam light to see the runway for that pilot will press a switch to turn on the light. After that when aircraft lands on the runway the system will indicate some parameters like speed, length, time for that an array of sensors are located on one side of the runway and laser diodes are located on other side of the runway the connection between TX and RX is establish on runway when the aircraft comes on the runway and due to its nose gear the connection between TX and RX will break the processing unit monitors this event and send the location of this point to the aircraft and show The remaining length of the runway from this point, The time to cross runway, Speed of the aircraft, Total length of the runway

By using breaking time of each point we can calculate the speed of aircraft and the time required to cross the runway and by using this information pilot can land safely in bad situation

Arrangement for distance measurement- In this system the number of points or Trans receiver station (unit of TX and RX) which will be located apart from the runway each point contain a fixed distance from the runway.

During the landing process pilot will start the system and the system will continuously send a signal (height of the aircraft) toward the ground when the aircraft will flying over the first point it receive the signal and send the distance to the aircraft from it to the runway each point send their position when will get signal from the aircraft. When will aircraft fly over the Trans receiver point then it send its location to the aircraft and also send a copy of it to ATC. It provides fixed distance of aircraft from the runway. With the help of this system

We can know the position of aircraft in bad weather or low visibility conditions

Calculation-each point have a fixe distance from the runway

- Point1=5km
- Point2=4km
- Point3=3km
- Point4=2km
- Point5=1km

For synchronization between aircraft and ATC we will add a delay with sending time of signal of the aircraft

The speed of EMT waves in air is

$$299\,792\,458 \text{ m/s or } 299\,792.458 \text{ km/s}$$

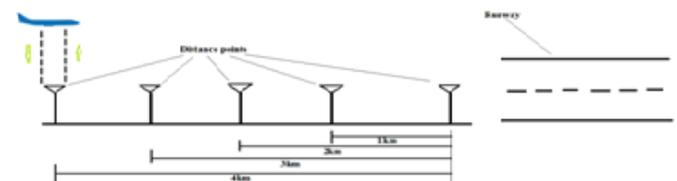
Now the time taken by the waves to cross to 1km will be

$$=1/299\,792.458$$

$$=3.3 \times 10^{-6} \text{ s}$$

If the height of the aircraft from the Trans receiver station is h and the distance between ATC and Trans receiver station is d

Then delay = $(d-h) 3.3 \times 10^{-6} \text{ s} \dots \dots \dots (1)$



Figuer-1 Trans receiver arrangement

Tran receiver station-This unit of system consisting from a transmitter and receiver this system can transmit and receive signal from or to a particular area for that we will used a yagi-uda antenna

Transmitter technical detail- Radio frequency module (RF-module-HR 1031)

Working frequency: 200or180 MHz

Ambient temperature: -30 °C ~ +55 °C

Modulation: MSK (minimum-shift keying)

Data transfer rate-9600bps

DC Voltage: 12V

Emission current: ≤ 6 A (transmit power of 25W)

Technical detail of RX unit- The receiver unit contain a radio receiver which receive information from the aircraft Radio frequency module (RF-module-HR 1031)

Working frequency: 150 or 120 MHz

Ambient temperature: -30 °C ~ +55 °C

Demodulation: MSK (minimum-shift keying)

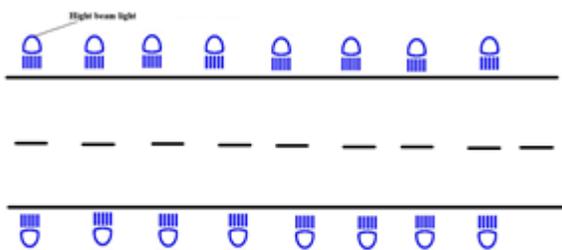
Data transfer rate-9600bps

Usable sensitivity: ≤0.25uV

DC Voltage: 12V

*Trans receiving unit in aircraft-*in aircraft a unit which transmit and receive signals from or to the base station this unit consisting of transmitter and receiver same as the base station and a display to show the distance

*Arrangement for lighting-*when aircraft will reach near to the runway and if runway is not properly seeing to the pilot then he can use the high beam light to see the runway for that pilot will press a switch to turn on the light in this system we can also control the brightness of the light in aircraft when pilot want to low beam then he can select low beam option and when he want to high then he can select high beam option.



Figher-2 Light arrangement

Arrangement for runway - for that an array of sensors are located on one side of the runway and laser diodes are located on other side of the runway the connection between TX and RX is establish on runway when the aircraft comes on the runway and due to its nose gear the connection between TX and RX

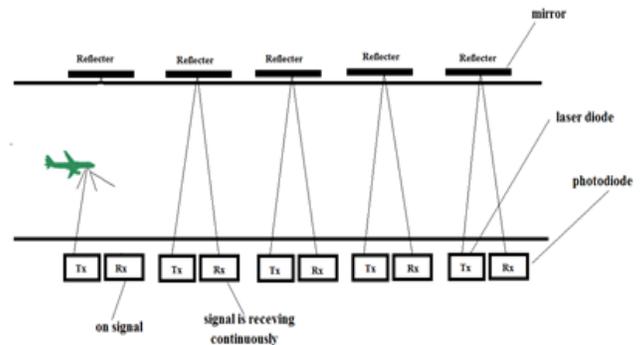


Figure-3 Runway arrangement

Will break the processing unit monitors this event and send the location of this point to the aircraft and show –

- (1) The remaining length of the runway from this point(m)
- (2) The time to cross runway(s)
- (3) Speed of the aircraft(m/s)
- (4) Total length of the runway(m)

Here each point has a value which is the length of the runway at each point in figure.2

By using breaking time of each point we can calculate the speed of aircraft and the time required to cross the runway and by using this information pilot can land safely in bad situation

When aircraft cross the first point its value will store in memory of processing unit and when aircraft cross the second point the processing unit will calculate the time taken by the aircraft to cross the distance from first point to second point and show the speed of aircraft this speed is more accurate by using this speed system will show other parameter more accurate.

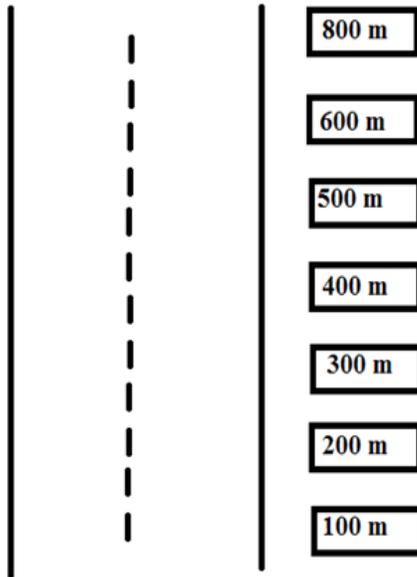


Figure-4 Runway valuation

Liquid arrangement -This is the arrangement of the liquid tank which contain the liquid to prevent the aircraft speed. The length of this part is one half of the runway length and width is the one fourth of the runway length it also contain the pump sets to pump the liquid and an arrangement to increasing the rolling friction which will low due to the liquid.in this part of system can control the liquid supply in the liquid contain part by using system control this arrangement is more use full for the airport where runway is short in such airport during the landing in bad weather is more difficult.

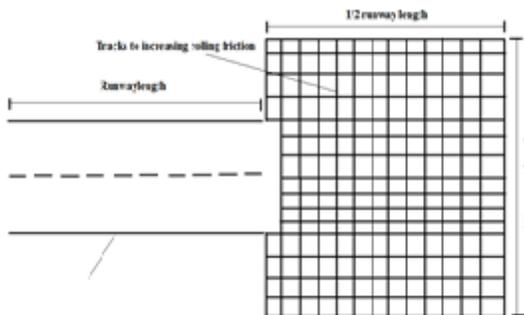


Figure-5 Arrangement of reserve part

IV. MATHEMATICAL CALCULATION

The mathematical calculation is important factor for any type of system in this system some parameters are calculated by using mathematical formulas

4.1 Length calculation-in length calculation we will take the value from each point

Let be each point contains **m** meter from one to other and runway contains total of the **n** points so the total length of the runway is

$$\text{Total length} = n \times m = nm \text{ meters} \dots \dots \dots (2)$$

Where $n=1,2,3,\dots$

4.2 Speed calculation-the speed calculation is done by using microcontroller counter if the time taken by the counter to complete the one count is **a** and time for **b** counts is **ab**

Then the actual speed of the aircraft will be

$$S = nm / ab \dots \dots \dots (3)$$

Where $b=1,2,3,\dots$ is time in second

By using this speed we can calculate the total time to cross the runway

$$TR = L / S \dots \dots \dots (4)$$

Where L is total length of the runway

4.3 Transmitter power calculation- The general rule of transmitter power is it will take four times the power to double the transmission distance. Transmission range could be increased by increasing antenna height without increasing power. Raise the height significantly increase broadcast distance. Typically, transmission power is measured in dBm. The greater transmission power, the greater distances can be achieved. Friis transmission equation is used to calculate transmitted and received power ratio (P_r/P_t). Whereas, equation 10 is used to calculate the power received.

$$P_r / P_t = G_t G_r (\lambda / 4 \pi R)^2 \dots \dots \dots (5)$$

Where G_t and G_r are transmitter and receiver antennas gains respectively, P_t and P_r are transmitted and received power respectively, λ is the wavelength, and R is the distance. A typical VHF station operates at about 100,000 watts (80 dB). Transmitter power = 100 KW (100,000 W). Transmitter power in dB = $10 \log 100,000 = 50 \text{ dBW} = 80 \text{ dBm}$

4.4 Receiving power calculation- Power received in dB

$$\begin{aligned} P_r &= P_t(\text{dB}) + G_t(\text{dB}) + G_r(\text{dB}) - 20 \log(4 d/\lambda) \\ &= -43.5 \text{ dBW} = 0.000,0447 \text{ W} = -13 \text{ dBm} \end{aligned}$$

4.5 Antenna height calculation- The height of the antenna is the most important factor to consider. It is used to calculate covered area. The area covered could be calculated from the formula:

$$\text{Distance (km)} = \sqrt{12.746 \times A_m} \text{ (10).....(6)}$$

Where A_m is the height of the antenna in meter.

For aircraft transmitter,

The coverage area is about 13 km. so,

$$13 = \sqrt{12.746 \times A_m} \text{ (11)}$$

$$A_m = 13.259 \text{ m}$$

For the ground transmitters, the covered distance includes the length of the runway. For large aircrafts, the runway is designed with a length of 3 km. This means for two back transmitters the covered distance must be taller to cover approximately 16 km

Hence:

$$= \sqrt{12.746 \times A_m} \text{ (12)}$$

$$A_m = 20.085 \text{ m}$$

Transmitter antenna radiates radio wave uniformly and continuously in all directions. Omni-directional antenna is

Used for transmission and reception of signal

V. SYSTEM COMPONENTS

- (1) Transmitter unit
- (2) Receiving unit
- (3) Processing unit
- (4) Sensors like Photodiodes and laser diodes

5.1 Transmitter unit- The transmitter unit contains a radio transmitter which transmits information to aircraft. Another TX is placed in the aircraft which transmits the control signals to the ground system to maintain liquid quantity.

Technical details of TX unit

Radio frequency module (RF-module-HR 1031)

Working frequency: 450 MHz

Ambient temperature: $-30^\circ\text{C} \sim +55^\circ\text{C}$

Modulation: MSK (minimum-shift keying)

Data transfer rate-9600bps

DC Voltage: 12V

Emission current: $\leq 6 \text{ A}$ (transmit power of 25W)

5.2 Receiving unit- The receiver unit contains a radio receiver which receives information from the aircraft and another receiver is placed on aircraft to receive the signal from the ground system

Technical detail of RX unit-

Radio frequency module (RF-module-HR 1031)

Working frequency: 350 MHz

Ambient temperature: $-30^\circ\text{C} \sim +55^\circ\text{C}$

Demodulation: MSK (minimum-shift keying)

Data transfer rate-9600bps

Usable sensitivity: $\leq 0.25\text{uV}$

DC Voltage: 12V

5.3 Processing unit- The work of the processing unit is the processing of information coming from the receiver and monitoring the sensors' connections of each point on the runway. Calculating the parameters like speed, length, time, and transmitting them to the aircraft

Technical detail of processing unit-

1. Microcontroller(AT89C51)
2. Crystal oscillator(12MHz)
3. Power supply(5V)
4. RS-232 IC
5. LN2003A

VI. SIMULATION DESIGN

ALL of the simulations are pre-format in Proteus v8 and Keil v3 simulation labs. generating of signals and codes (0's and 1's) to be decoded.

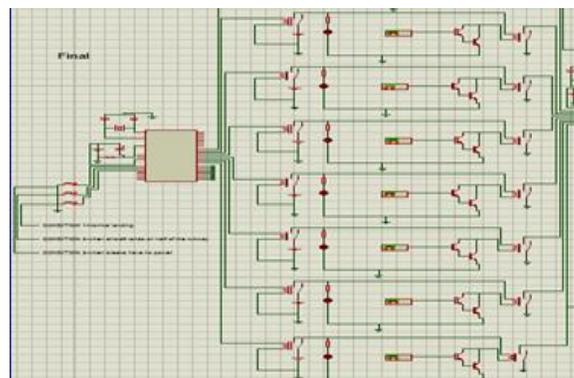


Figure-6 Sensors arrangement

Each one of the two transmitters has its unique code which is used by the receiver to identify transmitters individually. After that signal is modulated and broadcasted through the channel. All signals are received by one receiver in the aircraft. Signals are demodulated, decoded, and then displayed.

Code received is used to determine transmitters' locations and distance to each one of them Data transmission takes place from each transmitter to receiver individually. One Transmitter/Receiver circuit the broadcasted signal contains a code generated by transmitters. Broadcasted signal includes: The time of message transmission and transmitter position when message is transmitted. Receiver receives the signal and generates internal code which is compared with transmitted code to determine lag time to each transmitter since each one has its unique code Figure 6 show an array of sensors are located on one side of the runway and laser diodes are located on other side of the runway the connection between TX and RX is establish on runway when the aircraft comes on the runway and due to its nose gear the connection between TX and RX will break the processing unit monitors this event and send the location of this point to the aircraft

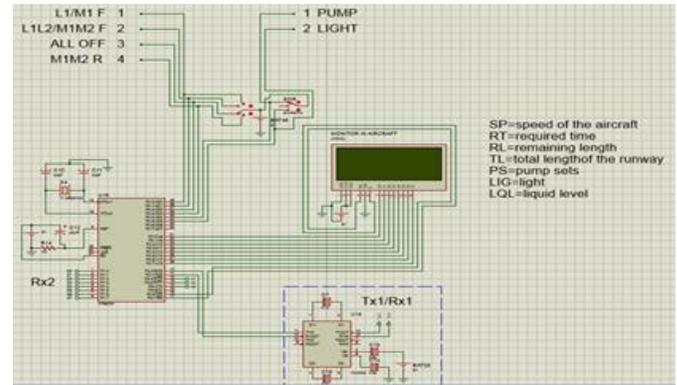


Figure-8 Controlling system in aircraft

The simulation design show a system which is mountain in the aircraft this system is the combination of the following components-

1. Microprocessor
2. Trans receiver module
3. Control switches
4. LCD monitor

This system sends some control signals and receives some indications when pilot wants to turn on the light then he will press a switch of light this signal is received by the microprocessor and after the process this signal is sent to the trans receiver module to send it to the ground base system to perform the task.

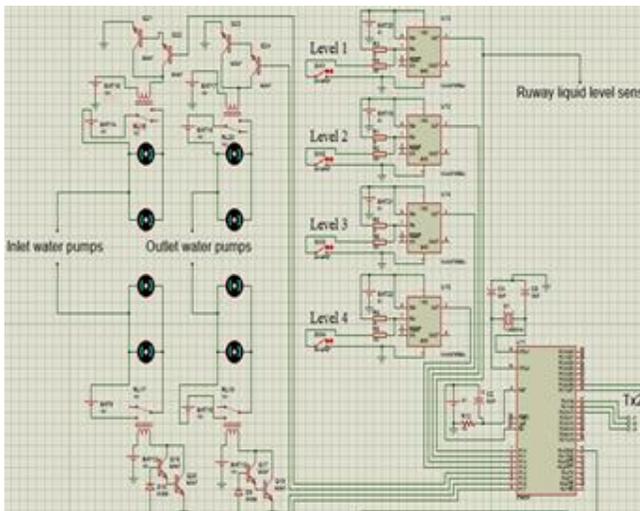


Figure-7 pumps set and control circuit to maintain the liquid level

This arrangement is used to maintain the liquid level according to the aircraft weight this is constructed by using-

1. Water pump
2. Higher power supply
3. Relays
4. Amplifier ICs
5. Water level indicator
6. Control unit

The control unit of this part of system follows the instructions of the pilot to maintain the level. The pump sets are to type one for inlet and other for outlet the pumps are controlled by the pilot. Level indicators show the level of liquid

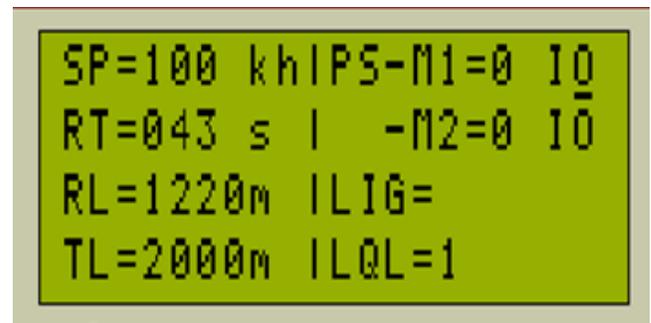


Figure-9 Display to the system parameters

This is the display which is mounted on the aircraft and A.T.C for showing system parameters this display will show four types of parameters-

- RT=Required time to cross the runway in s (second)
- RL=Remaining length in m (meter)
- SP=Aircraft speed in km/s
- TL=Total length of the runway in m (meter)
- PS= pump sets
- LIG=Lights
- LQL=Liquid level

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