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Marker Beacon – Review

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Abstract - This paper aims to highlight and explain the fundamental aspects of the Instrument Landing System (ILS), a radio navigation system known for its high precision and accuracy. The ILS is primarily a ground-based system that uses a combination of radio signals received by airports and airlines worldwide. It offers lateral and vertical guidance to aircraft during approach and landing, particularly in varying metrological conditions.

***Key Words*: Localizer, Glideslope, Marker Beacon, Instrument Landing System, Fabrications**.

1. INTRODUCTION

The Instrument Landing System is used to help aircraft land safely when visibility is limited. The radio navigation system guides the aircraft along a precise path down to the runway's touchdown zone. It uses multiple radio signals to enable an accurate approach. One of these signals comes from the localizer, which provides horizontal guidance, keeping the aircraft aligned with the runway centerline. Another signal, the guidance, offers vertical guidance, directing the airplane down the correct descent path to the touchdown point. Compass locator signals from the outer and middle marker beacons assist pilots in joining the ILS approach path. Marker beacons also indicate the aircraft's distance from the runway.

Together elements create an extremely accurate and dependable system for landing aircraft.

2. METHODOLOGY

A. *Localizer (LOC):-* Is a signal, part of the Instrument Landing System (ILS), operates within the VHF frequency range of 108MHz to 111.95MHz, using only odd decimal frequencies (e.g., 108.1, 108.3MHz). The localizer antenna is positioned beyond the departure end of the runway, transmitting two distinct signals that overlap to create a guidance field. This field is approximately 2.5 wide (covering about 450 meters at a distance of 8km from the runway) and narrows to align with the runway width near the landing threshold. The left side of the approach path transmits a 90Hz modulated signal. The right side transits a 150Hz modulated signal. When the aircraft VOR/ILS receiver is tuned to the localizer frequency, the standard VOR circuitry is bypassed, and localizer-specific components process the signals. The received signals are filtered and converted to DC power, which drives the Course Deviation Indicator (CDI).

B. *Glideslope:* **-** The vertical guidance necessary for an aircraft's descent during landing is provided by the ILS glideslope. Radio signals guide the airplane down the runway touchdown point at an approximate angle of 3. The glideslope transmitting antenna is positioned to the side of the runway, about 1000 feet from the threshold. It emits a signal in a wedge-shaped pattern, with the field narrowing as it nears the runway.

The glideslope transmitter antenna is horizontally polarized and operates within the UHF frequency range of 329.3 MHz to 335 MHz. Its frequency is paired with the ILS localizer frequency. When the VOR/ILS receiver is tuned for an approach, the glideslope receiver is automatically adjusted. Resembling the localizer, the glideslope transmits two signals: one modulated at 90Hz and the other at 150Hz. The aircraft's glideslope receiver interprets these signals in much the same way as the localizer receiver. It drives a vertical course deviation indicator known as the glideslope indicator. This indicator functions similarly to the localizer CDI but is oriented 90 degrees to it. The VOR/ILS localizer CDI and the glideslope are displayed on the aircraft's instrumentation.

C. *Compass Locator:* **-** To utilize the Instrument Landing System (ILS) efficiently, a pilot must first establish the correct approach path. They are the radio transmitters that aid the aircraft in intercepting the ILS signal.

The outer marker compass locator functions as a 25-watt non-directional beacon (NDB) with an effective range of about 24km. It emits omnidirectional low-frequency radio signals within the 190Hz-535Hz frequency band.

D. *Marker Beacon:* **-** They are the final radio transmitters used in the ILS. They transmit signals that indicate the position of the aircraft along the glide path to the runway. As mentioned an outer marker beacon transmitter is located 6-11 km from the threshold. It transmits a 75 MHz carrier wave modulated with a 400Hz audio tone in a series of dashes. The transmission is very narrow and directed straight up.
A marker beacon receiver receives the signals and uses them to light a blue light on the instrument panel. This, plus aural tone in combination with the localizer and the glideslope indicator, positively locates the on an approach.

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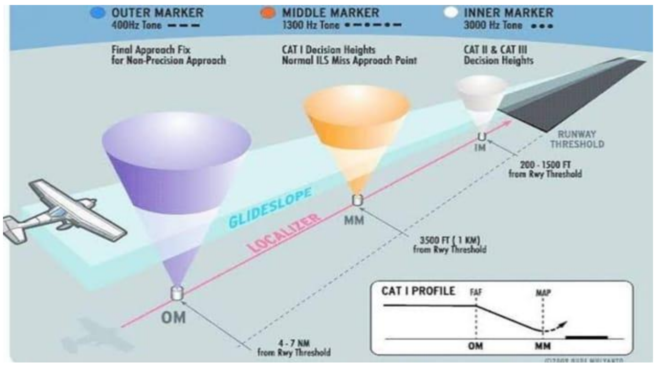
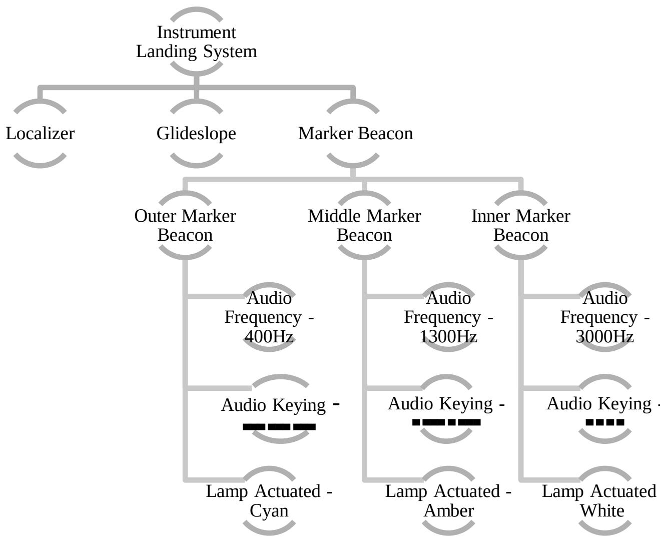
A Middle Marker Beacon is located approximately 1km from the runway. It transmits at 75MHz. The middle marker transmission is modulated with a 1300Hz tone that is a series of dots and dashes. When the signal is received, it is used in the receiver to illuminate an amber-colored light on the instrument panel.

An Inner Marker Beacon that transmits a signal modulated with 3000Hz in a series of dots only. It is placed at the land-or-go-around decision point of the approach close to the runway threshold. If present, the indication when received is used to illuminate a white light on the instrument panel.

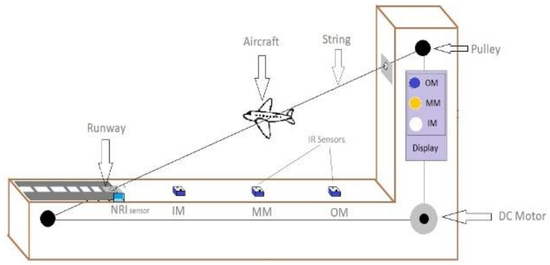
An Outer Marker Beacon is approximately four nautical miles from the runway threshold, and for identification purposes, its transmitted signals are coded with continuous dashes. The signal is modulated at a frequency of 400 Hz, made up of a Morse code – a group of two dots per second. On the aircraft, the signal is received by a 75 MHz marker receiver. The pilot hears a tone from the loudspeaker or headphones and a blue indicative bulb lights up. Anywhere an outer marker cannot be placed due to the terrain, a DME unit can be used as a part of the ILS to secure the correct fixation on the localizer.





A Visual Flight Rule (VFR) transmitter directs its signal upward in a small fan-shaped pattern positioned along the flight path at strategic locations, to provide accurate positional information to the aircraft during approach.

This system ensures the safe landing of an aircraft. It helps the pilot to navigate the distance from the runway threshold to the airplane.



We have used:
1. 4 IR proximity sensors (each used for outer, middle and inner marker beacon + non return indication sensor)
2. LED's
3. Speaker
4. Arduino
5. Breadboard & connecting wire
6. Adapter

IR (Infrared) Proximity sensor: - It is an electrical component that detects radiation. It enables the system to detect the surrounding environment and respond to it positively.

The functioning of an IR sensor involves detecting infrared waves emitted from an object entering the sensor area of the device containing an IR sensor, this information is then altered and used for various functions such as detecting objects in its vicinity, identifying whether something is in motion or steering towards a target site via detecting the distance data provided by the IR signal noticed at each point along its track within the range of vision.

The primary precedence of infrared sensors is their low power consumption, simple design, and beneficial features.

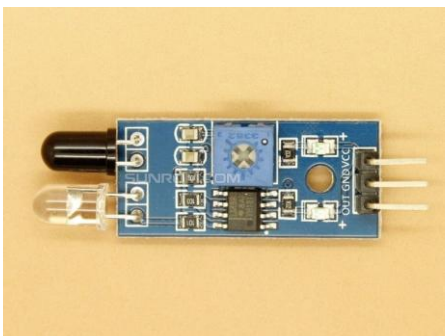


Fig.1 Infrared Sensor

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LED (Light Emitting Diode):- is a semiconductor device that emits light when an electric current passes through it. They are widely used because they use very little power, last for a long time, and give off a bright light. It shows indications, gives illumination, and signals to the pilot. These LEDs help pilots know their location, complementing the audio tones transmitted by the Marker beacon.

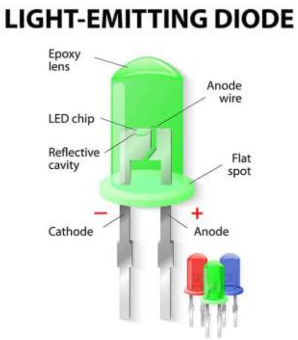

Fig.2 Light Emitting Diode

Speaker: - Relies on the fundamental concept of electromagnetism. When an electric current flows through a conductor within a magnetic field, it generates a mechanical force. This phenomenon is succinctly described by Fleming's Left-Hand Rule, which dictates the direction of the force. When an amplified audio signal is applied to the speaker coil, it induces vibrations that precisely mirror the signal's voltage fluctuations. Notably, the produced sound is a faithful reproduction of the original audio signal input into the amplifier, ensuring an accurate and high-fidelity audio experience.

Fig.3 Speaker

***Arduino*: -** An Arduino is a small, easy-to-use electronic board that can control devices and respond to signals. This device is used commercially to create different electronic projects as it is simple and flexible. The role of an Arduino in a marker beacon system is usually for testing or practice. Create marker beacon signals for practice and testing. Turn on lights or sounds when a marker beacon signal is detected. Read and show information from a signal receiver.

Fig.4 Arduino

Adaptor: - An adaptor is a device or component that enables two or more incompatible systems, devices, or interfaces to work together.

Fig.5 Adaptor

Breadboard: - A breadboard is a simple tool used to build and test electronic circuits without needing to solder (attach) anything permanently. It helps to easily plug in electronic parts and wires. Inside the breadboard, metal strips connect the holes so electricity can flow between the components.

Connecting wires (also called jumper wires) are used to link different parts of the circuit.

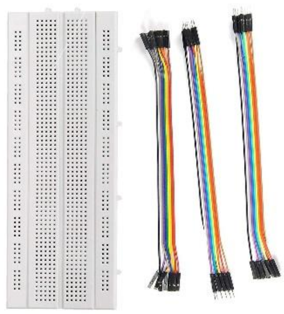

Fig.6 Breadboard and connecting Wire

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3. IMPLEMENTATION

This project involves several key steps to create a practical demonstration model of Marker Beacon.

In the initial phase, the physical model was fabricated and planned with careful consideration given to materials, size, and structural stability.

The Rack and Pinion mechanism was unified into the model ensuring that the pointer was securely attached to the pinion. Additionally, a small toy aircraft attached to two rods was allowed to move laterally along the track and indicate the position on the runway as it made contact with the pinion.

To simulate the Marker Beacon, 3 IR sensors were incorporated into the model, each connected to a corresponding LED of cyan, amber, and white color. These IR sensors were strategically positioned along the path of the toy aircraft to detect its proximity as it approached landing. The IR sensors were carefully calibrated to ensure accurate detection and responsiveness of the airplane movement.

Extensive testing and calibrations were conducted to ensure both, the functionality and accuracy of the model. The movement of the rack and pinion mechanism was verified to ensure smooth lateral motion of the rods attached to the toy aircraft along the track.

The responsiveness of the IR sensors was tested to confirm their ability to detect the presence of the toy aircraft and trigger the corresponding LED illumination. Calibrations were made to optimize the sensitivity of IR sensors.

Throughout the implementation process, data and measurements were collected to evaluate the performance of the demonstrated model. Any discrepancies or areas for improvement were identified and addressed.

Circuit Diagram Connections

A) IR Proximity Sensor Connections

1. Connect the OUT pin of the inner marker sensor to the Arduino digital pin.

2. Connect the OUT pin of the NRI (No Return Indication) sensor to the Arduino digital pin.

3. Connect the GRD (ground) pins of all sensors to Arduino's ground pin.

4. Connect the VCC pins of all sensors to Arduino's pin.

B) LED Connections

1. Connect the positive (+ve) terminal of the inner marker LED to the Arduino digital pin.

2. Connect the positive (+ve) terminal of the middle marker LED to the Arduino digital pin.

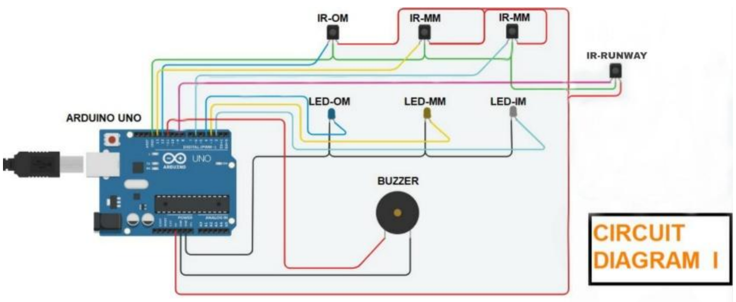
3. Connect the positive (+ve) terminal of the outer marker LED to the Arduino digital pin.

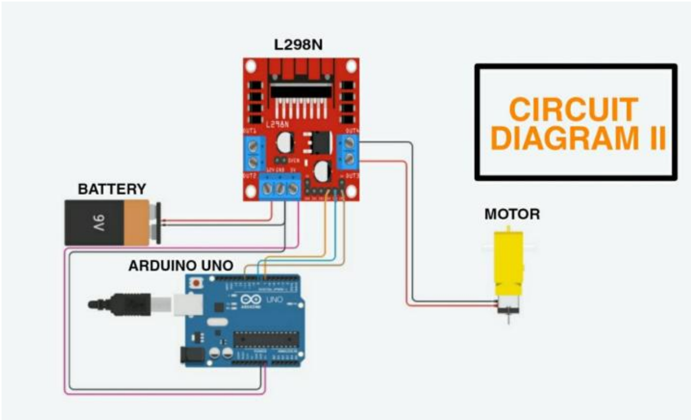
4. Connect the negative (-ve) terminals of all LEDs to Arduino's ground pin.

C) Buzzer Connection

1. Connect one terminal of the buzzer to the Arduino digital pin.

2. Connect the other terminal of the buzzer to Arduino's ground pin.





3. CONCLUSION

The project's advantages lie not only in its educational value but also in its simplicity and affordability. The utilization of easily accessible materials and components makes it accessible to a wide range of audiences, including students,

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aviation enthusiasts, and professionals. Its interactive nature fosters active learning and understanding, promoting a deeper appreciation for the instrument landing system's significance in aviation safety.

The project on the demonstration of the instrument landing system has successfully provided a comprehensive and engaging learning experience. The composition of the rack and pinion mechanism, toy aircraft, string, and IR sensors with LEDs has effectively showcased the localizer working and marker beacon indication. This project serves the purpose of a valuable tool in educating individuals about the instrument landing system, its components, and its role in safe aircraft navigation.

ACKNOWLEDGEMENT

I want to express my heartfelt gratitude to Mr. Ajit Kumar Kaundal for their invaluable guidance and support throughout this project. His expertise, insights, and encouragement have been instrumental in shaping this work. I am incredibly grateful for the time and effort he devoted to helping me navigate the challenges of this project and for his unwavering patience and mentorship.

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