ENEL 351 Project Deliverables Summary

Project Title: Smart Distance Warning Aid
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1. Deliverables Checklist

This summary outlines the deliverables presented for the ENEL 351 final demonstration. All items below have been completed and match the original Functional Specification.

🔧 Hardware & Firmware Implementation

- **STM32F103RB-based embedded system (Nucleo-64):** Core microcontroller board used to drive the logic and I/O of the entire system.

- **Input 1: HC-SR04 Ultrasonic Sensor (Digital):** Measures distance using sound waves and sends echo signals back to the microcontroller.

- **Input 2: IR Proximity Sensor (Digital input):** Detects near-field presence and is used to gate ultrasonic data and enhance filtering.

- **Output 1: LED (PA6) with variable blinking pattern:** Visual feedback indicating the proximity level of obstacles.

- **Output 2: Buzzer (PA7) synchronized with LED:** Audible feedback that mirrors the LED pattern to assist visually impaired users.

- **Output 3: Vibration Motor (PA4):** Provides tactile feedback. Vibrates at system startup to indicate power-on state and was also used in earlier designs to respond to proximity.

- **Output 4: USART serial data to terminal (PA9/PA10):** Sends real-time distance data and system diagnostics to Putty.

- **Non-blocking delay logic using SysTick:** Ensures time-controlled operations do not block system responsiveness.

- **Input capture logic using Timer2 for pulse timing:** Accurately measures echo pulse width from the ultrasonic sensor.

- **Filtering for ghost signals, echo timeouts, sudden drops, and jump suppression:** Software filtering ensures stable and realistic readings.

🧠 Software Features

- **Fully functional main.c file with inline comments:** Code is clear, modular, and well documented for reproducibility.

- **Startup pattern with LED, buzzer, and vibration motor:** Visual/audio/tactile cue to indicate that system is booted and ready.

- **Range-based response algorithm with 6 alert levels:** Custom logic maps distance ranges to feedback intensity.

- **Serial monitoring with debug messages:** Helpful during testing and validating system behavior.

- **Distance validation and IR gating:** Ensures ultrasonic readings are only trusted when IR sensor confirms presence.

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2. Datasheets and Schematic

All datasheets and the finalized system schematic have been included in the folder:
/Datasheets and Schematic/

📑 Included Documents:

- **STM32F103RB MCU.pdf** – The microcontroller at the heart of the system. Responsible for processing sensor inputs, handling timing logic via SysTick and TIM2, and managing output devices.

- **HC-SR04 Ultrasonic Sensor.pdf** – A digital distance sensor that sends out ultrasonic pulses and listens for echoes to calculate distance. Its echo time is captured using Timer2 for accurate measurement.

- **IR Proximity Sensor.pdf** – A digital sensor that detects nearby objects. Used in this project to gate ultrasonic measurements and suppress false readings from distant reflections.

- **Buzzer.pdf** – An active piezo buzzer that provides audible feedback to the user. Its tone frequency and duration are controlled by toggling PA7 at fixed intervals.

- **Vibration-Motor.pdf** – A low-profile, coin-style motor that provides tactile feedback. Integrated to vibrate at power-on, replacing the role of a capacitive touch sensor.

- **Final Schematic.pdf (CAD-generated):** Created using CAD and includes all labeled pin mappings and interface connections. Includes vibration motor wiring and GPIO assignment on PA4.

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3. User Guide (Quick Start)

SMART DISTANCE WARNING AID – USER GUIDE

Getting Started:

1. Power the system using USB (5V) or through an external regulated source.

2. Open Putty or any terminal emulator on your PC and connect via COM port at **9600 baud**.

3. **Observe the startup LED, buzzer, and vibration motor pattern** — this is a tactile/visual/audio cue that the system is ON.

Using the System:

4. Place the device in front of the obstacle zone.

5. The IR sensor will detect nearby presence to activate the system.

6. Distance will be read automatically.

7. The buzzer and LED will begin blinking based on how close an object is.

8. Distance readings will be printed in real-time on the terminal.

9. The vibration Motor stays on as a "**Device is ON**" indicator.

Reset or Reposition:

10. Disconnect and reconnect USB power or press the onboard reset button to restart the system.

11. To reorient, simply change the sensor's facing direction — no buttons required.

Note: The device has built-in filtering for glitches, sudden drops, and false echoes. In addition to LED and buzzer cues, **a brief vibration at power-on replaces the capacitive touch activation originally proposed**.