Ultrasonic Sensor Timing Sequence

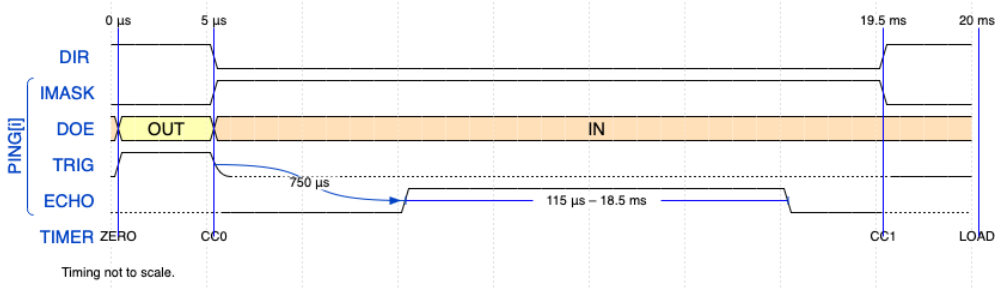

Figure 1: PING))) Ultrasonic Sensor Timing Sequence (Single-Sensor Cycle).

One full 20 ms measurement cycle for a single **Parallax PING))) Ultrasonic Distance Sensor** via an **SN74LVC245A** bidirectional level shifter. The MCU issues a 5 µs trigger, then reconfigures the shared I/O to input to measure the echo pulse width (time-of-flight).

Signal	Name / Direction	Description
DIR	Buffer Direction	*SN74LVC245A* direction control. 1 = MCU → Sensor (trigger phase). 0 = Sensor → MCU (echo phase).
PING[i]	Sensor GPIO (Group)	Bidirectional MCU GPIO shared with ultrasonic sensor i. Logical group encompassing IMASK, DOE, TRIG, and ECHO signals. Manages the trigger, echo, and interrupt states for each sensor in the round-robin sequence.
IMASK	Interrupt Mask	Per-pin interrupt enable for the PING line. 1 = Interrupt enabled (ECHO edge capture active). 0 = Interrupt disabled (no capture events forwarded to NVIC).
DOE	Data Output Enable	MCU GPIO output-enable control for the PING line. Input: idle and echo phases (interrupts disabled during idle). Output: trigger phase.
TRIG	Trigger Pulse	5 µs rising-edge pulse driven by MCU to initiate ultrasonic burst from the sensor.
ECHO	Echo Pulse	Return pulse width proportional to target distance. Minimum: 115 µs Maximum: 18.5 ms.
TIMER	Capture / Compare	Timer capture/compare reference points (ZERO, CC0, CC1, LOAD) aligned with echo pulse duration measurement.

Notes.

1. Timer in edge-aligned up-count mode (LOAD = period limit).
2. Preload GPIO output before asserting DOE to avoid transients.
3. Round-robin across sensors with 20 ms spacing to avoid ultrasonic crosstalk.
4. SN74LVC245A provides 5 V ↔ 3.3 V logic compatibility.

Multi-Sensor Schedule Cycle

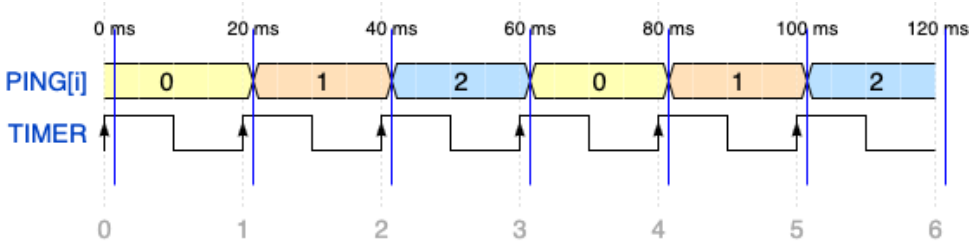

Figure 2: Round-robin schedule for three ultrasonic sensors.

The system operates three ultrasonic sensors in a round-robin sequence to prevent acoustic interference between transducers. Each sensor is allocated a dedicated 20 ms time slot encompassing its trigger, echo measurement, and a brief guard interval before the next sensor's cycle begins. This ensures that no two sensors emit ultrasonic bursts simultaneously.

Slot	Time Window	Active Sensor
0	[0 ms, 20 ms)	PING[0]
1	[20 ms, 40 ms)	PING[1]
2	[40 ms, 60 ms)	PING[2]

Cycle repeats every 60 ms, yielding an update rate of 16.7 Hz per sensor.

Timing considerations. As shown in the single-sensor timing diagram, each measurement cycle consists of a short trigger, a fixed holdoff interval, and an echo pulse lasting up to approximately 18.5 ms. Including these intervals yields a total cycle time of about 19.2 ms, so a 20 ms slot provides a small but sufficient margin to accommodate overhead and ensure all echoes have dissipated before the next sensor begins.

Notes.

1. Only one sensor is active per slot; the remaining sensors stay configured as inputs with their internal pull-downs enabled to prevent bus contention and maintain a defined low idle state.
2. The MCU cycles through sensors sequentially every 20 ms.
3. This schedule avoids cross-interference while maintaining a 50 Hz global timing base.
4. Additional sensors can be supported by proportionally extending the total cycle period.