

## How Amplitude, Frequency, and Other Parameters Identify Elephant Presence

### Key Parameters Used

- **Frequency:** The speed at which the ground vibrates, measured in hertz (Hz).
- **Amplitude:** The strength or height of the vibration signal (how “big” the vibration is), measured in microvolts ( $\mu\text{V}$ ).
- **Signal Pattern:** The shape and repetition of vibrations, matching the rhythm of elephant walking.

### Simple Process Explained

#### 1. Monitoring Vibrations in the Ground

- A **geophone sensor** is placed underground on a path where elephants may pass.
- When an elephant moves, its big, heavy steps create ground vibrations.

#### 2. Measuring Frequency

- **Elephant footsteps** typically cause vibrations at a frequency around **24 Hz** (meaning 24 cycles per second).
- Other sources, like humans, have different frequencies (human footsteps are usually around **70 Hz**; motorcycles even higher).
- The system captures and analyzes these frequencies, looking for the ones in the elephant’s range (about 20–26 Hz is typical).

#### 3. Measuring Amplitude

- **Elephant steps** generate much stronger (higher amplitude) signals than smaller animals or humans.
- For instance:
  - At close distances (3–12 meters): Elephant footstep signals can reach  **$\sim 4,178 \mu\text{V}$**  (peak-to-peak).
  - At further distances (40 meters): Still strong, around  **$1,458 \mu\text{V}$** .
- Only signals with a large enough amplitude are considered likely to be from elephants, helping ignore minor vibrations from other sources.

4. Analyzing Signal Pattern and Other Factors

- The system checks if the signal has a repetitive, rhythmic pattern matching elephant walking.
- It also considers the duration and consistency of the vibration events.

5. Combining Parameters for Accurate Detection

- The system only signals “elephant detected” when:
  - The frequency matches the elephant range.
  - The amplitude is strong enough for a large animal.
  - The signal pattern fits an elephant's footfall.
- Events with too high or too low frequency, or weak (low amplitude) signals, are ignored or classified as something else.

Why This Works

- **Frequency** acts as a fingerprint—elephant movements have a unique rhythm.
- **Amplitude** ensures only big, heavy events (like elephants) are counted.
- **Signal Pattern** gives extra confirmation, matching not just “any” heavy vibration, but one that fits an elephant’s characteristic walk.

Example Table

Parameter	Elephant	Human	Motorcycle
Frequency	20–26 Hz	~70 Hz	Higher/variable
Amplitude	1,458–4,178 μV	Much lower	Variable/noisy
Pattern	Regular footfalls	Faster steps	Irregular noise

**In summary:** The system matches ground vibrations to elephants by checking if the signal is strong enough (amplitude), at the right rhythm (frequency), and has the repeating pattern of elephant movement, ensuring high accuracy and minimal false alarms.

