Radar and Ultrasonic Level from Time of Flight

Level in a tank from the echo time of a radar or ultrasonic level transmitter, with the speed of sound in air from temperature for ultrasonic devices.

Method: Time of flight d = c t / 2; speed of sound in dry air √(γ R T / M) with c_p from NIST Shomate data

Input parameters

Unit system: SI

Parameter	Value	Unit
Device	Ultrasonic in air (speed of sound at the temperature below)	
Echo time (there and back)	0.023000	s
Air temperature above the liquid (ultrasonic)	40.000	°C
Distance from the sensor face to the tank bottom	6.0000	m

Calculated results

Parameter	Value	Unit
Wave speed used	354.68	m/s
Distance to the surface c t / 2	4.0788	m
Level above the bottom	1.9212	m

Formula and method

$$d = \frac{c\,t}{2}, \quad L = H - d, \quad c_{air} = \sqrt{\gamma \frac{R}{M} T}, \quad \gamma = \frac{c_p}{c_p - R/M}$$

Variables

device	Device	-
t	Echo time (there and back)	s
T	Air temperature above the liquid (ultrasonic)	K
H	Distance from the sensor face to the tank bottom	m
C	Wave speed used	m/s
d	Distance to the surface c t / 2	m
L	Level above the bottom	m

Method and standards

Echo travel time.

Assumptions and limits

- Dry air for ultrasonic; clear echo. Solvent or water vapour in the headspace changes the speed of sound (often by several per cent); there is no input for it, so use a reference target or the instrument's compensation.

References

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Report details

Report reference	FCC-7J37-DT3X (the same inputs always give the same reference)
Generated	17 November 2026, 19:46 UTC
Calculator	Radar and Ultrasonic Level from Time of Flight
Method last reviewed	12 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/instrumentation/pressure-level/level-time-of-flight

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.