Environmental Monitoring Solutions

ToTEM

Total Environmental Monitoring Compact Stations

- Compact station for measuring the main meteorological quantities with accuracies in accordance with WMO (World Meteorological Organization)
- Family consisting of different models depending on the measured quantities
- A fully integrated solution that can operate both as a Single AIO Sensor or as a Multi-Sensors Suite wired connected to a Data Acquisition System (DAS)
- Various communication options: local via digital outputs, remote via LTE-M modem (with an integrated e-SIM) or LoRa radio
- Possibility of connecting additional sensors via Input Extension Module
- Smart heating included in all models
- Field-replaceable T/RH/Press and radiation sensors
- Certifiable by the LSI LASTEM laboratory accredited ISO17025

ToTEM, an acronym for **ToTal Environmental Monitoring**, is a new family of compact environmental stations designed for the accurate measurement of the main meteorological and environmental quantities. Thanks to the integration of high-performance sensors, flexible communication systems and smart features, ToTEM represents a complete solution for environmental monitoring in professional applications where reliability, precision and continuity of measurement are fundamental requirements.

The measurement performance of the ToTEM family complies with the **accuracy specifications defined by the WMO – World Meteorological Organization**, making these stations suitable for professional meteorological applications and for all those contexts where the quality of the data is an essential element. To support the metrological reliability of the products, LSI LASTEM also has an **internal ISO/IEC 17025:2017 accredited laboratory**, to guarantee the technical competence and traceability of calibration activities.

The ToTEM family has been developed to meet the needs of **various application areas**, including meteorology, roads, renewable energy, heat stress assessment, smart cities, agriculture, environmental and infrastructural monitoring. The compact design allows for quick and easy installation even in contexts where available space is limited, while maintaining high measurement performance and a robust structure, suitable for outdoor use.

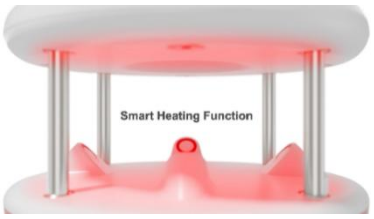
The range consists of **different models**, configurable according to the quantities to be monitored and the type of communication required. The starter model integrates sensors for measuring wind speed and direction using ultrasonic technology, air temperature, relative humidity and atmospheric pressure. The most complete models allow monitoring to be extended to other quantities, such as precipitation, solar radiation using class A, B or C radiometers, black globe temperature and atmospheric particulate matter. This modularity allows you to choose the most suitable configuration for your specific application, optimizing functionality, costs and ease of management.

One of the distinctive features of the ToTEM family is the **wide range of communication options available**. The stations can be used in local mode via digital outputs, including RS-485, RS-232 and SDI-12, or in remote mode using integrated LoRa radio systems or LTE-M modem with e-SIM. This flexibility makes ToTEM suitable for both stand-alone installations and distributed monitoring networks, facilitating integration with data loggers, cloud platforms, supervisory systems and IoT infrastructure.

LoRa™ LTE-M eSIM

MW9000-ENG-08-08/09/2026

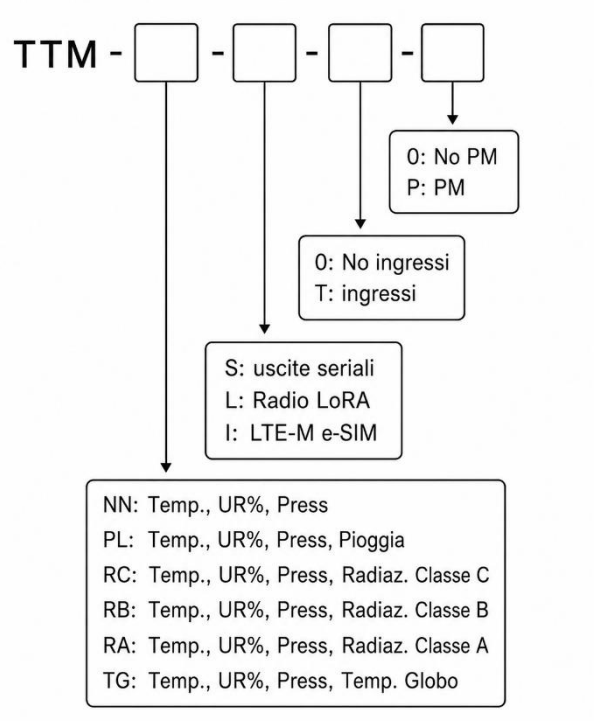
Some models in the family are equipped with an **Additional Input Module**, which allows the connection of external sensors, even third-party ones. This feature further expands the possibilities of use of the station, allowing the integration of specific quantities not included in the standard configuration and the creation of customized monitoring systems according to the needs of the project. The module can also accommodate a dust meter for air quality measurements.



To ensure continuity and quality of measurement even in critical environmental conditions, all ToTEM models integrate a **smart heating system**. The ultrasonic wind transducers and sensor roof are intelligently heated to reduce the risk of condensation and ice build-up, helping to maintain measurement reliability even in low temperatures or high humidity. In addition, the sensor body integrates a smart ventilation function, designed to improve the measurement conditions of the thermo-hygrometer.

Attention has been paid to **ease of maintenance**. The temperature, relative humidity, and pressure measuring head is easily replaceable by the user, as are the Class A and B radiation sensors, reducing downtime and simplifying periodic maintenance. The presence of a USB-C port also allows for simple and immediate configuration of the station, simplifying installation, parameterization, and diagnostics.

Coding models



ToTEM compact environmental stations can be installed in different configurations depending on the needs: it can be powered by the mains or by a solar panel, connected to additional sensors, installed stand-alone with remote communication without the need to be connected to a data logger.

ToTEM models (integrated sensors only, no particulate matter – PM)

	PN					
Serial output	**TTMNNS00**	**TTMPLS00**	**TTMRCS00**	**TTMRBS00**	**TTMRAS00**	**TTMTGS00**
LTE-M e-SIM	**TTMNNI00**	**TTMPLI00**	**TTMRCI00**	**TTMRBI00**	**TTMRAI00**	**TTMTGI00**
Radio LoRa**	**TTMNNL00**	**TTMPLL00**	**TTMRCL00**	**TTMRBL00**	**TTMRAL00**	**TTMTGL00**
						
Wind speed	x	x	x	x	x	x
Wind direction	x	x	x	x	x	x
Air temperature	x	x	x	x	x	x
RH%	x	x	x	x	x	x
Pressure	x	x	x	x	x	x
Rain	-	x	-	-	-	-
Solar radiation	-	-	Class C Radiometer	Class B Radiometer	Class A Radiometer	-
Globe temperature						x
Output	TTMxx**S**xx: RS-485, RS-232, SDI-12; TTMxx**I**xx: LTE-M; TTMxx**L**xx: LoRa radio					
Consumption	TBD					
Size / Weight	280x106 mm / 1.4 kg	304x106 mm / 1.5 kg	321x106 mm / 1.5 kg	390x119 mm / 2 kg	390x119 mm / 2 kg	453x152 mm / 1.7 kg

***Models available from June 2027.*

The ToTEM family adapts to numerous applications thanks to the availability of different models, selectable according to the quantities to be measured, and the possibility of integrating additional sensors even from third parties. This modularity allows the system to be used in areas such as professional meteorology, roads, renewable energy, thermal stress, smart cities, air quality, agriculture, environmental monitoring.

ToTEM models with Input Extension Module and/or particulate matter (PM) measurement

	PN					
Serial output						
• PM	TTMNNS0P	TTMPLS0P	TTMRCS0P	TTMRBS0P	TTMRAS0P	TTMTGS0P
• Inputs*	TTMNNST0	TTMPLST0	TTMRCST0	TTMRBST0	TTMRAST0	TTMTGST0
• PM+inputs*	TTMNNSTP	TTMPLSTP	TTMRCSTP	TTMRBSTP	TTMRASTP	TTMTGSTP
Modem LTE-M						
• PM	TTMNNI0P	TTMPLI0P	TTMRCI0P	TTMRBI0P	TTMRAI0P	TTMTGI0P
• Inputs*	TTMNNIT0	TTMPLIT0	TTMRCIT0	TTMRBIT0	TTMRAIT0	TTMTGIT0
• PM+inputs*	TTMNNITP	TTMPLITP	TTMRCITP	TTMRBITP	TTMRAITP	TTMTGITP
Radio LoRa**						
• PM**	TTMNNL0P	TTMPLL0P	TTMRCL0P	TTMRBL0P	TTMRAL0P	TTMTGL0P
• Inputs**	TTMNNLT0	TTMPLLT0	TTMRCLT0	TTMRBLT0	TTMRALT0	TTMTGLT0
• PM+inputs**	TTMNNLTP	TTMPLLTP	TTMRCLTP	TTMRBLTP	TTMRALTP	TTMTGLTP
						
Wind speed	x	x	x	x	x	x
Wind direction	x	x	x	x	x	x
Air temperature	x	x	x	x	x	x
RH%	x	x	x	x	x	x
Pressure	x	x	x	x	x	x
Rain	-	x	-	-	-	-
Solar radiation	-	-	Class C Radiometer	Class B Radiometer	Class A Radiometer	-
Globe temperature						x
Inputs Extension Module	Included for TTMxxx**T models**					
Particulate matter (PM1-2.5-10)	Included for TTMxxxx**P models**					
Output	TTMxx**S**xx: RS-485, RS-232, SDI-12; TTMxx**I**xx: LTE-M; TTMxx**L**xx: LoRa radio					
Consumption	TBD					
Size / Weight	366x106 mm / 2.4 kg	407x106 mm / 2.5 kg	390x106 mm / 2.5 kg	476x119 mm / 3 kg	476x119 mm / 3 kg	539x152 mm / 2.7 kg

***Models available from April 2027. **Models available from June 2027.*

Technical features

Wind speed	Principle	Ultrasonic
	Field	0… 70 m/s
	Accuracy	<35 m/s: 0.3 m/s (or 3%); >35 m/s: 5%
	Threshold	0.3 m/s
	Resolution	0.01 m/s
	Response time	250 ms
	Calculated quantities	• Gust of wind • Turbulence • % Wind Calm • Theoretical wind speed at 2 m • Wind chill
Wind direction	Principle	Ultrasonic
	Field	0...360°
	Accuracy	1%
	Speed threshold for wind direction calculation	0.3 m/s
	Resolution	0.01°
	Response time	250 ms
Air temperature	Principle	Semiconductor sensor
	Field	-40… 90 °C
	Accuracy @ 5... 60 °C	±0.1 °C
	Resolution	0.01 °C
	Response Time (T90)	Default 60 s (based on programmable digital filter)
	Long-term stability	<0.03 °C/year
	Replaceable measuring element	Yes
	Calculated quantities	• Dew Point • Absolute humidity • Specific humidity • Heat Index
Relative humidity	Principle	Capacitive with hygroscopic polymer
	Field	0...100%
	Accuracy @ 15... 55 °C	±1%
	Resolution	0.01%
	Response Time (T90)	Default 60 s (based on programmable digital filter)
	Long-term stability	<0.25 % / year
	Hysteresis	±0.5 %
	Sensitive element desaturation	Heating algorithm for desaturation of the humidity measuring cell
	Replaceable measuring element	Yes
Pressure	Principle	Piezoresistive
	Field	260…1260 hPa

	Accuracy	0.15 hPa @ 0... 65 °C @ 800...1100 hPa
	Resolution	0.1 hPa
	Response Time (T90)	1 s
	Long-term stability	0.1 hPa/year
	Thermal drift	0.01–0.02 hPa/°C
	Replaceable measuring element	Yes
	Calculated quantities	• QNH (sea level pressure)
Solar radiation Class C (only TTMRCxxx models)	Principle	Thermopile
	ISO 9060:2018 classification	Spectrally flat Class C (Second Class)
	Estimate on the achievable accuracy for WMO daily sums	±10%
	Spectral Field	285...3000 nm
	Measuring range	0… 2000 W/m^2
	Response time	<30 s
	Zero offset A (response to a net thermal radiation of 200 W/m^2)	<20 W/m^2
	Zero offset B (response to 5 K/h of room temperature change)	<±5 W/m^2
	Zero total offset	<±30 W/m^2
	Non-stability	<±1% difference per year
	Nonlinearity	±1% (100...1000 W/m^2)
	Directional response (0...180 °C field of view)	<±30 W/m^2
	Spectral error of horizontal global irradiance with clear sky	< ±1 %
	Temperature response	<7% (-10...40 °C)
	Tilt response	<±1%
	Additional signal processing errors	<±2 W/m^2
	Leveling bubble	No
	Replaceable measuring element	No
Solar radiation Class B (only TTMRBxxx models)	Principle	Thermopile
	ISO 9060:2018 classification	Spectrally flat Class B (First Class)
	Estimate on the achievable accuracy for WMO daily sums	±5%
	Spectral Field	285...3000 nm
	Measuring range	0… 2000 W/m^2
	Response time	<15 s
	Zero offset A (response to a net thermal radiation of 200 W/m^2)	<12 W/m^2
	Zero offset B (response to 5 K/h of room temperature change)	<±3 W/m^2

	Zero total offset	<±21 W/m^2
	Non-stability	<±1% difference per year
	Nonlinearity	<±1% (100...1000 W/m2)
	Directional response (0...180 °C field of view)	<±20 W/m^2
	Spectral error of horizontal global irradiance with clear sky	< ±0.5%
	Temperature response	<2% (-15...35 °C)
	Tilt response	<±2%
	Additional signal processing errors	<±5 W/m^2
	Leveling bubble	Yes
	Replaceable measuring element	Yes
Solar radiation Class A (only TTMRAxxx models)	Principle	Thermopile
	ISO 9060:2018 classification	Spectrally flat Class A (Secondary Standard)
	Estimate on the achievable accuracy for WMO daily sums	±2%
	Spectral Field	285...3000 nm
	Measuring range	0…2000 W/m^2
	Response time	<5 s
	Zero offset A (response to a net thermal radiation of 200 W/m^2)	<±7 W/m^2
	Zero offset B (response to 5 K/h of room temperature change)	<±2 W/m^2
	Zero total offset	<±10 W/m^2
	Non-stability	<±0.8%
	Nonlinearity	<±0.5%
	Directional response (0...180 °C field of view)	<±10 W/m^2
	Spectral error of horizontal global irradiance with clear sky	<±0.5%
	Temperature response	<±1%
	Tilt response	<±0.5%
	Additional signal processing errors	±2 W/m^2
	Leveling bubble	Yes
	Replaceable measuring element	Yes
Total rainfall (only TTMPLxxx models)	Principle	Optical
	Measuring range	0… 200 mm/h
	Resolution	0.1 mm
	Calculated sizes	• Rainfall intensity • Total rain over 1, 10, 60 minutes
Globe Temperature (only TTMTGxxx	Principle	Digital I2C
	Measuring range	-20… 80 °C

models)	Accuracy	• ±0.1 °C @ -20... 50 °C • ±0.15 °C @ 50... 70 °C • ±0.2 °C @ 70... 80 °C
	Resolution	0.01 °C
	Response time	Tip. (heating up) 10 min; Max (cooling) 20 min
	Material	Copper
	Calculated magnitude	• WBGT with and without solar load • Wet Temperature (Tnw)
PM1, PM2.5, PM10 particulate matter (only TTMxxxxP models)	Principle	Laser scattering
	Measuring range	0… 1000 µg/m^3
	Sensitivity	< 1 µg/m^3
	Linear error	<5%
	Repeatability	<3%
	Thermal drift	• 0%/°C @ 0... 30 °C • <+1%/°C @ -20... 0 °C • <-0.8%/°C @ 30... 70 °C
	Accuracy	10% @ 0… 30 °C
	R2 correlation coefficient vs FEM (Federal Equivalent Method) systems	• PM2.5: 0.95 – 0.99 • PM1: ~0.97 • PM10: ~0.88 – 0.95
	Replaceable measuring element	Yes
Digital Outputs	Type	RS-485, RS-232, SDI-12
	Protocols	Modbus RTU, SDI-12 V. 1.4
	Configurable Modbus parameters	• Baud rate, parity, stop bits • Network address • Function code (Read holding/ read input register) • Data format: floating, 16-bit integer, 16-bit signed integer, 32-bit integer, 32-bit signed integer • Byte order (default endian or little endian or big endian or reverse endian) • Error value used in case of measurement problems
Input extension module for additional sensors	Type of inputs	• N.3 Voltage/Current inputs (ADC 24-bit resolution) • N.1 Impulsive (rain gauge) • N.1 RS-485 Modbus Master • N.1 SDI-12 • N.1 I2C
	Power outputs	Switched output for sensor power supply
General	Power supply	9… 30 V DC; 24 AC/DC (heating)
	Heating	Yes - for Sonic Wind Transducers, for Sonic Sensor Roof, for T/RH% Sensor Decontamination
	Forced ventilation	Yes - to variable modulation according to environmental conditions
	Tilt	Built-in inclinometer
	Cable connector	M16
	Configuration port	USB-C
	Cable	Not included (see Accessories)

	Material	ASA
	Temperature and operating RH%	-40…60 °C
	Degree of protection	IP65
	Mounting	On pole Ø 35...50 mm with bracket (included)

Accessories

	CCCFA6300	Cable L=5 m
	CCCFA6400	Cable L=10 m
	CCCFA6500	Cable L=25 m
	CCCFA6600	Cable L=50 m
	**SPMCA1006**	Interchangeable T/RH/Press measuring head for ToTEM
	SVICA2203	Calibration report in accordance with ISO 9001 (Wind speed)
	SVICA2304.1	Calibration report in accordance with ISO 9001 (Wind direction)
	SVACA2216	Calibration certificate in accordance with ISO/IEC 17025 (Wind speed)
	SVICA0003	Calibration report in accordance with ISO 9001 (Temperature)
	SVACA0006	Calibration certificate in accordance with ISO/IEC 17025 (Temperature)
	SVICA1003	Calibration report in accordance with ISO 9001 (RH%)
	SVICA1005.1	Calibration certificate in accordance with ISO/IEC 17025 (RH%)
	SVICA4001	Calibration report under sun in accordance with ISO 9001 (Irradiance)
	SVICA4701	Calibration report under lamp in accordance with ISO 9001 (Irradiance)
	SVACA4001	Calibration certificate under lamp in accordance with ISO/IEC 17025 (Irradiance)

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