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FR-Tracker

Repeater, Multi-Sensor, Base-Station

Theory of Operation

000140, 000252, and 000472

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Revision History

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1 **Principle of Operation**

The FR-Tracker™ sensor system evaluates the state of the floating roof to determine whether it is operating safely. Wireless sensors are permanently installed on the deck and constantly monitor a variety of parameters. The sensor information is relayed wirelessly to an intelligent controller for analysis and long-term recording of data. Alarms are generated and relayed to the plant's DCS when abnormal conditions are detected that may be caused by:

- Dangerous rain water accumulation
- Excessive snow load
- Overfilling
- Loss of buoyancy due to leaky pontoon or punctured deck
- Roof misalignment
- Abnormal rotation of the FR
- Sticking seals
- Sticking ladders
- Delayed roof collapse as a result of seismic events
- Large gas bubbles in liquid product

The system simultaneously interprets data from multiple sensors across the floating roof to ensure reliability, detection accuracy, and immunity to false alarms.

2 System Components

The FR-Tracker™ monitoring system consists of Multi-Sensors, Repeaters, and a Base Station. To minimize installation and maintenance costs, the Multi-Sensors and Repeaters are battery-operated wireless devices with battery life expectancy exceeding 10 years. The three devices are shown in Figure 1, and how they interact with each other is shown in Figure 2.



Figure 1: The three devices in the FR tracker system.

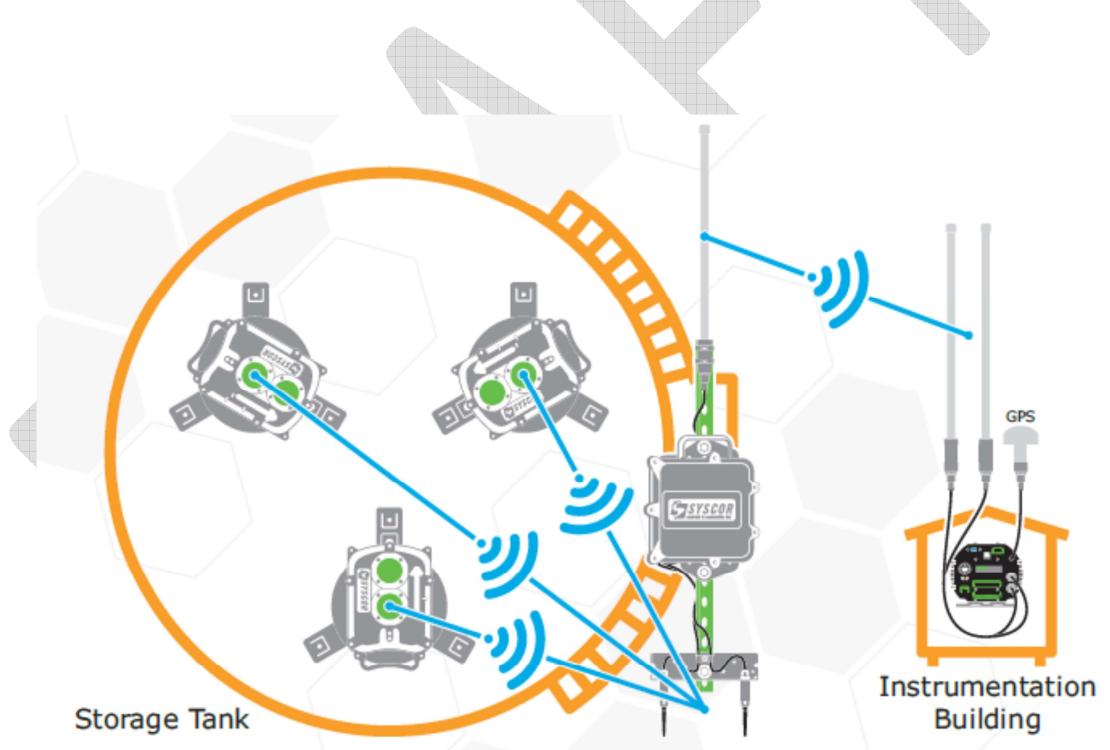


Figure 2: Example of a complete system.

2.1 Multi-Sensor Specifications

Inclination

- Micro-Electro-Mechanical System (MEMS)

Technology

- Accuracy: 0.1°
- Resolution: 0.025°
- Dual-axis, inclinometer range: ±30°

Liquid Level Detector

- Capacitive Ceramic Technology
- Liquid depth Full Scale Output (FSO): 0"-39" (0-1000mm)
- Accuracy: 3/32" (2.5mm)
- Long term stability < ± 0.1 % FSO / year

Elevation Alarm

- Magnetically activated internal Reed Switches
- 2-trigger positions; 0.5" (13mm) apart
- Accuracy: 1/4" (6mm)

Vibration/Acceleration

- Micro-Electro-Mechanical System (MEMS)

Technology

- Dynamically selectable range ±2g/±4g/±8g/±16g
- 1 Hz to 5 kHz sampling frequency
- Motion detection
- Embedded self-test

Temperature Sensor

- ± 1.8°F (1.0°C)

Altimeter/Atmospheric Pressure

- Micro-Electro-Mechanical System (MEMS)

Technology

- Altimeter Measurement Mode (AMM) resolution: 12" (300 mm)
- Barometric Measurement Mode (BMM) resolution: 4.4x10-4inHg (1.5Pa)

GPS

- SiRF Star IV high-sensitivity technology
- Precise Point Positioning (PPP): <39" (1m)
- Precision timing based on GPS synchronization: 1μs
- Optimized for performance in urban canyon and dense foliage environments

Operating Temperature Range

- -40°F to 140°F (-40°C to 60°C)

Materials

- SS316 stainless steel body and mounting bracket, Sabic XYLEX X7519HP antenna ports, carbon fiber elevation whisker with Sabic VALOX V3900WX holder

Environmental Protection

- IP 68 (EN 60529)
- License-free 2.4 GHz IEEE 802.15.4 radios
- Modulation: Direct Sequence Spread Spectrum (DSSS)
- Security: AES-128 Data Encryption

Power Supply

- Integrated Lithium Thionyl Chloride (Li-SOCl2) battery pack. -67°F to 185°F (-55°C to 85°C), estimated life span >10 years

Electrical Interfaces

- None

Wireless Communication

- License-free 2.4 GHz IEEE 802.15.4 radios
- Modulation: Direct Sequence Spread Spectrum (DSSS)
- Security: AES-128 Data Encryption

Certifications

- Environmental: NEMA 4X enclosure
- Safety:
 - Intrinsically safe (Exia)
 - Class I, Division 1, Groups A, B, C & D
 - Ambient temperature -40°C to 60°C
 - Temperature code T5
 - CSA Standard CAN/CSA-C22.2 No. 157-92 (R2006)
 - UL Standard No. 913, 7th Edition
- Telecommunications Compliance:
 - FCC Part 15B
 - FCC Part 15.247

2.2 Repeater Specifications

Temperature Sensor

- Accuracy Options: $\pm 0.9^{\circ}\text{F}$ (0.5°C), $\pm 1.8^{\circ}\text{F}$ (1.0°C), $\pm 4.5^{\circ}\text{F}$ (2.5°C)

Altimeter/Atmospheric Pressure

- Micro-Electro-Mechanical System (MEMS)

Technology

- Altimeter Measurement Mode (AMM)

resolution: 12" (300 mm)

- Barometric Measurement Mode (BMM)

resolution: 4.4×10^{-4} inHg (1.5Pa)

GPS

- SiRF Star IV high-sensitivity technology

- Precise Point Positioning (PPP): $<39"$ (1m)

- Precision timing based on GPS

synchronization: $1\mu\text{s}$

- Optimized for performance in urban canyon and dense foliage environments

Operating Temperature Range

- -40°F to 140°F (-40°C to 60°C)

Materials

- SS316 stainless steel body, Sabic XYLEX

X7519HP antenna ports

Environmental Protection

- IP 66 (EN 60529)

Power Supply

- 2 x Integrated Lithium Thionyl Chloride (Li-SOCl₂) battery packs. -67°F to 185°F (-55°C to 85°C), estimated life span >10 years

Electrical Interfaces

- None

Wireless Communication

- License-free 2.4 GHz IEEE 802.15.4 radios
- Modulation: Direct Sequence Spread Spectrum (DSSS)
- Security: AES-128 Data Encryption

Certifications

- Environmental: NEMA 4X enclosure
- Safety:
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2.3 Base Station Specifications

Summary

- Standard PC/104 aluminum enclosure with support for 4 PC/104 modules:
 - CPU module
 - Wireless module
 - I/O module (many I/O configurations available)
 - Optional communications module (GSM, Satellite)

CPU Module

- PC/104 standard compliant x86 compatible module
- Fanless
- Linux OS

Storage

- Industrial grade SSD (solid state disk)

Wireless Module

- License-free 2.4 GHz IEEE 802.15.4 radios
- Modulation: Direct Sequence Spread Spectrum (DSSS)
- Security: AES-128 Data Encryption

GPS (located on Wireless Module)

- SiRF Star IV high-sensitivity technology
- Precise Point Positioning (PPP): <39" (1m)
- Precision timing based on GPS synchronization: 1µs
- Optimized for performance in urban canyon and dense foliage environments

Operating Temperature Range

- -40°F to 140°F (-40°C to 60°C)

Operating Humidity Range

- 10-90% non-condensing relative humidity

Materials

- Standard PC/104 aluminum enclosure.

Environmental Protection

- IP 40 (EN 60529)

Power Supply

- External power 4.5 Vdc to 33 Vdc
- UPS capability

Electrical Interfaces

- 1 x 10baseT/100base-TX Ethernet communication port (RJ 45 connector)
- 1 x Type A USB port
- 2 x Isolated RS-485 ports (screw terminal block)
- 16 x SPDT Relays

Interface Protocols

- Supports Modbus TCP/IP
- Supports Modbus RS485

Certifications

- Telecommunications Compliance:
 - FCC Part 15B
 - FCC Part 15.247

2.4 Antennas

To reduce potential radio interference to other users, the antenna types and their gains must be so chosen such that the equivalent isotropically radiated power (EIRP) is not more than that permitted for successful communication.

The system has been designed to operate with the antennas listed below, and having a maximum gain of 8 dB. Antennas not included in this list or having a gain greater than 8 dB are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

- Base Station: Taoglas Limited part number OMB.242.08F21
- Repeater (downstream): Taoglas Limited part number OMB.242.08F21
- Repeater (upstream): Antenna Factor Part number ANT-2.4-CW-CT-SMA
- Multi-Sensor: integrated antenna



