RESENSYS

Application Note

Monitoring Bridge Bearings using Resensys Wireless Tilt SenSpot Sensors

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Temperature variation causes a bridge deck and superstructure to expand and contract. Bearings are designed to accommodate the resulting thermal movements. In case that the accommodation is not performed properly a large amount of strain (stress) will be accumulated in bridge structural elements and in particular, in the girders and support beams. Accumulated stress as a result of malfunctioning bearings can result in damage in the form of fatigue cracks in steel and major damage or cracks in bridge piers and abutments. Resensys sensors provide accurate information about tilt, temperature and strain on bridge bearings; using the system can detect instances where the bearings are partially or completely frozen.

Resensys manufactures wireless SenSpot sensors as a versatile sensing and wireless communication platform for long term structural health monitoring; SenSpot sensors are capable of monitoring strain, vibration, tilt, inclination, displacement, temperature, and humidity. Tilt SenSpots are suitable for monitoring the operation of bridge bearings by measuring tilt with accuracy to a tenth of a degree. Using this technology, thermal movements of the bridge can be tracked and problems are detected in an early stage, before they become a major issue and lead to safety compromise and/or road closure.

Important features of Resensys precision tilt SenSpot:

- **Ultra-low-power** (minimum of 10 years of operation without battery replacement)
- **Wireless communication** (IEEE 802.15.4)
- **Small size and lightweight**, Dimensions: 1.35in × 3in × 0.6in and weight about 35 gr.
- **Easy mounting** and quick installation (Self-adhesive or Flange mount)
- **Accuracy**: 0.1 degrees
- **Working temperature:** -40 to +150°F (-40 to +65°C)
- **Long communication range:** 0.62mi (1.0Km) free space
- **Ingress Protection:** completely weatherproof, IP65 protection

A complete Resensys SHM system includes software and hardware components for (1) the reliable collection of SenSpot data, (2) aggregation of the data, (3) the addition of timestamps, (4) communication of data to a remote server, and finally, (5) an interface for data visualization and detection of structural issues. Figure 1 shows a picture of a practical Resensys SHM system which can be used for bridge monitoring.

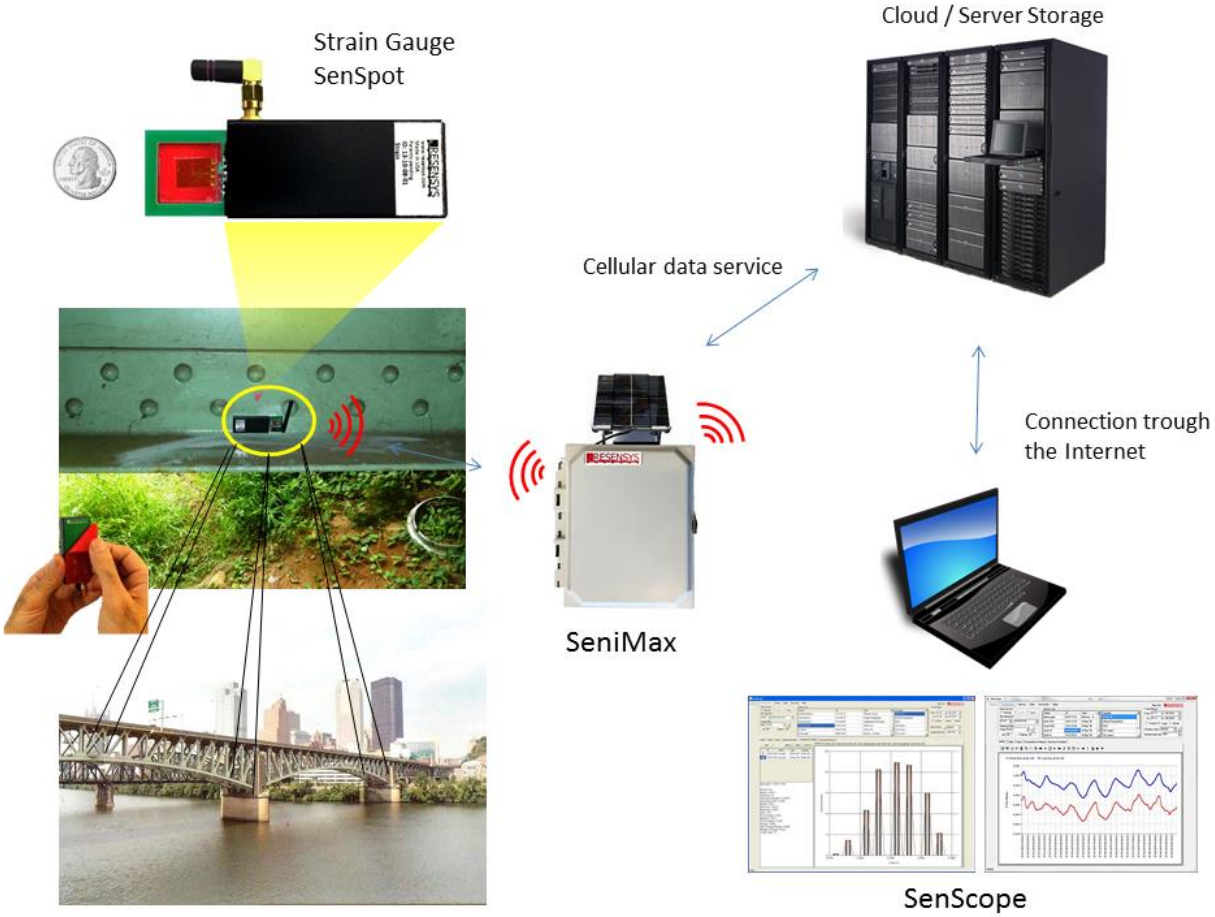

Figure 1: Illustration of Resensys SHM based on SenSpot sensors.

The system includes the following components:

- **SenSpot sensors:** which are attached to a bridge (typically one per bearing).
- **SeniMax:** which collects SenSpot data at the site and sends it to a remote server (one unit can cover as many as 100 SenSpots).
- **Repeater:** may be used to extend the range of the SenSpot sensors.
- **SenScope:** software for data analysis and visualization.

In the following, an example application will be discussed about monitoring rocker bearings.

Monitoring Bridge with Rocker Bearing:

Rocker bearings handle the thermal expansion of a bridge deck through rotation. Resensys tilt SenSpots have been used in several projects to monitor such movements. As a secondary measurement, in addition to the tilt SenSpots on the bearings, strain SenSpots can be used on the bridge girders to measure any accumulated stress in proximity of the bearings that are being monitored. When bearings become completely or partially frozen, strain is expected to accumulate in girders close to malfunctioning bearings. Such a strain is often cyclic due to daily temperature variations. Cyclic strain (which is proportional to stress), however, is harmful to the bridge and can cause fatigue and formation of cracks in steel. Additionally, the non-relived thermal expansion/contraction force, which is a result of frozen bearings, can damage a bridge piers and abutments. Figure 2 shows rockers bearings which are being monitored using SenSpot technology.

Figure 2: Some deployed tilt SenSpots on the rocker bearings.

Figure 3 shows two strains gauges deployed on the bridge girders. Figure 5 shows the variation of a bearing tilt measured by one SenSpot versus the temperature of the girder and on the left tilt is plotted versus temperature.

Figure 3: Strain gauge SenSpots installed on the bridge girders.

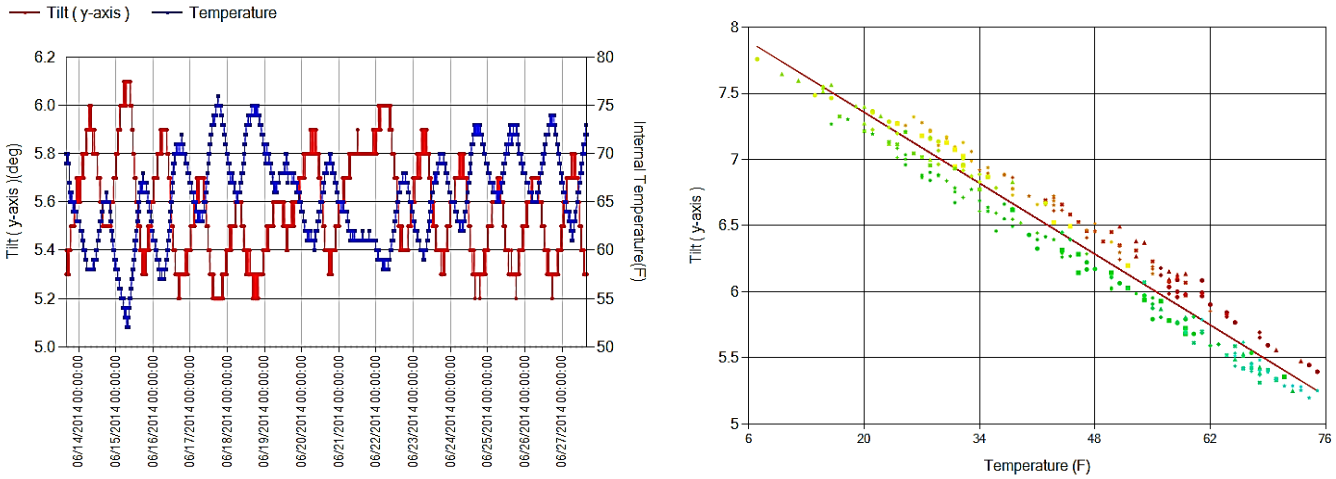

Figure 4: On the left variation of a bearing tilt measured by one SenSpot versus the temperature of the girder. On the right tilt versus temperature.