Application Note

Deploying Sensys Networks Wireless Vehicle Detection System With SCATS Adaptive Control

INTRODUCTION

The Sydney Co-ordinated Adaptive Traffic System (SCATS) is an adaptive traffic management system used to link multiple traffic signal controllers together to reduce travel times and fuel consumption. SCATS adaptive control systems manage traffic at more than 11,000 intersections with over 50 different agencies worldwide.

The key statistical measurement used by the SCATS algorithm to make signal timings decisions is the Degree of Saturation (DOS). The degree of saturation is a measure of the ratio of effectively used green time versus the total available green time. The DOS is calculated based on the input of vehicle detection located near the stop bar at the intersection. The most commonly deployed detection technology has been inductive loops.

PROBLEM

The Achilles' heel of any adaptive control system is the need to install and maintain an extensive network of vehicle detection. While properly installed and well maintained inductive loops offer a high level of performance, they are prone to failure due to:

- Roadway Cracks
- Freeze Thaw Cycles
- Roadway Displacement
- Poor Installation
- Roadside Construction
- Roadway Construction

When any part of the inductive loop wiring becomes damaged or destroyed, the inductive loop becomes either erratic or non functional. Both of these situations have an immediate and noticeable impact on the ability of SCATS to react to the changing traffic patterns, minimizing the value of its adaptive control capabilities.

SOLUTION

Leveraging the recent development of ultra-low-power components developed for the wireless sensor networking industry, Sensys Networks has introduced a new style of vehicle detection to the transportation industry, the Sensys Networks VDS240 Wireless Vehicle Detection System (WVDS). Combining state-of-the-art magnetic sensors with innovative low-power radio technologies, these wireless sensors enable transportation infrastructure designers to rapidly deploy vehicle detection precisely where they need it.

WVDS employs ruggedized pavement-mounted magneto-resistive sensors to detect the presence and movement of vehicles. The Sensys vehicle sensors are wireless, transmitting their real-time detection data via radio to a nearby access point that then communicates the data to a local traffic controller, to a remote traffic management system, or to both at once. Thanks to patented innovations in low-power circuitry and communications protocols, the useful battery life of a sensor is 10 years or more.

The detection methodology of the WVDS is based on changes to the earth's magnetic field as a vehicle passes over the sensor. This is similar in concept to how inductive loops detect vehicles, with one significant difference. With inductive loops, the inductive field is created by power injected into it and analyzed by the loop amplifier, often located up to 100 m away. With Sensys Networks WVDS, the sensor measures the

naturally occurring earth's magnetic field and performs the detection calculation within the sensor at the source. Due to the significant similarities in detection methodology, the detection performance and accuracy are remarkably similar. However, due to the installation methodology used with Sensys Networks WVDS, the reliability and expected life is greatly increased, while minimizing the detection failures and down times which have a direct impact on SCATS operation.

As the WVDS sensors are small in size (less than 7.4 cm wide by 7.4 cm long and 4.9 cm deep), they are easily installed and have virtually no impact on the integrity of the roadway.

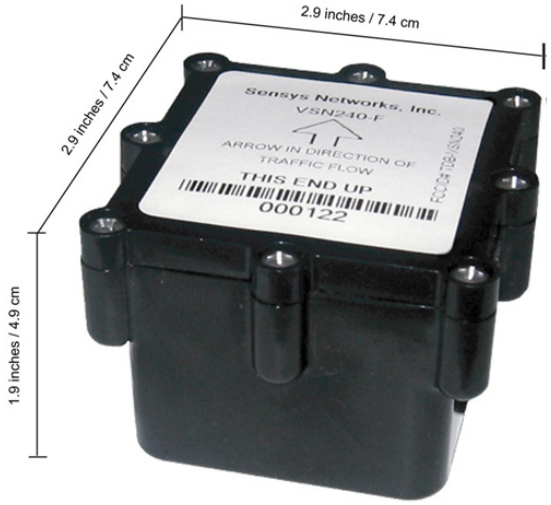

Figure 1: Photo of a WVDS sensor with Dimensions

Roads agencies need the ability to install the system cost effectively with minimal damage to the roadway or right of way and to maintain the detection network after the initial project is completed. Often, the system performance is affected by the agencies' inability to maintain a high level of detection operation.

With the sensors being completely wireless and self powered, the cutting of loop lead-ins and other destructive installation techniques are eliminated. Sensys Networks WVDS sensors are often installed in poor pavement conditions where inductive loops could never be re-installed.

Figure 2: Photo showing WVDS installation within a failed inductive loop in very poor pavement

IMPLEMENTATION

SCATS is deployed using inductive loops in two configurations with similar results. Loop installations are commonly installed using either a 2 m by 4.5 m long loop or two closely spaced 1.75 m by 1.75 m loops per lane.

Deploying WVDS within SCATS is very similar to the two loop configuration. The first sensor is located near the first loop wire vehicles would cross. The second sensor is located approximately 0.5 m before the last loop lead-in wire a vehicle would cross while departing the detection area. This is shown in Figure 3.

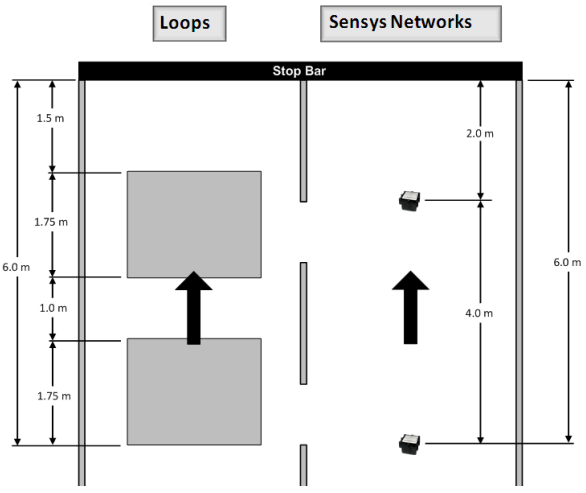

Figure 3: Layout showing how inductive loops and Sensys Networks WVDS are deployed within SCATS

To insure a consistent single detection area, a detection extension is added to the output of Sensor Y. Table 1 below illustrates the amount of extension needed for this sensor, based on the design speed.

Sensor Y Extension Times			
Speed (km/h)	Extension (milliseconds)	Speed (km/h)	Extension (milliseconds)
45	344	75	206
50	310	80	194
55	281	85	182
60	258	90	172
65	238	95	163
70	221	100	155

Table 1: Extension Times for Lead Sensor

PROVEN PERFORMANCE

Sensys Networks WVDS has deployed over 35,000 sensors for roads agencies worldwide in a variety of demanding applications including:

- Intersection Presence Detection
- Intersection Advance/Dilemma Zone Detection
- System Count Applications
- Freeway Management
- Ramp Management
- Red Light Enforcement

Sensys Networks WVDS has been proven in numerous evaluations to provide accurate detection under all weather and lighting conditions.

FAST INSTALLATION

Installation of each Sensys wireless sensor takes less than 10 minutes. Installation simply requires boring a 10cm diameter hole approximately 5.7 cm deep at the desired sensing location, placing the sensor into the hole so that it is properly aligned with the direction of traffic, and sealing the hole with fast-drying epoxy. No lead-in cabling or long saw cuts are required, and the circular pavement hole produces little damage and stress to the roadway.

The sensors communicate with the Sensys Networks Access Point (AP). The AP can communicate with up to 48 sensors simultaneously. The AP is typically mounted on the pole nearest the traffic control cabinet. The recommended minimum mounting height for the AP is 6 meters. When the AP is mounted at this height, it can communicate with sensors up to 45 meters away.

SYSTEM MANAGEMENT

WVDS offers an agency the unique ability to actively and automatically manage their detection system using Sensys Networks SNAPS software or the System Manager (SSM) appliance. SNAPS/SSM are server based applications which enable the user to:

- Remotely monitor the WVDS systems
- Remotely diagnose and configure the WVDS systems
- Automatically collect and store detection data for analysis

SNAPS/SSM automatically collects key operational parameters of the WVDS including RF signal strengths and link quality, battery levels and individual sensor–to-sensor comparisons. When a deviation from the acceptable levels are measured, a diagnostic alarm can be sent to the maintaining agency, arming it with the information required to take pro-active measures to insure a very high level of detector availability. A color coded map can be populated to provide a fast and easy system health reference as shown below.

SNAPS and SSM enable remote management all the WVDS systems connected to the Traffic Management Center (TMC) via Ethernet or cellular modem. Additional tools implemented include the ability to remotely configure, manage and operate each

individual system just as if you were present at the location. As Sensys Networks enhances the firmware of the system, SNAPS/SSM can remotely upgrade the entire sensor network.

SNAPS/SSM collects and archives every detection event for data analysis and diagnostics. SNAPS collects and stores this information indefinitely, while SSM will store the last 90 days of data.

LONG LIFE

Sensys has mechanically designed its wireless sensor to survive in a pavement-mounted environment, operating over a temperature range from 40°C to +85°C. Because of its small size and its placement in the center of a lane, a sensor will only occasionally endure the full weight of a vehicle's wheel. Additionally, the flush-mount sensor receives considerable physical support from the pavement in which it is embedded.

Sensys has invested significant technical effort to reduce the power consumption associated with a sensor's wireless communications. The battery life of a Sensys wireless sensor depends in part on the vehicle detection application and how the sensor is configured. The average battery life of a Sensys wireless sensor is expected to be 10 years.

Finally, operational life is further extended by the ability to download new firmware to the Sensys wireless sensors over-the-air by radio from the Sensys access point. As a result, installed sensors can benefit from any new features or bug fixes that may have been developed since their initial deployment.

DEPENDABILITY

Life cycle costs are significantly reduced with WVDS as they are extremely low in maintenance. Failure rates are very low, as virtually all the wires have been removed from the system. The most common failure point in an inductive loop system is the wire. Loop wires can be easily cut from weather conditions creating pavement shift, poor roadway conditions (cracking, etc.), construction in the road, as well as the right of way (new driveway cutting the loop lead ins).

By eliminating wire failures, Sensys Networks WVDS offers a very high degree of reliability and dependability.

In addition to the low physical failure rates, the detection itself is continuously adapting to the environment and is always performing using the latest magnetic background reference. Even in the event of a significant (or minor) change in the earth's localized magnetic field, the sensor will automatically adapt.

CONCLUSION

Sensys Networks Wireless Vehicle Detection System delivers numerous benefits to an agency deploying SCATS including:

- Fast Installation
- High Accuracy Combined With High Operational Availability
- Long Life Cycle

Sensys Networks is uniquely positioned to deliver the benefits of SCATS to the motoring public.

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