



Sensys™ Wireless Vehicle Detection System

Installation Guidelines for Freeway & Arterial Applications

P/N 152-240-001-011 Rev E
November 2009

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Document Properties

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P/N 152-240-001-011 Rev E

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Regulatory Statements

FCC Compliance Statement

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference.
- (2) This device must accept any interference received, including interference that may cause undesired operation.

Any changes or modifications to this product not authorized by Sensys Networks, Inc., could void the EMC compliance and negate the authority to operate the product.

RF Exposure Statement

This device has been tested and meets the FCC RF exposure guidelines. It should be installed and operated with a minimum distance of 20 cm between the radiator of RF energy and the body of users, operators or others.

Improper use or tampering with the device is prohibited and may not ensure compliance with FCC exposure guidelines.

Warnings

No Safety Switching

Sensys Networks, Inc. does not allow its equipment to be used for safety applications such as controlling a mechanical gate or switching a train to avoid a collision.

Lithium Thionyl Chloride Batteries

Sensys Networks uses Lithium Thionyl Chloride batteries in the following products:

- Sensors (VSN240-F, VSN240-T, VSN240-S)
- Repeaters (RP240-B, and RP240-B-LL)

Lithium batteries are widely used in electronic products because they contain more energy per unit - weight than conventional batteries. However, the same properties that deliver high energy density also contribute to potential hazards if the batteries are damaged. Improper use or handling of the batteries may result in leakage or release of battery contents, explosion or fire.

Following are the recommendations of the battery manufacturer for proper use and handling of batteries in the Sensys devices mentioned above:

- **DO NOT** charge or attempt to recharge the batteries (batteries are NOT rechargeable)
- **DO NOT** crush or puncture batteries
- **DO NOT** short-circuit the batteries
- **DO NOT** force over-discharge of the batteries
- **DO NOT** incinerate or expose batteries to excessive heating
- **DO NOT** expose battery contents to water
- **DO** dispose of batteries and devices containing batteries in accordance with local regulations

Sensys Networks sensors contain no serviceable parts and should never be disassembled. Installation and removal of sensors from pavement should only be done by trained personnel and care should be taken to insure that the sensor casing is not punctured or crushed.

Additional safety information is available from the battery's manufacturer:

- Sensor battery cell: http://www.able-battery.com/msds/ABLE_MSDS_ER14505.pdf
- Repeater battery cell: http://www.able-battery.com/msds/ABLE_MSDS_ER34615.pdf

Document Control

Sensys Networks continually reviews and revises its technical publications. Please address questions, suggestions or corrections to support@sensysnetworks.com.

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CHAPTER 1

Introduction

This document discusses installing a Sensys™ Wireless Vehicle Detection System for use in common freeway and arterial applications.

It is primarily intended for installers, project estimators, and distributors. A working knowledge of the components of a Sensys network, the capabilities of each component, and how they work together to form a wireless vehicle detection solution is assumed.

What's Inside

This document includes the following chapters:

- Chapter One, *Introduction*, defines the purpose and scope of the document.
- Chapter Two, *Required Equipment*, reviews the components, tools, and supplies required to successfully install a Sensys network.
- Chapter Three, *Before the Installation*, describes activities that precede deployment work.
- Chapter Four, *Installation*, surveys the installation process. (Refer to the Sensys installation guides¹ for detailed step-by-step installation procedures.)
- Chapter Five, *Estimating Labor Requirements*, provides guidelines for forecasting the labor costs of a typical installation.

¹ The documents are *Sensys Wireless Sensor Installation Guide*, *Sensys Access Point Installation Guide*, and *Sensys Repeater Installation Guide*.

Other Documents

General and Reference Information

- *The Sensys Wireless Vehicle Detection System – System Overview*
- *Sensys Wireless Vehicle Detection System Reference Guide*

Freeway and Arterial Applications

- *Design Guidelines for Freeway & Arterial Applications*
- *Configuration Guidelines for Freeway & Arterial Applications*
- *Installation Guidelines for Freeway & Arterial Applications*

Intersection Applications

- *Design Guidelines for Intersection Applications*
- *Configuration Guidelines for Intersection Applications*
- *Installation Guidelines for Intersection Applications*

Installation and Maintenance Procedures

- *Sensys Wireless Sensor Installation Guide*
- *Sensys Access Point Installation Guide*
- *Sensys Repeater Installation Guide*
- *Sensys Contact Closure Card Installation Guide*
- *Sensys Wireless Sensor Removal Guide*
- *Tools Required for Installing Sensys Equipment*
- *Replacing Batteries in the RP240B Repeater*

Application Notes

- *Using Sensys Networks With Motorcycles*
- *Executing Commands on a Access Point with HTTP*

Sensys Management Server

- *SNAPS Professional 2.0 Set Up and Operating Guide*
- *Sensys System Manager Set Up and Operating Guide*

Readers of this document are encouraged to contact Sensys Networks, Inc. (www.sensysnetworks.com) for the latest information, design guides, and best practices.

Freeway & Arterial Applications

The installation considerations discussed in this document assume a requirement to implement a Sensys Wireless Vehicle Detection network in conjunction with one of the following uses:

- Count station (permanent or temporary) on a freeway or major arterial
- Census data station
- Advance detection
- Ramp metering

See the Sensys document *Installation Guidelines for Intersection Applications* if your requirements involve stop bar applications or traffic signal controllers.

Assumption Regarding Installation Teams

The installation procedures for Sensors differ markedly from the procedures required to install Access Points and Repeaters. While it is conceivable that a single installation team could handle both activities, in this document it is assumed that two discrete teams are used – a *Sensor team* that puts the wireless Sensors into the pavement and an *Access Point team* that hangs Access Points or Repeaters from utility, signal or sign poles available at the site.

Configuration and field verification of the network is essential to long-term usefulness. In many cases, network components are pre-configured and field verification is performed by the Access Point team. This aspect is not directly addressed herein. See the Sensys document *Configuration Guidelines for Freeway and Arterial Applications* for more information regarding configuration and verification of network performance.

CHAPTER 2

Required Equipment

This chapter reviews the equipment, accessories, tools, and supplies required to install a Sensys™ Wireless Vehicle Detection network for a freeway or arterial application.

Sensys Components

Sensys components consist of the following four types:

- *Wireless Sensor*

Sensors come in two sub-models: the **F model**, which supports operating modes for freeway/arterial uses and an array of operating modes suitable for traffic signal control, and the **T model**, which supports only traffic signal control.

Typical count installations require between two and 20 Sensors depending on the number of lanes and the requirement for calculations of speed, occupancy, and classification.

- *Access Point*

A variety of models are available, differentiated by (i) the ability to interface with a traffic signal controller, (ii) the presence of an on-board Ethernet interface, and (iii) the type of cellular data modem (GSM/GPRS or CDMA2000/1xRTT).

A minimum of one Access Point is required per installation.

- *Repeater*

Repeater models differ by the expected life of their batteries. Repeaters may or may not be required depending on the site layout and application.

- *Contact Closure Card*

Contact Closure (CC) cards interface a Sensys network to a traffic controller. They are discussed in the design, configuration, and installation documents that relate to intersection applications.

Sensys Accessories

The following accessories are required for installation. These parts are sold by Sensys Networks and are typically ordered and shipped with the Sensys equipment:

Access Point Accessories (one each per Access Point)

- *Power supply and POE injector*

Use the following table to determine the correct power accessories for each Access Point.

Power Source	Power Accessories Required	Part Number	Use With Access Points
110 – 220 VAC	48 VDC power supply and PoE injector	AP240-E-48PS	AP240-E, AP240-EG, AP240-EC
12 VDC	Low voltage PoE injector	AP240-E-POE	AP240-E, AP240-EG, AP240-EC
Controller shelf	Power supplied through Sensys Contact Closure (CC) master card and Sensys AccessBox	CC-170 or CC-TS2, and CC_ACC	AP240-S

Table 1: Access Point Power Accessories

- *Mounting hardware kit*

The kit includes a mounting bracket, double-socket arm, and universal clamp band.

- *Ethernet cable*

Use CAT-5, CAT-5e, or CAT-6 outdoor-rated, shielded, solid core cable. Cut to length and terminate onsite with RJ45 male connectors suited to solid core cable.

Repeater Accessories (one per Repeater)

- *Mounting hardware kit*

The kit includes a mounting bracket, double-socket arm, and universal clamp band.

Sensor Accessories (one per Sensor)

- *Two-part, molded plastic Sensor Shell (one per Sensor)*

- *One tube Fabrik Joint Seal (FJS) epoxy*

This is a minimum; always includes several additional tubes as spares.

Tools, Supplies, and Equipment for Access Point Installers

Equip each Access Point installation team with the following:

- Bucket or ladder truck to install Access Points and Repeaters at a minimum of eight feet (2.4 meters) above the road surface
- RJ 45 crimp tool and cable stripper²
- Cordless 3/8" drill and grommets for drilling into traffic signal or light poles to route Ethernet cable (as needed)
- Fish tape or other wire pulling tools
- #10 AWG copper grounding wire, as needed to ground PoE injector
- Hand tools (1" wrench or crescent wrench, Phillips screwdriver, flathead screwdriver, shears or snips, Loctite, tape measure, electrical tape, shop cloth, etc.)

Tools, Supplies, and Equipment for Sensor Installers

Equip each Sensor installation team with the following:

- Dual component epoxy applicator³
- Core or hammer drill with 4-inch (10-cm) bit suited to the type of road surface

Sensys Networks recommends a hammer drill with a carbide tip or a water-cooled core drill with a diamond tip. (See the section *Coring and Drilling Considerations* below for more information.)
- A portable wet/dry shop vacuum, or other means to quickly remove debris from each Sensor hole
- Standard work-zone and lane closure equipment (cones, variable message signs, etc.)

² Sensys recommends the EZ-RJPRO (P/N 100044) from Platinum Tools.

³ Available from Sensys Networks (P/N VSN240-EPX).

CHAPTER 3

Before the Installation

This chapter discusses activities that precede the deployment of the Sensys components.

General Preparation

Prepare for the installation by following these procedures:

- Confirm that a complete system design – including a map of the intended locations for all component – is available.
- Inventory all components, accessories, and supplies. Ensure that adequate spares and extra consumables are available.
- Label all components such that their intended location and device ID is easy to see.
- (*Recommended*) Simulate a network deployment in a lab to configure and test all components.

Sensors

Provide the Sensor installation team with training in regard to the coring and Sensor installation procedures. Perform a “dummy” installation in an available surface similar to the target road to confirm task timing and technique. Be sure to kit each Sensors with a two-piece molded plastic shell.

Coring and Drilling Considerations

Sensor Depth

Sensys Wireless Sensors are installed at a nominal depth of 2¼” (6 cm).

*Note: Sensors **must** be installed at the nominal depth of 2¼” (6 cm). Doing otherwise voids the product license and warranty unless certified by Sensys Networks, Inc.*

Other Considerations

Sensor holes can be created with either a core drill or hammer drill. When a core drill is used with a bit requiring water cooling⁴, ensure the following items are available:

- Water in sufficient quantities to cool the drill
- Hand chisel or other tool to clear the hole
- Propane torch or other tool to dry the hole prior to application of the epoxy

Note: apply epoxy only to a hole that is completely dry. Moisture in any amount may impede the curing process and jeopardize the installation.

Additionally, ensure that adequate plans have been made to capture the slurry resulting from drilling into the road. Dispose of it according to local environmental regulations.

When a hammer drill with carbide or other tip is used, be sure that the tip will last for the number of Sensors planned for installation. Keep a spare tip in reserve if possible.

Access Points and Repeaters

Review the Access Point and Repeater installation procedures with the team assigned to installing those components. If the Access Point is specified to use an integrated cellular modem, ensure that an appropriate SIM chip is available or has been installed in the Access Point.

Installation Considerations

Occasionally, the poles available at a site are not suitable for installing Access Points or Repeaters. Be prepared to install mast extensions or new masts in order to meet minimum height and antenna orientation requirements.

In some atypical situations, where existing infrastructure is locked down, regulated or not available, new poles, cable conduit, and trenching equipment may be required.

⁴ Such as the diamond tip bit available from Sensys Networks.

CHAPTER 4

Installation

This chapter surveys the installation procedures. (Refer to the documents *Sensys Wireless Sensor Installation Guide*, *Sensys Access Point Installation Guide*, and *Sensys Repeater Installation Guide* for detailed, step-by-step procedures.) Each Sensys component must be installed in the correct location to ensure proper vehicle detection and radio communications between the components.

Sensor Installation

Sensor installation begins with enclosing the Sensor in a 2-piece molded plastic shell. Place the Sensor into the shell bottom and snap the shell pieces together by pressing along the edges.

Sensor installation requires boring a 4-inch (10-cm) diameter hole approximately 2¼ inches (6 cm) deep in the road at the desired location. The objective is to bury the Sensor while leaving enough top clearance to avoid damage to the Sensor from passing vehicles. Optimal performance is attained by ensuring a minimum clearance of ¼" (0.6 cm) and a maximum clearance of ½" (1.3 cm) between the Sensor top and the road surface.



Note: Sensors *must* be installed at the nominal depth of 2¼" (6 cm). Doing otherwise voids the product license and warranty unless certified by Sensys Networks, Inc.



Figure 4.1 – Coring and Clearing a Sensor Hole

Ensure that the hole is dry and clear of all debris. Begin filling the hole – approximately one-quarter of the way to the top – with the fast drying epoxy. (Sensys Networks recommends the 2:1 ratio pack of Fabick Joint Seal (FJS), a two-component 100% solid silicone polyurea-based joint sealant, available from Sensys or directly from the manufacturer.)

Place the Sensor in the hole with the label face up and the arrow on the label aligned with the direction of traffic. Document the Sensor's ID number and the location.

Fill the hole, covering the Sensor and its label, with epoxy. In temperatures from 20°F to 180°F (6.6°C to 82.2°C), FJS epoxy cures in approximately five minutes. Because it dries so quickly, be sure to manage the work so that an open tube is used immediately.



Figure 4.2 – Epoxying Sensor Into Hole

Access Point and Repeater Installation

The basic installation guidelines for Access Points and Repeaters are the same. A few Repeater-specific notes are included at the end of this section.

Each device is mounted a minimum of eight feet (2.4 meters) above the road surface and oriented so that it faces the Sensors it services. Guidelines for the supported distance between an Access Point or Repeater and Sensors are given in the table below:

Height of Access Point or Repeater Relative to Road Surface	Maximum Recommended Range to Sensor
8 – 12 feet (2.4 – 3.7 meters)	75 – 100 feet (22.9 – 30.5 meters)
16 feet (4.9 meters)	100 – 125 feet (30.5 – 38.1 meters)
20 feet (6.1 meters) and above	125 – 175 feet (38.1 – 53.3 meters)

Table 2: Recommended Sensor Ranges by Access Point/Repeater Mounting Height

The actual range attained in the field is determined by site specific factors such as local terrain, mounting height, and antenna orientation. **Always verify** the wireless radio signal strength and link quality after an installation.⁵

Typically, an existing pole such as a traffic signal or light pole is used. Alternatively, a mast arm, retaining wall, overpass or other vertical surface may be used. The amount of setback from the roadway, the stability of the mounting point, the relative angle of the sun, and other considerations required by competing vehicle detection systems are not important.

Sensys recommends an *unimpeded line-of-sight* between an Access Pointer/Repeater and its Sensors, and between Access Points and Repeaters. Optimal radio performance is attained when the devices face each other, however up to a $\pm 60^\circ$ difference in both top-to-bottom and side-to-side antenna orientation (relative to the other device) is supported. Beyond this, the signal strength drops off rapidly.

Repeaters can be up to 1,000 feet (310 meters) from an Access Point, assuming ideal, face-to-face orientation. Alternatively, a Repeater can be installed on the same pole as an Access Point, separated by a few feet, but pointed in the opposite direction. In this configuration, the Access Point and Repeater can service a Sensor dispersion that includes Sensors in front of and behind the Access Point.

Because Repeaters are battery powered, ensure that they can be serviced easily to replace the battery pack.



Access Point Cabling and Power

Access Points receive power via a solid core, shielded CAT-5, CAT-5E, or CAT-6 Ethernet cable. The maximum run length of this cable is 328 feet (100 meters). The ideal Access Point location minimizes the cable length and any new conduit that must be installed to accommodate it.

⁵ Refer to the Sensys document *Configuration Guidelines for Freeway and Arterial Applications* for information and procedures.

Always thread the cable through conduit and the bulkhead connector of the Access Point before terminating it. Use the RJ45 crimp tool to wire the pins according to the TIA/EIA 568-B specification for standard, straight-through Ethernet connections.⁶

As noted in *Table 1* above, an Access Point used in a freeway or arterial application can be powered in one of the following ways:

- 110 / 220 VAC
- 12 VDC (such as from a solar panel)
- from a traffic signal controller shelf or rack via a Contact Closure (CC) master card from Sensys Networks

Refer to *Table 1* above to ensure that the appropriate power accessories are on hand; refer to the document *Sensys Access Point Installation Guide* for detailed cabling diagrams.

⁶ Refer to the document *Sensys Access Point Installation Guide* for more detailed procedures including a pin-out diagram.

CHAPTER 5

Estimating Labor Requirements

This chapter provides guidelines for estimating the labor costs associated with installing a Sensys Wireless Vehicle Detection network.

General Notes

The labor units in this chapter are derived from the experience of Sensys Networks, Inc. and its key contractors and may not represent your environment. It is assumed that existing infrastructure is available and suitable for installation. Therefore, additional resources and costs related to installation of new mounting poles, conduit runs, solar panels, or any other equipment are not included.

Labor requirements are discussed in terms of (i) staffing requirements, (ii) vehicle requirements, and (iii) standard labor units.

Staffing Requirements

A typical installation is staffed with three teams:

- *Access Point Installation Team*

A team of two, with at least one individual a certified IMSA Level 2 traffic signal technician (or equivalent). Each team member should be able to operate a bucket/ladder truck and pull cable through conduit. One team member must be qualified to terminate an Ethernet cable using male RJ45 jacks.

- *Sensor Installation Team*

A team of two, with each individual capable of operating a hammer or core drill and installing Sensors as described in this document.

- *Traffic Control Team*

A team of flagmen with traffic control equipment as dictated by standard, local practices.

Notes

1. Typically, a single Access Point team is sufficient even if Repeaters are included in the design. This team may benefit from waiting until after the Sensor team has started work.
2. For small arterials, the Sensor team may be able to take responsibility for traffic control and lane closure.
3. Freeway and major arterials may benefit from rolling lane closures co-ordinated with the local state highway patrol command post and implemented by its officers.
4. Additional Sensor teams may be required in large installations with multiple Sensor locations.

Vehicle Requirements

A typical installation allocates the following vehicles:

- A bucket or ladder truck is assigned to the Access Point team
- A core or hammer drill truck is assigned to each Sensor team

Notes

1. Additional trucks may be required to implement traffic control and lane closures.
2. In large installations, efficiencies may be gained by mounting the drill on a truck so that it can be rapidly moved to the next Sensor location.

Labor Units

Use the labor units in the table below to compute the overall estimated labor effort.

Description of Operation	Estimated Time
Access Point Installation (includes mounting devices on poles, orienting them toward Sensors, running Ethernet cable to power source, threading cable through Access Point connector, terminating cable, connecting to power source, conducting a power-on self-test)	1 – 2 hours
Detection Network Configuration (includes running TrafficDOT software to configure the Sensors, Access Point and Repeaters [if used], verifying wireless radio performance metrics for an adequate duration, making field adjustments)	1 – 2 hours
Repeater Installation (includes mounting devices on poles, and orienting them toward Sensors and Access Point)	30 minutes
Sensor Installation (includes drilling setup, drilling a hole, cleaning out the hole, applying first epoxy layer, placing Sensor in hole, covering Sensor with epoxy, and an average drying time of five minutes per Sensor)	8 – 12 minutes per Sensor
Lane Closure (includes setup of a traffic configuration that meets local requirements for safety and is suited to the installation tasks)	45 – 60 minutes

Table 3: Estimated Time Requirements for Installation Activities

Example Labor Estimates

This section presents an example of calculating labor estimates for the installation of a typical freeway count station as shown in the figure below.

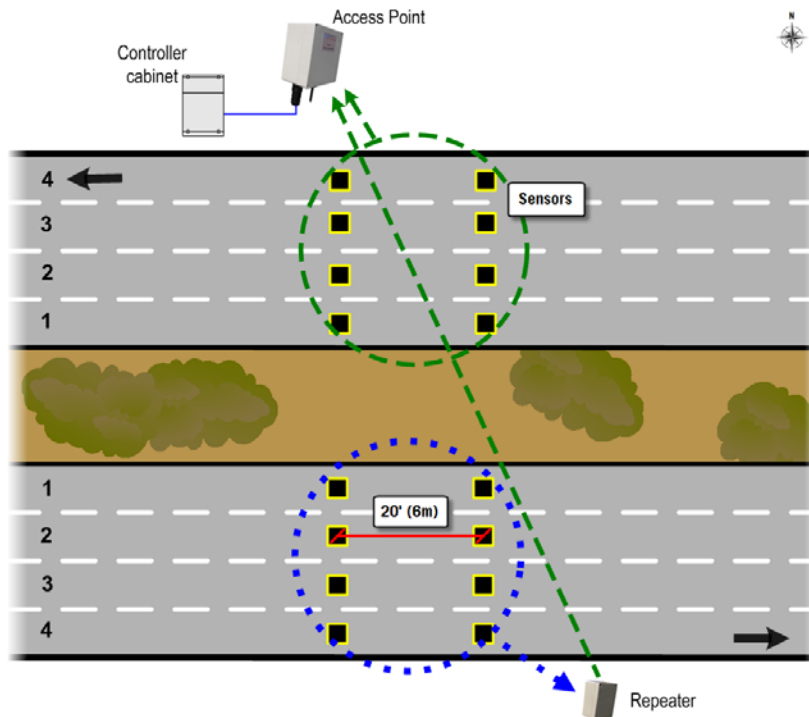


Figure 5.1 – Freeway Count Station

The installation consists of 16 Sensors, deployed in pairs in each lane of traffic. The Access Point services eight Sensors installed in the westbound lanes; a Repeater services eight Sensors installed in the eastbound lanes.

Based on the estimates specified in the table above, the project labor⁷ can be computed as follows:

Equipment Summary

- Number of Sensors: 16
- Number of Access Points: 1
- Number of Repeaters: 1
- Traffic lanes: 8

Estimated Access Point/Repeater Installation Time

- 2½ hours
- Basis: (1 Access Point * 2 hours) + (1 Repeater * ½ hour)

Estimated Network Configuration Time

- 2 hours

Estimated Time to Secure Work Zones

- 4 hours
- Basis: (8 lanes / 2 lanes closed at the same time) * 1 hour)

Estimated Sensor Installation Time

- 3 hours 12 minutes
- Basis: (16 Sensors * 12 minutes)

A sample work breakdown chart for the installation is shown below.

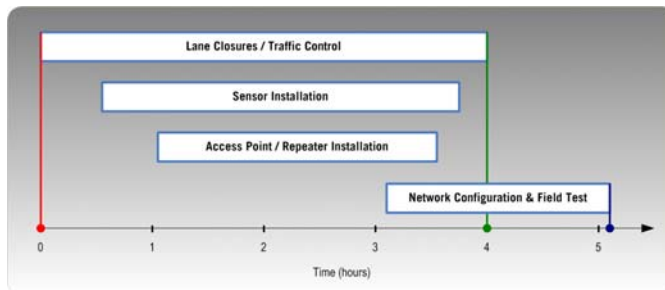


Figure 5.2 – Sample Work Plan for Example Installation

⁷ One Access Point team and one Sensor team are assumed; conservative values for labor units are used; all times are approximate.