Planning for Wireless Sensors

Application Guide

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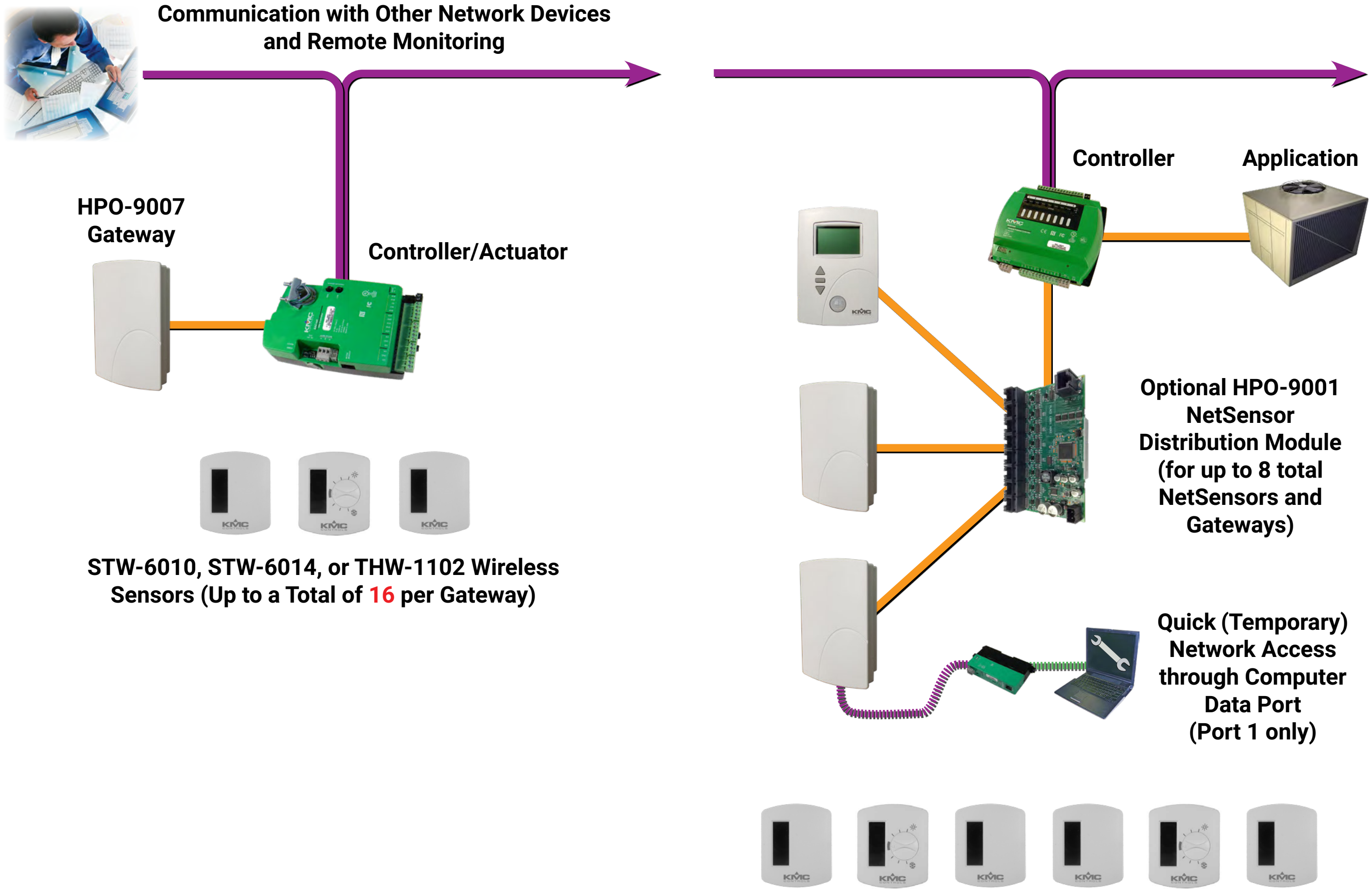
Introduction

When installing building automation systems, wireless sensor networks can provide (especially in retrofit applications) lower installation costs and increased flexibility compared to wired sensor systems. This application guide provides information to help engineers and technicians (who are experienced with building automation systems) understand, plan, and install KMC wireless STW/THW sensors and HPO-9007 gateways on KMC Conquest controllers.

Basic Sensor Network



FOR USE...	FREQUENCY	SENSORS*			GATEWAY MODEL
		Temperature (Only)	Setpoint Adjustment (Pot)	Humidity	
In North America	902 MHz	STW-6010NW	STW-6014NW	THW-1102NW	HPO-9007NW
Outside of North America	868 MHz	STW-6010DW	STW-6014DW	THW-1102DW	HPO-9007DW
*All sensors include temperature.					

A KMC wireless sensor network consists of the following devices (as shown in the illustration above):

- STW-6010, STW-6014, and/or THW-1102 wireless sensors
- HPO-9007 gateways (designed to work with KMC Conquest controllers)
- KMC Conquest controllers, routers, and other devices in the building automation system
- Operator workstations (such as **KMC Connect**™ software, **KMC Total-Control**™ software, or **KMC Converge**™ module for Niagara WorkBench)

An HPO-9007 gateway is the access point through which the data from the sensors is made available to the controllers. The wireless sensor objects are configured, using KMC software, as if they were objects from a wired sensor system.

Compatibility with other EnOcean Systems

KMC Controls is part of the **EnOcean** alliance of manufacturers that use the EnOcean (ISO/IEC 14543.3.1x) wireless connectivity protocol. In addition to the KMC sensors, other compatible devices may include light sensors, lighting switches and relays, card readers, magnetic door contacts, and occupancy sensors.

For the EnOcean compatibility, see the EnOcean profile on individual product data sheets.

STW/THW Sensor Installation Factors

Introduction

Proper mounting location for wireless, solar-powered sensors is far more critical than for traditional wired sensors. When picking a location to mount the sensor, the installer must be aware of optimal placement regarding **all three factors in the following sections.**

NOTE: Also consider the future use of the room and avoid locations that may be later used for filing cabinets, shelf units, or other large obstructions that could block air flow, light, and/or the RF signal.

Accurate Temp/Humidity Measurement

Install the sensor on an **inside wall** where it can sense the average room temperature/humidity and be **away from direct sunlight, heat sources, windows, air vents, and air circulation obstructions (curtains, furniture, etc.).**

See the **Room Sensor and Thermostat Mounting and Maintenance Application Guide** for additional mounting and troubleshooting information **for measuring temperature and humidity**.

Adequate Light for Sensor Charging

To keep the energy-harvesting, solar-powered sensor properly charged, **mount the sensor in an area with a minimum illumination of 200 lux** (e.g., typical light levels of interior corridors, stairwells, storage rooms, or mechanical rooms) **for three to four hours every day.** The light source can be either artificial or daylight.

NOTE: Artificial lighting sources are **not** as effective in keeping sensors charged as indirect daylight because of spectrum and intensity differences. LED lights (although energy efficient) are even less effective in charging sensors than incandescent or fluorescent lights. **In an interior room that has LED (only) lighting, a sensor should have a battery installed as a backup.**

Avoid recessed areas that are not sufficiently illuminated throughout the day. Avoid mounting the sensor angled away from light sources. The **long-term illumination should not exceed 1000 lux** (equivalent to outdoors on an overcast day). The sensors can be mounted with the solar cell toward a window but **not in direct sunlight at any time of the day** since direct sunlight will give false temperature values.

Adequate RF Range/Path to the Gateway

For the RF signal, the maximum theoretical straight-line distance between the gateway and sensors is about 100 feet (30 meters). However, in practice, **the maximum distance will be substantially reduced by obstacles in the path, the shape of the room, sources of radio interference, and placement/orientation of the sensors and gateway!**

The rest of this application guide describes factors involving the wireless signal.

NOTE: To provide optimized placement for all three sensor location factors, repositioning the wireless gateway may be necessary.

Principles of Wireless Networks

Introduction

Wireless systems can reduce labor and increase flexibility of a controls system, but gains in savings or flexibility require careful planning. Read the following sections before planning a wireless system.

Estimating Wireless Signal Coverage

Factors Affecting Coverage

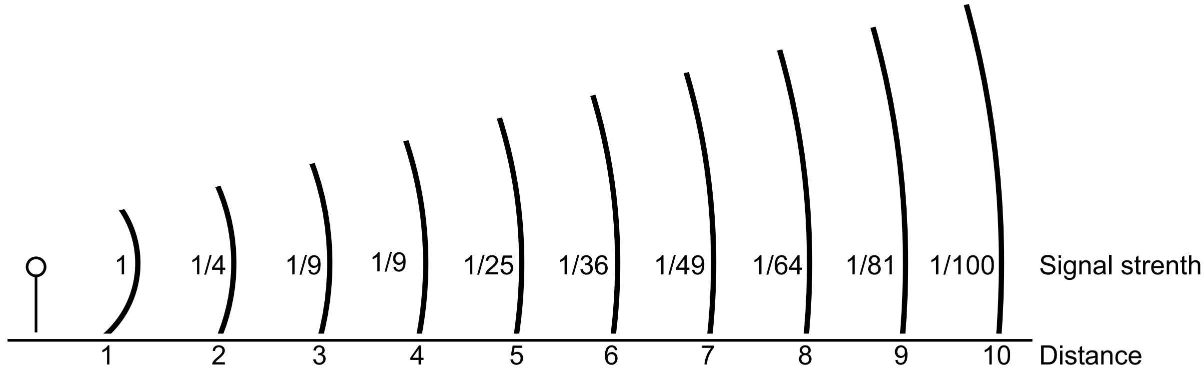
Three main factors that determine the size and shape of the coverage area of a wireless sensor network are:

- The distance between the sensors and the receivers
- The materials that block the direct path of the wireless signal
- The shape of the room

Additional factors that degrade performance include RF interference from electrical sources and “dead spots” caused by signal reflections from nearby conductive objects. These are discussed more in the following sections.

Distance and Construction Materials

The strength of a wireless sensor radio signal decreases as it travels. This reduction takes place because radio waves follow the inverse square law of physics. The law states that if the distance between a transmitter and receiver is doubled the signal will be only one-fourth as strong. The following illustration shows how the signal continues to weaken the farther it travels.



Signal Strength and the Inverse Square Law

The exact range will depend on the type of structure and building materials surrounding the system. The following distances are the maximum planning ranges for KMC wireless sensors:

- In closed spaces with walls or other obstructions, the maximum range may be less than 33 feet (10 m).
- In open areas, place the sensor no farther away than about 98 feet (30 m) from the gateway.

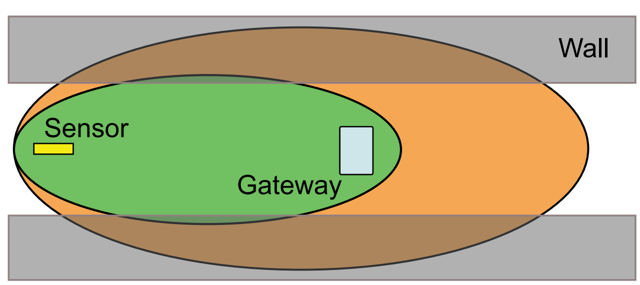
Even though radio waves can penetrate walls, attenuation is higher than if the signal traveled an unobstructed path. Building materials and objects that decrease or constrain coverage include:

- Metal interior walls
- Hollow, lightweight walls filled with insulating wool or metal foil
- Drop ceilings with panels made of metal or carbon fiber
- Steel furniture
- Glass with metal coating (typically not used indoors)
- People and objects within a room

WIRELESS RANGE REDUCTION BY CONSTRUCTION MATERIALS	
Material	**Approximate Range Reduction**
Wood, plaster, drywall, uncoated glass	0 to 10%
Brick, particle board	5 to 35%
Sensor mounted on metal surface	30%
Metal, iron reinforced concrete, mirrors	10 to 90%

Room Shape

In narrow rooms, the coverage of a wireless network forms an ellipsoid with the transmitter and receiver located at the focal points. The “width” of the range may be half or a third of the “length” of the ellipsoid.



Wireless Coverage in a Narrow Room

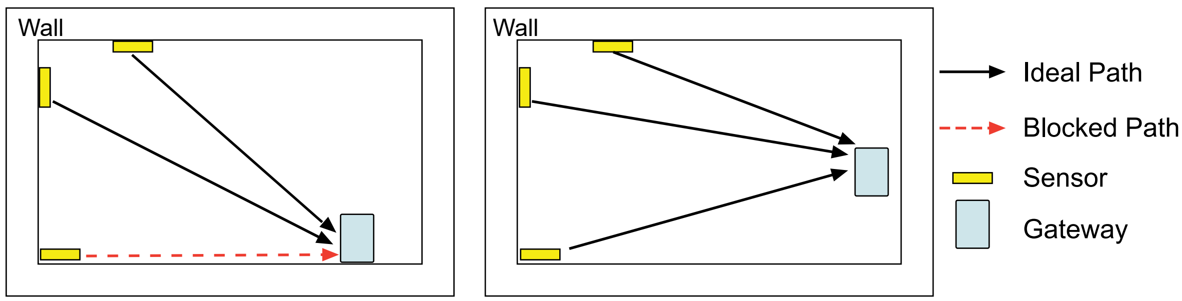
Sensor Placement in a Room

Effects of Placement

The location of wireless devices within a space is critical to the success of a network. Devices that appear to be within range still may not communicate because of poor placement.

Avoid Wall Reflections

Avoid placing transmitters and receivers along the same wall. Near a wall, the radio waves are subject to interfering reflections. The ideal placement in the room for a receiver is a central location. All devices should be at least 4 inches (10 cm) away from a wall corner or concrete ceiling. Also avoid wall niches as a niche will create reflections.



Attenuation from Wall Path Reflections

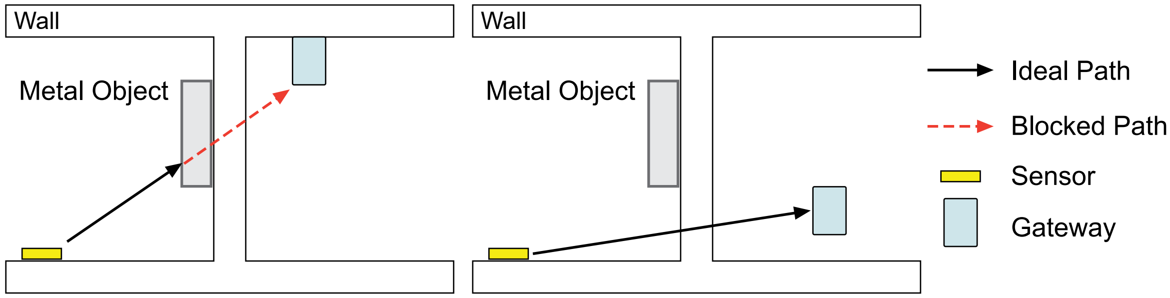
NOTE Avoid placing devices on the same wall. Reflections will produce interference and reduce the range. Reposition the sensor, the gateway/receiver, or both. Alternately add a gateway.

Avoid Object Screening

Massive objects made of metal, such as metal reinforced interior walls, metal ceilings, and the metal foil on insulation will all reflect or block radio waves. The reflection creates a radio shadow or screening. Fire-safety walls, elevator shafts, staircases, and supply areas with metal shelves are areas that will screen radio signals.

Very small items such as the metal nails or screws that fasten gypsum dry wall, however, typically do not cause significant screening.

NOTE: Avoid the effects of screening by repositioning the sensor, the gateway/receiver, or both. Alternately add a gateway.

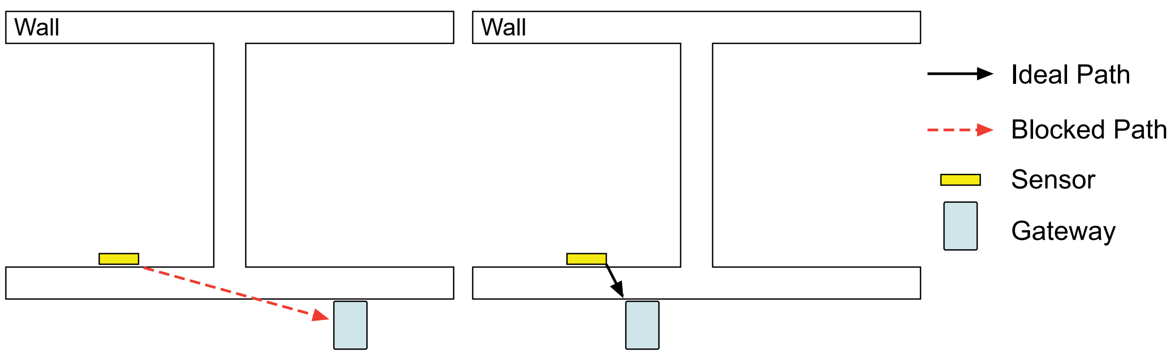


Attenuation from Obstacles

Even though placing wireless devices on the opposite side of a metal wall may work, the practice should be avoided. Radio waves can reach the next room or floor by passing through non-metallic openings such as a wooden door or an indoor glass window, but the range will be reduced.

Avoid Low Signal Angles

The angle at which the transmitted signal approaches the wall is important. The effective wall thickness, and with it the signal attenuation, varies according to this angle. Signals should be transmitted as **directly** as possible through the wall.



Attenuation from Signal Angle

NOTE: Avoid unfavorable signal angles by repositioning the sensors, the gateway/receiver, or both. Alternately add another gateway. See **Adding Gateways to Extend Coverage on page 8**.

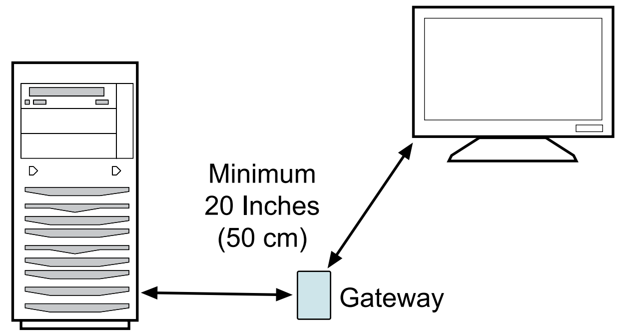
Separation of Receivers and Interference Sources

Because gateways receive very small signals from the transmitters in wireless sensors, gateways are very sensitive to sources of high-frequency interference, such as:

- Computers and computer equipment
- Wireless LAN or Wi-Fi access points
- Fluorescent lights
- Motors
- Base units for cordless telephones

- Audio and video equipment
- GMS and cell phone sites
- Radio Frequency Identification (RFID) scanners or sensors

Maintain at least 20 inches (50 cm) between a receiver/gateway and any source of interference. Sensors, however, can usually be installed near a high-frequency transmitter without a significant loss of sensor range.

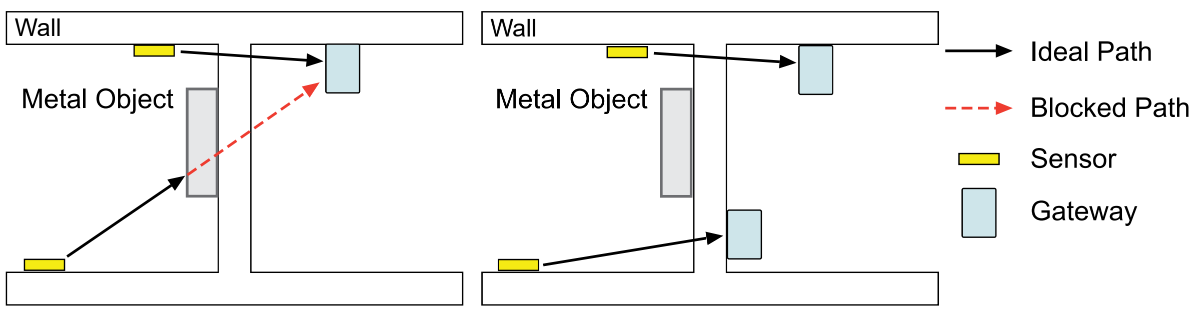


Minimum Distance from Interference

NOTE Do not use 868 MHz power RFID and 868 MHz EnOcean receivers in the same room.

Adding Gateways to Extend Coverage

Environments with poor coverage may need additional gateways. Adding additional HPO-9007 gateways to a single controller requires an **HPO-9001 distribution module**. See **Basic Sensor Network on page 2**.



Extending Range (around and through Obstacles) with an Additional Gateway

Testing Field-Strength

For HPO-9007s, KMC software shows signal strength of received transmissions from discovered wireless sensors. (See the **HPO-9007 Series Gateway Installation Guide**.)

Hand-held field-strength meters can also aid an installer with:

- Planning sensor and receiver locations for new installations
- Verifying the performance of a system once it is installed
- Troubleshooting problems with existing systems

NOTE: A meter can display the field intensity of each transmission received and any interfering radio signals within the frequency range of the meter. Meters must operate on the same frequency as the sensors and receivers.

KMC STW/THW sensors normally transmit only several times per hour to conserve power. To trigger a transmission for **testing signal strength** of a KMC STW/THW sensor:

- Remove the cover and **momentarily press the Learn button** (on the side or top of the button body) with a small screwdriver. (See the **STW/THW Series Installation Guide**.) This will trigger an immediate transmission (but that signal will not contain temperature, setpoint, or humidity values).
- Alternately on an STW-6014, **rotate the setpoint dial** (a quarter turn or more). The change in setpoint will trigger a transmission within two minutes or less some delay before transmission).

Conducting Site Surveys

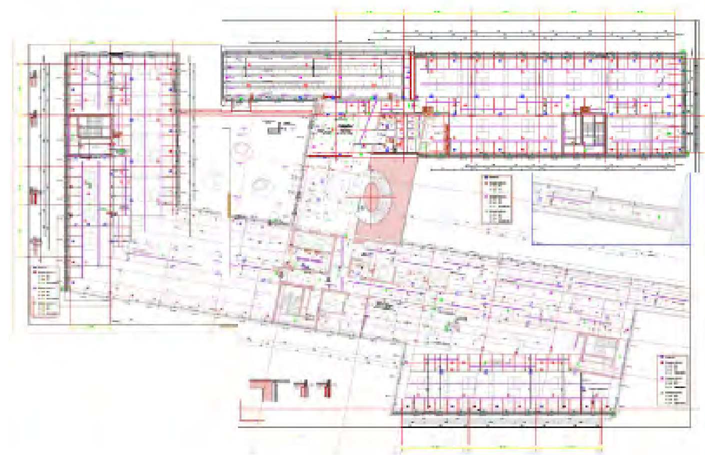
Introduction

A quality wireless sensor system begins with a careful site survey. Results from the survey will help determine the best locations for gateways and sensors. To perform a survey you will need the following:

- A set of accurate floor plans.
- Drawing compass
- Ruler or architect's scale
- Field strength meter
- Tape measure or laser distance meter

(Step 1) Obtain the Building Floor Plans

To start a site survey, obtain a complete and current set of floor plans.

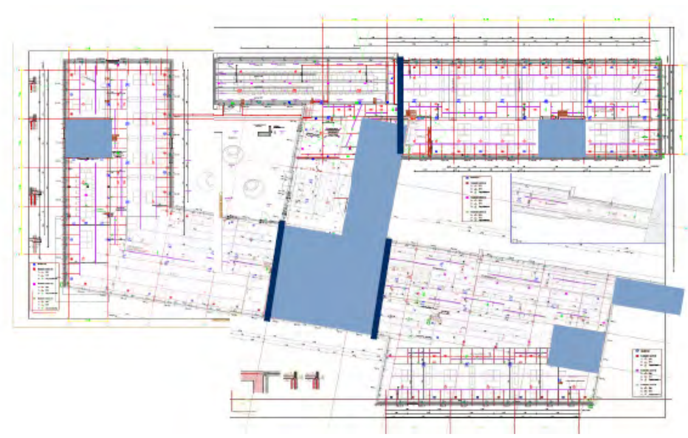


(Step 2) Mark Problem Areas on the Floor Plans

Review the floor plans and identify any areas that may block radio signals. This can include, but is not limited to, the following:

- Fire protection walls
- Lavatories
- Staircases
- Elevator shafts
- Supply areas

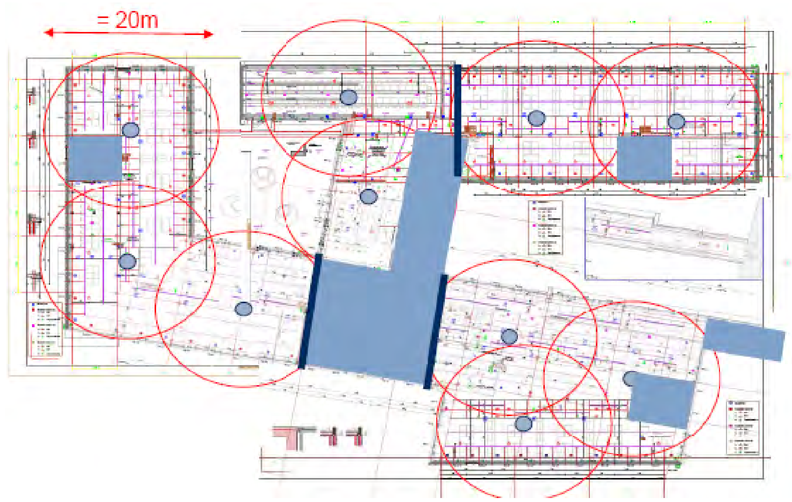
Mark the areas on the floor plans. In the following illustration, the problem areas are shaded blue.



(Step 3) Add Coverage Areas to the Floor Plans

Use a compass to draw potential good-signal coverage areas on the floor plans.

- The center of the circles are the ideal locations for the gateways.
- Locate the gateways in such a way that no shaded areas block the path to potential sensor positions.



(Step 4) Test and Verify

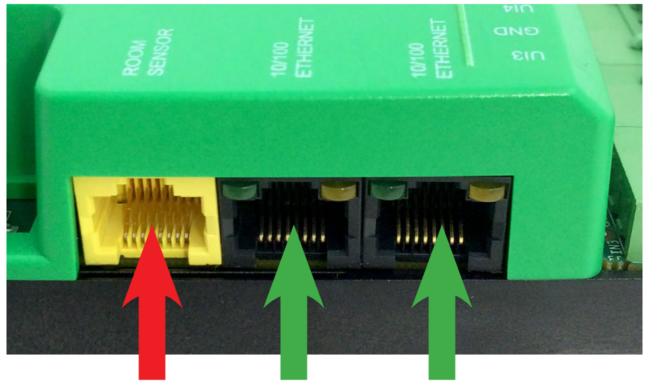
After careful planning, conduct field tests with a field-strength meter and a representative sensor to verify proper reception at the receiver positions. Improve unfavorable conditions by moving sensors, moving gateways, and/or adding gateways. As each location is verified, record the field strength measurements on the floor plans.

(Step 5) Document the Results

Document the results for future reference with the following:

- Final coverage area maps with the location of gateways and sensors
- Field strength readings at each location
- Other relevant information (such as potential sources of RF interference or possible addition of future obstacles)

Installation Precautions



(Room Sensor Connection) Ethernet Connections (BAC-90xxE Shown)

⚠ CAUTION

On a KMC Conquest Ethernet model controller, do NOT accidentally connect a cable to the Room Sensor port from an Ethernet port on a switch, router, or another daisy-chained Conquest controller! The **voltage from the Room Sensor port** (that powers STE-9xxx NetSensors and HPO-9007 gateways) **WILL DAMAGE the connected Ethernet port!** If the Ethernet port is damaged, the wireless connection may still work, but communication with connected devices will be lost.

NOTE: HPO-9007 gateways **are** plugged into the Room Sensor port.

NOTE: Room Sensor ports were black before 2016 and yellow after.

NOTE: KMC Conquest BAC-5901CE and BAC-9xxxCE model controllers have **dual** Ethernet ports for daisy-chaining. The Room Sensor port is **next** to the Ethernet ports in the BAC-90xxE VAV controllers. It is on the **opposite** side on BAC-93xxE and BAC-59xxE controllers.

For digital devices, take reasonable precautions to prevent electrostatic discharges to the devices when installing, servicing, or operating them. Discharge accumulated static electricity by touching one's hand to a securely grounded object before working with each device.

Glossary of Wireless Sensor Terms

antenna—A device that radiates or receives radio frequency energy. An antenna can be either internal or external. The general size and shape of an antenna is determined by the frequency of the signal it manages.

attenuation—The process of reducing the amplitude of a signal.

dB—Decibel (dB) is a unit for measuring relative power ratios in terms of gain or loss. The units of dB are expressed in terms of the logarithm to base 10 of a ratio and typically are expressed in watts. For example, a –3dB loss indicates a 50% loss in power; a +3dB reading is a doubling of power; 10 dB indicates an increase (or a loss) by a factor of 10; 20 dB indicates an increase (or a loss) of a factor of 100; 30 dB indicates an increase (or a loss) by a factor of 1000.

dBm—A unit of measure of RF power expressed in decibels relative to one milliwatt.

dBµV/m—A unit of measure of RF power expressed in dB-microvolts per meter.

energy harvesting—Energy harvesting is the process in which energy is captured from a system's environment and converted into usable electric power. Energy harvesting examples include light (captured by photovoltaic cells), vibration or pressure (captured by a piezoelectric element), temperature differentials (captured by a thermo-electric generator) and radio energy (captured by an antenna). Energy harvesting is also known as power harvesting or energy scavenging.

gateway—A node on a network that enables communication between computer networks that use different communications protocols (e.g., wireless to wired).

ground plane—A conducting surface of continuous metal or discrete wire that acts to create an electrical image of an antenna.

RF—Radio Frequency, typically a frequency from 20 kHz to 100 GHz. RF is usually referred to whenever a signal is radiated through an enclosed medium like a transmission cable or air.

RFI—Radio Frequency Interference, unwanted noise from RF sources.

RFID—Radio Frequency IDentification (RFID), a method for uniquely identifying an object using a transponder tag or chip that carries a unique ID number or code. The tags feature an antenna to transmit and receive radio signals. RFID uses low-powered radio transmitters to read data stored in the tag at distances ranging from one inch to 100 feet. RFID tags are used to track assets, manage inventory, and authorize payments. They increasingly serve as electronic keys for everything from autos to secure facilities.

wireless—Using the radio-frequency spectrum for transmitting and receiving communications signals.

Important Notices

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