Planning Guide For Wireless Sensors

Contents

Revision A

KMC CONTROLS

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Section 1: Introduction

This section is contains topics that will help you get started with planning wireless networks.

When installing building automation systems, wireless sensor networks can provide lower installation costs and increased flexibility compared to installing wired systems. The recommendations in this planning guide are provided as an aid for the successful installation and reliable operation of wireless products sold by KMC Controls, Inc.

The topics in this section

Additional sections in this guide

- The section *Principles of wireless networks* on page 5, covers fundamental issues that affect the range and coverage of a wireless sensor network.
- *Conducting site surveys* on page 13 is a step-by-step procedure to plan the best location for wireless devices.
- The *Glossary of wireless terms* on page 17 is a list of words and terms that may be new to wireless users.

Who should read this guide?

This guide is prepared for application engineers, controls system engineers, and controls technicians who are experienced with planning building automation systems.

Basic sensor network

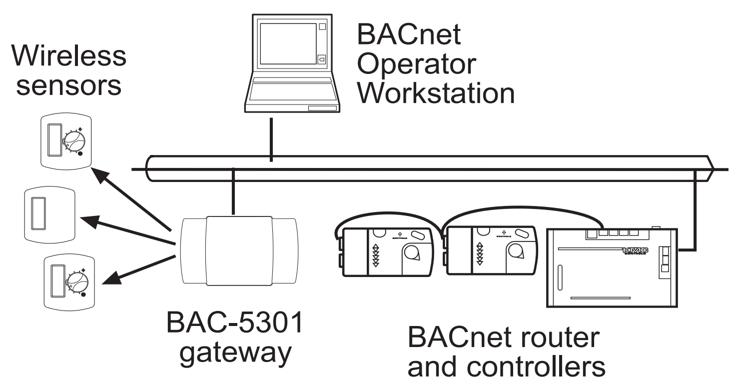
A KMC wireless sensor network consists of the following devices:

- The controllers and routers in the building automation system
- Operator workstations
- A wireless access point such as a BAC-5301
- Wireless sensors or other devices

It is through the access point that the data from the sensors is made available to the building automation controllers.

In the system shown in *BACnet sensor network* on page 4, a BAC-5301 gateway is the wireless access point to the building automation system. The gateway receives the wireless signals from the wireless sensors. A controls technician that is configuring the BACnet system sees the sensors listed as BACnet devices with input or value objects and properties. These objects and properties are then used to configure the BACnet system just as if they were objects and properties from a wired system.

Illustration 1–1 BACnet sensor network



Compatibility with other systems

KMC Controls is part of the EnOcean alliance of manufacturers that use the EnOcean wireless protocol. In addition to the KMC sensors and devices, other compatible devices include light sensors, lighting switches and relays, card readers, magnetic door contacts, actuators, and occupancy sensors.

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

Section 2: Principles of wireless networks

Wireless sensor networks that use radio transmitters and receivers require careful planning before and during system installation. Topics in this section cover basic principles of radio frequency systems.

Wireless systems can reduce labor and increase flexibility of a controls system. However, any gains in savings or flexibility require careful planning. Review the topics in this section before planning a wireless system.

Estimating the coverage of wireless signals

Three basic factors determine the size and shape of the coverage area of a wireless sensor network.

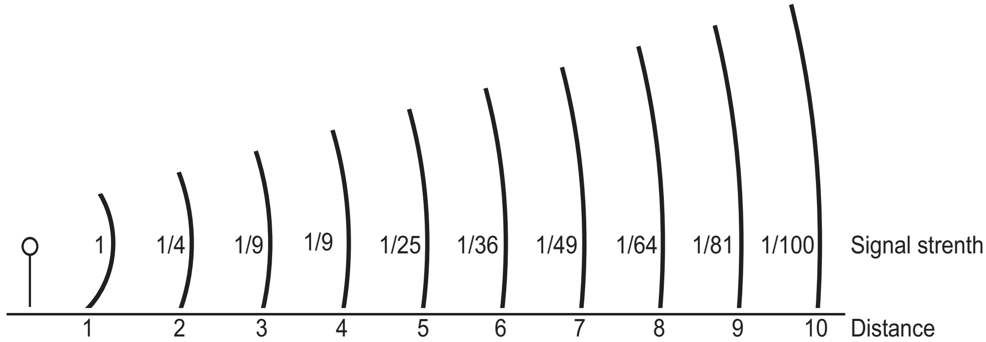
- The distance between the sensors and the receivers in access points
- The materials that block the direct path of the wireless signal
- The shape of the room

Additional factors, such as sensor placement and antenna orientation, will also affect performance. This is discussed in the topic *Placement of sensors within a room* on page 7.

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 from 10 feet to 20 feet the signal will be only one-fourth as strong. The illustration *Signal strength and inverse square law* shows how the signal continues to reduce the farther it travels.

Illustration 2–1 Signal strength and 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 sensors from KMC Controls.

- 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 98 feet (30 m) from the receiver or gateway.

Even though radio waves can penetrate walls, attenuation is higher than if the signal traveled on an unobstructed path. Building materials and objects are all factors that decreases or constrains coverage:

- 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

The table *Wireless range reduction by construction materials* lists various materials that will reduce the range of wireless devices.

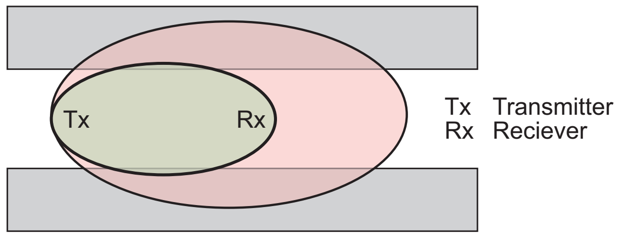
Table 2–1 Wireless range reduction by construction materials

Material	Range reduction
Wood, plaster, drywall, uncoated glass	0-10%
Sensor or switch mounted on metal surface	30%
Brick, particle board	5-35%
Metal, iron reinforced concrete, mirrors	10-90%

Room shape and wireless coverage

In narrow rooms the coverage of a wireless network forms an ellipsoid with the transmitter and receiver located at the focal points. At a range of 98 feet (30 m) the theoretical wireless coverage of the ellipsoid is no more than 30 feet (10 m) for 868 MHz sensors and 55 feet (17 m) for 315 MHz sensors. Coverage is further reduced based on signals obstructed by construction materials as discussed in the previous topic.

Illustration 2–2 Wireless coverage in a narrow room



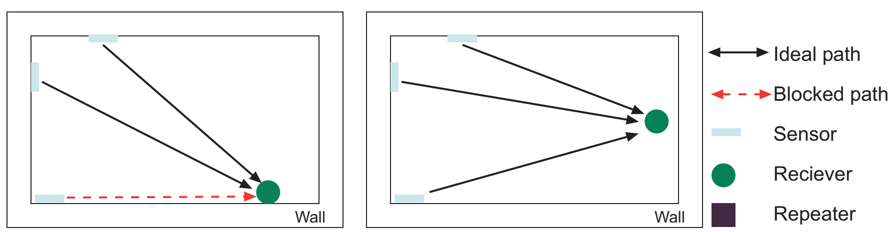
Placement of sensors within a room

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

Placement along walls

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. Where possible all devices or antennas should be at least 4-6 inches (10 – 15 cm) away from a wall corner or concrete ceiling.

Illustration 2–3 Avoid paths along a wall



Tip: Avoid placing devices on the same wall. Reflections will produce interfeance and reduce the range

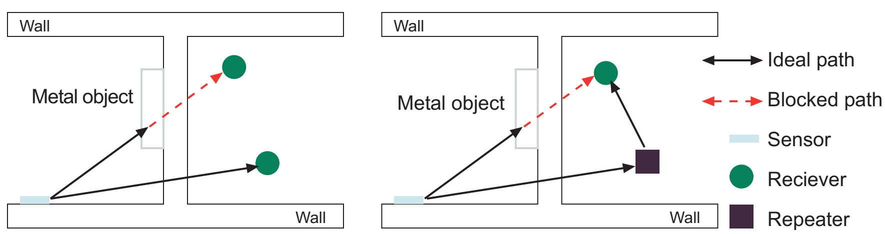
The effects of screening

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

Fire-safety walls, elevator shafts, staircases and supply areas with metal shelves are also areas that will screen radio signals.

Tip: Avoid the effects of screening by repositioning the transmitting antenna or sensor, the receiving antenna or both to avoid the screening shadow or by adding a repeater.

Illustration 2–4 Signal loss from screening

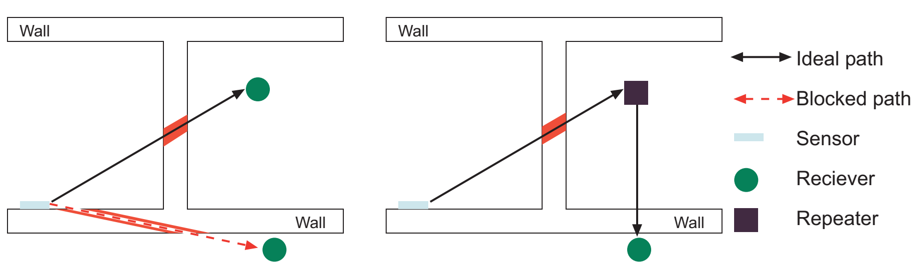


Even though placing wireless devices on the opposite side of a metal wall may work, the practice should be avoided. Radio waves can reach the next room or floor by passing through a non-metallic opening such as a wooden door or an indoor glass window but the range will be reduced.

Signal angle

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. Also, avoid wall niches as a niche will create reflections.

Illustration 2–5 Signal angle



Tip: Avoid an unfavorable signal angle by repositioning the transmitting antenna, the receiving antenna, or both or by adding a repeater.

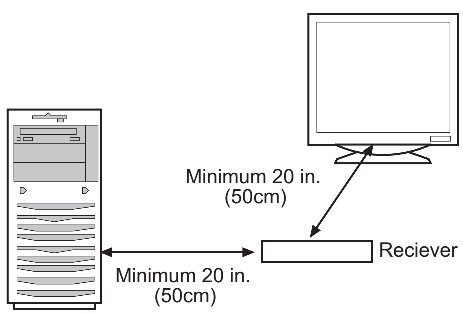
Separation of receivers and sources of interference

Because gateways and access points receive very small signals from wireless transmitters, they are very sensitive to sources of high-frequency interference. This interface can come from any of the following sources.

- Computers and computer equipment
- Wireless LAN or WiFi access points
- Florescent lights
- Motors
- Base units for cordless telephones
- Audio and video equipment
- GMS and cellular phone sites
- Radio Frequency Identification (RFID) scanners or sensors

Maintain at least 20 inches (50 cm) between a receiver or gateway and any source of interference. Transmitters however, can be installed next to any other high-frequency transmitter without a loss of range.

Illustration 2–6 Minimum distance to interference



Caution

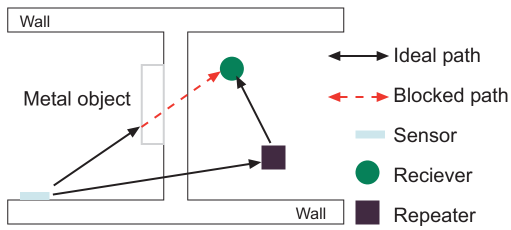
Do not use 868 MHz power RFID and 868 MHz EnOcean receivers in the same room.

Tip: Separate a gateway or access point from a source of interference by at least 20 inches (50 cm), the transmitter position is not critical.

Extending coverage with repeaters

To extend wireless coverage or to penetrate heavy screening a repeater may be required. Repeaters receive a weak radio signal and then retransmits the signal with a stronger signal. This can nearly double the range of a sensor without adding network access points. Typical uses for repeaters are shown in the following illustration.

Illustration 2–7 Extending range with repeaters



Tip:

While planning for wireless sensors, consider using repeaters to reduce the number of gateways or other access points. However, using too many repeaters will increase the system cost and can result in data telegram collisions.

Repeaters require only an AC power supply and do not require any configuration or programming. Level-1 EnOcean repeaters cannot be cascaded; data telegrams that have been repeated are not repeated again. EnOcean repeaters which can be switched to Level-2 function allow two repeaters to be cascaded. This is usually only needed in extreme cases.

Using field strength meters

Handheld field strength meters can aid an installer with any of the following wireless sensor network tasks.

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

The meter displays the field intensity of each radio telegram received and any interfering radio signals within the frequency range of the meter.

To use the meter, one person triggers a sensor to send data. The controls technician then checks the received field strength on the display of the meter to determine if the signal is received.

The meters must be used on the same frequency as the sensors and receivers. An EnOcean EPM 300C meter operates in the 315 MHz range; the EPM 300 meter operates in the 868 MHz range.

Illustration 2–8 Field strength meter

Section 3: Conducting site surveys

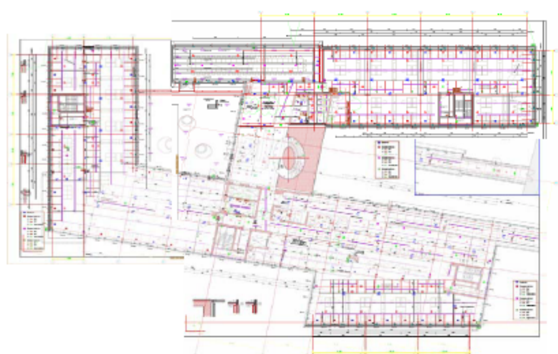
Use the procedures in this section to plan the location for wireless sensors and access points.

A quality wireless sensor system begins with a careful site survey. Results from the survey will help determine the best location for access points 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: Start with the building floor plans

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



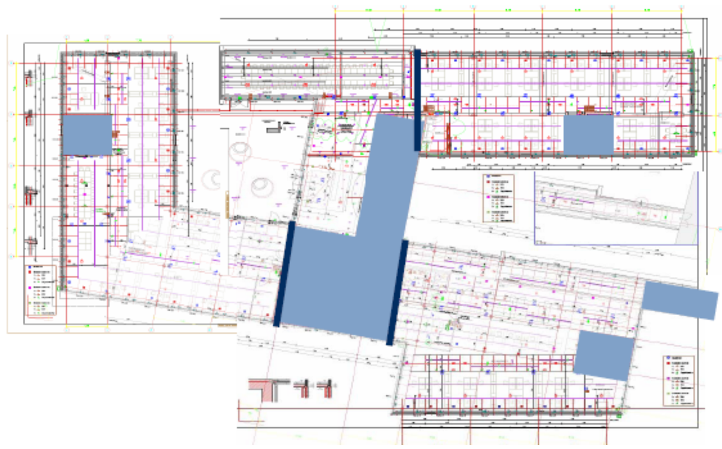
Step 2: Mark shaded areas on the floor plan

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 shaded areas are marked in blue.

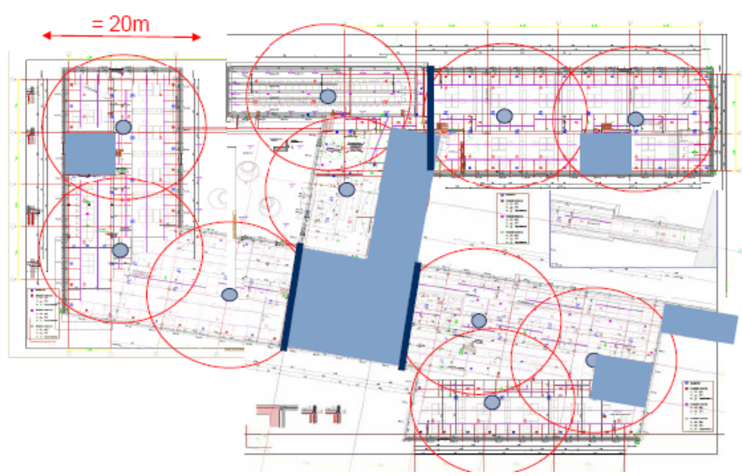
Illustration 3–1 Shaded areas



Step 3: Add coverage areas to the floor plans

Use a compass to draw coverage areas on the floor plans.

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



Step 4: Verify with field testing

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, changing antenna positions, or adding repeaters. As each location is verified, record the field strength measurements on the floor plans.

Step 5: Document the field test

Document the field tests with the following:

- Final coverage area maps with the location of access points and sensors
- Field strength readings at each location

Other information such as network access points or potential sources of interference may also be added to the report.

Section 4: Glossary of wireless terms

This section lists some of the common terms used in wireless networks.

A

access point

A wireless network transceiver that connects a wired local area network to one or many wireless devices.

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.

B

Bluetooth

The name for a technological standard (a communications protocol) that enables mobile devices equipped with a special chip to send and receive information wirelessly. Using Bluetooth, electronic devices such as desktop computers, wireless phones, electronic organizers and printers can communicate over short-ranges using the 2.4 GHz spectrum band.

C

coaxial cable

A type of feed line with one conductor inside the other and both sharing a concentric central axis.

D

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.

dBi

Antenna gain in decibels compared to a theoretical isotropic antenna as a reference.

dBm

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

dipole

An antenna consisting of a straight conduction approximately ½ wavelength long and fed in the middle.

directional antenna

An antenna with gain in one or more preferred directions.

E

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.

G

gateway

A node on a network that enables communication between computer networks that use different communications protocols. A gateway may be hardware or software.

ground plane

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

I

isotropic antenna

An isotropic antenna is a theoretical point source of electromagnetic or sound waves which radiates the same intensity of radiation in all directions. It has no preferred direction of radiation. It radiates uniformly in all directions over a sphere centred on the source. Isotropic radiators are used as reference radiators with which other sources are compared.

R

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.

repeater

Devices that receive a radio signal, amplify it and re-transmit it in a new direction. Used in wireless networks to extend the range of base station signals and to expand coverage. Repeaters are typically used in buildings, tunnels or difficult terrain.

RF

See Radio Frequency.

RFI

Radio Frequency Interference: Unwanted noise from RF sources.

RFID

Radio Frequency IDentification (RFID) is 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, and they increasingly serve as electronic keys for everything from autos to secure facilities.

W

WiFi

Wireless Fidelity or WiFi provides wireless connectivity over unlicensed spectrum using the IEEE 802.11a or 802.11b standards. It is generally in the 2.4 and 5 GHz radio bands. Wi-Fi offers local area connectivity to WiFi-enabled computers.

wireless

Using the radio-frequency spectrum for transmitting and receiving voice, data and video signals for communications.

WLAN

Wireless Local Area Network—The WLAN supports network communication over short distances using radio or infrared signals instead of traditional network cabling. A WLAN typically extends an existing wired local area network.