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(54) Title: MULTI TIER WIRELESS COMMUNICATION SYSTEM

(57) Abstract

A monitoring system is provided with a two tier communication network. Multiple first tier nodes comprising wireless or RF sensors are each equipped with transceivers operating at a first, low power level. Multiple second tier nodes are spaced to communicate with selected sensors at the lower bandwidth level, and also communicate with each other at a higher power level and higher bandwidth, to route sensor communications to a central controller. The sensors comprise standard home and small business sensors such as motion detectors, glass breakage, pressure, temperature, humidity and carbon monoxide sensors to name a few, each equipped with a transceiver. The sensors are placed throughout a structure to be protected or monitored. Since such structures can be quite large, several second tier routers are provided such that at least one is within range of each sensor to receive its low power signals. A routing table is dynamically generated to direct communications between routers and the controller.

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MULTI TIER WIRELESS COMMUNICATION SYSTEM

FIELD OF THE INVENTION

The present invention relates to communication systems, and in particular to multi tier communication system for communicating between multiple devices.

BACKGROUND OF THE INVENTION

Home and business security, automation, and monitoring systems, and industrial and factory control and communication systems are becoming more and more sophisticated. When installed during the building of a structure such as a house, business office tower factory or warehouse, remote devices, such as sensors, motors, switches and other actuators may be hardwired into a central control panel without much disruption to use of the structure. However, as the number of devices in such systems increases, the wiring into the central control panel becomes more and more complex. Physical connections must be provided for devices to be added, leading to very large control panels, and strict limits on the expansion capacity of each control system.

A further problem associated with hardwired systems is that devices may be added following completion of construction of a structure, but may require a crew of workers taking many hours, either tearing into walls to add wiring, or the use of additional devices utilizing radio frequency RF transmission capability. It is also difficult to integrate new, higher function devices which require high bandwidth data transmission capabilities. Two way communication may also not be provided by existing wired systems. Installing a new system in an existing structure can require significant structure invasive and labor intensive wiring done by a work crew causing much disruption of the use of the structure. Wireless devices can also be used when adding a new system, but when located further from the control panel, they require high power radio transmission capability which is regulated by the Federal Communications Commission (FCC), and are either coupled directly to an AC power source, or contain batteries that need to be replaced quite often. Thus, the use of either wired and wireless devices in such systems can be both costly and inconvenient. The use of both wired and wireless device leads to increased complexity and compounds the problems associated with each.

There is increasing interest in using wireless devices to alleviate some of the wiring problems described above. The FCC provides for use of low-power communication devices under Part 15 of its rules. Part 15 permits unlicensed operation of devices at selected frequencies at low powers to promote the use of such devices. The low power operation ensures that there will be little interference, especially when used by spread spectrum systems which reduce power density of electromagnetic radiation transmitted at any frequency or narrow band of frequencies within a total frequency bandwidth. This further reduces the chances of interference between different systems.

However, as discussed above, one problem in using such devices for systems is that the distance such devices can transmit is limited by the available transmission power. As structures in which such systems are installed can be quite large, there is a need to increase the range that a controller can communicate with the devices. Much research has gone into enhancing the power output of transmitters while still complying with FCC regulations. This has lead to the cost of wireless devices increasing dramatically. In addition, higher power levels have shortened battery life, which then require replacing more often. More expensive batteries have somewhat solved this problem, but have dramatically increased the overall cost of the devices. While some devices can be plugged into AC outlets, they are not always conveniently located.

With larger structures being fitted with systems, the distance between devices and a controller has further exacerbated the transmission distance problem. Many times, the controller is located in an inconvenient central location in order to ensure that it can receive transmissions from each device. For further distances, some devices need to be hardwired. Hardwired devices in a mostly wireless systems add complexity to the system, further increasing the costs. Also, since the hardwired devices are only used for the longest distances from the controller, the inconvenience and expense of wiring increases.

Many more devices are being used in recent years, including temperature sensors, pressure sensors, level sensors, flow meters, carbon monoxide sensors, motors, switches, actuators, video cameras and other devices found in security systems, automation systems and process control systems. Retrofitting these to existing systems has proven costly. With the advent of voice and video devices and other high function

and high bandwidth devices coupled to systems, the demands placed upon system communication networks require higher and higher bandwidth solutions. Making devices with transmitters that can interface into such networks is further increasing the overall cost of the devices.

There is a need for a system which can utilize wireless devices located further from a controller or control panel. There is a further need to be able to place the control panel in any desired location within a structure which is convenient. There is a need to decrease the complexity caused by large numbers of hardwired devices in the system. There is yet a further need to reduce the power consumed by the wireless devices to increase their battery life. There is a need for a communication system having high bandwidth for selected devices which need to transmit data intensive information, and for a communication system that provides bidirectional capability as well as expansion capability for high bandwidth devices. There is still a further need for devices which can be quickly and easily installed with minimal disruption of use of a structure in which the system is installed.

SUMMARY OF THE INVENTION

A two tier communication infrastructure is provided for wireless devices coupled to a controller in a system. Multiple first tier nodes of the communication infrastructure comprise devices which are equipped with transceivers operating at a first, low power level. Multiple second tier nodes are spaced to communicate with selected devices at a low bandwidth level, and also communicate with each other at a higher power level and higher bandwidth, to route communications to the controller.

In one embodiment, the first tier node devices are battery powered and communicate via the first tier using a low power, short range, single chip transceiver operating at unlicensed frequencies such as approximately 300 or 433 MHz. Bidirectional communication is provided, and the power level is low for short range transmission. The low power levels limit the range of transmission, but also provide for extended battery life or the use of cheaper batteries. The transceiver is also very inexpensive and need not be optimized for longer transmission distances. The devices comprise standard home, small business, commercial and industrial sensors, identification tags and actuators such as motion detectors, glass breakage, pressure,

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