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(54) Ceiling tile transmitter and receiver system

(57) A ceiling tile transmitter and receiver system has at least one transmitter/receiver device, such as an RF antenna, located in a ceiling tile (1) during the ceiling panel fabrication process. The transmitter/receiver device is embedded inside the ceiling tile (1).

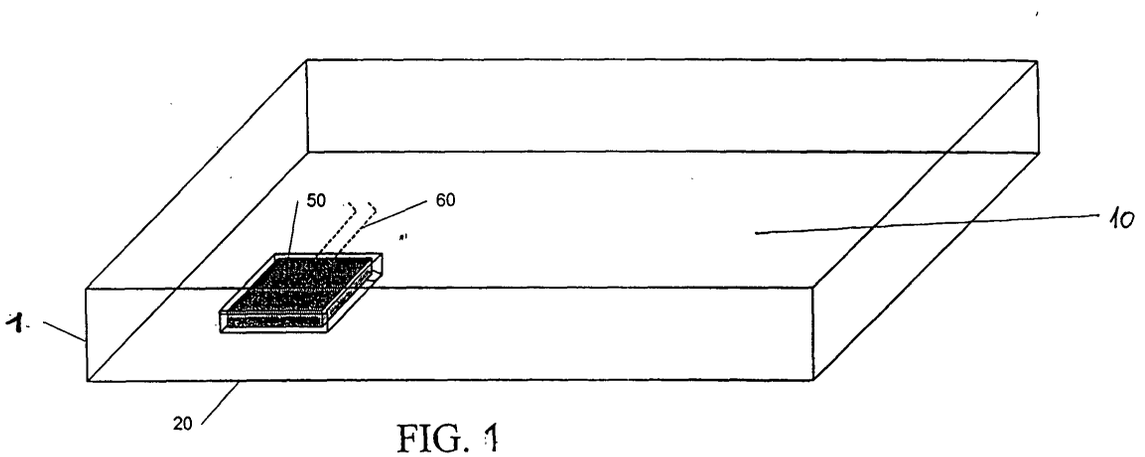

FIG. 1

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Description

[0001] The invention relates to a ceiling tile transmitter and receiver system for transmitting and receiving electromagnetic signals in a defined area of a building space comprising a ceiling tile or panel including a front surface to be faced towards the room, a back surface to be faced towards the plenum, and lateral surfaces and at least one transmitter/receiver device supported by the ceiling tile.

[0002] During recent years in the designing or retrofitting of buildings, there has become an ever more pressing need to increase design flexibility. With the pervasive use of digital electronics, building designs now need to incorporate such infrastructure as digital communications, Internet connections, local area network connections, increased voice communications capability, and the like. Also, more and more appliances, such as security, sound, paging, heating, ventilating and air conditioning (HVAC), lighting, heating and cooling systems are digitally controlled. This technology has placed even more stress on the building design which has to include communications bus systems between the various appliances and some central control system.

[0003] The building management systems that control these appliances have also evolved. Computer control is now fundamental to building management systems. This has lead the way to the measurement and control of the aforementioned appliances. By adding computer control, great savings in energy costs are achieved in terms of turning devices on or off, or adjusting appliances, based upon user needs or even user projected needs. Also, the remote control of systems has enabled the building management function to be done off premises.

[0004] Building management systems contain various appliances for building service functions, a control system for control and regulation of the appliances, and a communication bus for communication of signals between the control system and the appliances. Such a system is used for the central management of building functions, such as lighting, heating, and ventilation etc. The appliances include, for example, lighting, heating equipment, air-conditioning devices or electrically movable window blinds. In office buildings and commercial and industrial complexes, the central management of energy consumption services allows a relatively easy adjustment of the level of light or temperature to the actual existing demand at any moment. This results in considerable savings of energy and costs. Such a system precisely monitors energy consumption and enables accurate billing of the users in a multi-user building. Such a building management system can also be used for peak saving purposes to comply with the requirements of an electric company to keep power consumption below an agreed maximum level.

[0005] Many building management systems have different capability, which leads to having different transmitter/receiver devices in the same ceiling system, or more importantly, a different method to integrate these different transmitter/receiver devices. For instance, one communication system may require one frequency setting whereas another communication system may require an entirely different frequency setting. Also, one communication system may require a certain power or gain, whereas another would be different. Antenna gain is related to antenna size, and therefore if more gain is needed, the size of the antenna is increased.

[0006] Aesthetics have become of primary importance in building ceiling systems. Many ceiling manufacturers offer a wide variety of designs and colors for their suspended ceiling systems.

[0007] Furthermore, many appliances are attached or hung from the ceiling panels or ceiling suspension grids. Today unfortunately, theft and vandalism have become issues, and at times devices such as smoke detectors, fire alarms, lighting fixtures, etc. have been vandalized.

[0008] In the known systems, the local controllers and the appliances are connected to the communication bus by wires. In a modem office building or commercial complex this is a drawback as space layouts are often changed. Changing space layouts almost always requires displacement of the appliances and frequently the tearing down and rebuilding of internal walls. To achieve a flexible floor layout at low cost, a minimum amount of wiring in the walls is required. However, it is also essential that the users of a building have full control over the location of the appliances; consequently, placing appliances only at predetermined locations is unacceptable. In current systems, a hard-wired communication bus is used to connect to the local room wireless transmitter/receiver systems. These wireless transmitter/receiver systems are used to communicate between the bus and the appliances in the room. However, the communication bus system is still a "hardwired" configuration. This leads to a decrease in flexibility, since a room's square footage may change over time, and therefore the transmitter/receiver devices and the hardwired communication bus may also need to be changed or rerouted. Rerouting or changing current transmitter/receiver devices requires modifying ceiling panels (drilling/punching/cutting) and replacing the ceiling tiles that had the transmitter/ receiver device in it.

[0009] Another problem occurs in that transmitter/receiver devices have poor aesthetics when suspended from ceiling panels. After much design and expense have been invested in a ceiling panel system, a rod or dish antenna system is added to the ceiling panel to allow it to communicate to appliances below. There has not been much consideration given in terms of the room aesthetics of a joint system of antennas and ceiling panels.

[0010] Another problem occurring in the industry is vandalism and theft. When devices can be physically seen, they are more prone to be tampered with or removed.

[0011] Still another problem occurs in the design of ceiling tile panels that can be integrated with antennas of different sizes. In the manufacturing and sales of ceiling tiles, processes have to be made flexible to account for all of the different part numbers corresponding to transmitter/receiver devices.

[0012] The prior art of the generic kind according to GB 2 283 642 A discloses a suspended ceiling consisting of runners, the flanges of which support the ceiling tiles. One of these ceiling tiles is modified by having mounted thereabove a base station for a radio telephone system. The base station has an H-field flat antenna printed on a printed circuit board. The antenna is coplanar with the ceiling tile and may be mounted on the upper or lower surface thereof. The underside of this modified ceiling tile matches the remaining ceiling tiles of the suspended ceiling.

[0013] US 4 923 032 discloses a suspended ceiling comprising a grid structure of inverted T-shaped runners supporting ceiling tiles of standard size. One or more of the ceiling tiles can be replaced by a loudspeaker module of the same size. This module consists of a mounting panel corresponding in size and shape to a ceiling tile. In the mounting panel a pair of speakers is installed. For enclosing the rear portions of the speakers and other system components a shallow rear housing is attached to the mounting panel provided with electrical connectors on its rear side, while on the opposite side a demountable grill is attached to the mounting panel to enclose the front faces of the speakers. The demountable grill includes an acoustically transparent covering of cloth or the like which may be colored and/or textured to match the surface of the adjacent ceiling tiles. Between the mounting panel and the supporting flanges of the grid an insulating foam material is located to provide a vibration absorbing interface between the module and the supporting grid. The deformable grill extends beyond the plane of the room facing surfaces of the runners.

[0014] It is the object of the invention to overcome the above-stated problems and to provide a ceiling tile transmitter and receiver system of the generic kind maintaining the shape and aesthetics of the whole tile independent of the size and shape of the transmitter/receiver devices.

[0015] This object is achieved with the system of the generic kind in that the transmitter/receiver device is embedded inside the ceiling tile.

[0016] Preferably the transmitter/receiver device is embedded adjacent to the front surface and a scrim cover is placed over the entire front surface of the ceiling tile.

[0017] The transmitter/receiver device may be encapsulated within the ceiling tile during manufacturing.

[0018] The transmitter/receiver device can also be embedded inside the ceiling tile by an adhesive that attaches a plug of the ceiling tile to the transmitter/receiver device to cover the opening created in the ceiling tile.

[0019] The transmitter/receiver device may be embedded in the front side of the ceiling tile and a "scrim" covering is placed over it. The transmitter/receiver device can also be embedded inside the ceiling tile. The transmitter/receiver device can also be embedded on the front surface of the ceiling tile, where the transmitter adds to, or integrates into, the overall aesthetics of the ceiling tile. Various combinations of these embodiments can be used with a single ceiling tile.

[0020] The ceiling tile transmitter and receiver system described herein can be incorporated into a wireless communication plane providing an umbrella of connectivity for devices. Such devices can span a range from appliances to computer clients (workstations, laptops, hand-held devices, etc.). In a wireless communication system, RF antennas, transceivers and receivers can be embedded in the ceiling tile.

[0021] As described herein, the transmitters/receivers can be embedded in the ceiling tile. The components of the transmitter/receiver system include miniature antennas, single chip transceivers, sensors, power supplies, microprocessors, etc. The transmitter/receiver system in one preferred embodiment employs an omnidirectional multistrip antenna that has a toroidal field pattern and provides omnidirectional coverage in any plane around the long axis of the antenna and two lobes in any plane parallel to the long axis. Such microstrip antenna and also omnidirectional air-loaded patch element antennas are available for different frequencies and application requirements. One exemplary antenna that can be used is the Microsphere omnidirectional microstrip antenna available from Xertex Technologies.

[0022] The invention is better described in the following detailed description of the invention with reference to the accompanying drawing figure.

[0023] Fig.1 illustrates a transmitter/receiver device embedded within a ceiling tile.

[0024] Shown in Fig. 1 is a section from a ceiling tile 1, with back surface (facing towards the plenum) 10 and a front surface (facing towards the room) 20. Throughout this description, the terms "back surface" and "upper surface" are used interchangeably. Likewise "front surface" and "lower surface" are interchangeable.

[0025] The transmitter/receiver device is embedded inside the ceiling tile. As illustrated in Fig. 1, in certain applications, the antenna 50 with extruding leads 60 can be effectively buried within the ceiling tile 1, with back surface 10 and front surface 20. Note that the extruding leads 60 are protruding from the back surface 10. This embodiment fully protects the antenna or device from any outside sources of mechanical damage, and provides the antenna or device with further environmental protection from moisture etc., that the ceiling tile allows.

[0026] The antenna or device can be encapsulated during part of the ceiling tile manufacturing process, if the highest temperature of the ceiling tile manufacturing process is lower than the limit that the antenna can withstand. During normal ceiling tile manufacturing, temper-

atures of 350°C are often reached. The semiconductor process used to form an antenna is usually above the 350°C level, and the thermoset glue used to hold the rest of the antenna structure together can be designed to be higher than the 350°C ceiling tile process limit.

Claims

1. Ceiling tile transmitter and receiver system for transmitting and receiving electromagnetic signals in a defined area of a building space comprising

   - a ceiling tile (1) including a front surface (20) to be faced towards the room, a back surface (10) to be faced towards the plenum, and lateral surfaces and
   - at least one transmitter/receiver device supported by the ceiling tile (1) **characterized in that**
   - the transmitter/receiver device is embedded inside the ceiling tile (1).

2. System according to claim 1, **characterized in that** that transmitter/receiver device is embedded adjacent to the front surface (20) and **in that** a scrim cover is placed over the entire front surface (20) of the ceiling tile (1).

3. System according to claim 1, **characterized in that** the transmitter/receiver device is encapsulated within the ceiling tile (1) during manufacturing.

4. System according to claim 1, **characterized in that** the transmitter/receiver device is embedded inside the ceiling tile (1) by an adhesive that attaches a plug of the ceiling tile (1) to the transmitter/receiver device to cover the opening created in the ceiling tile (1).

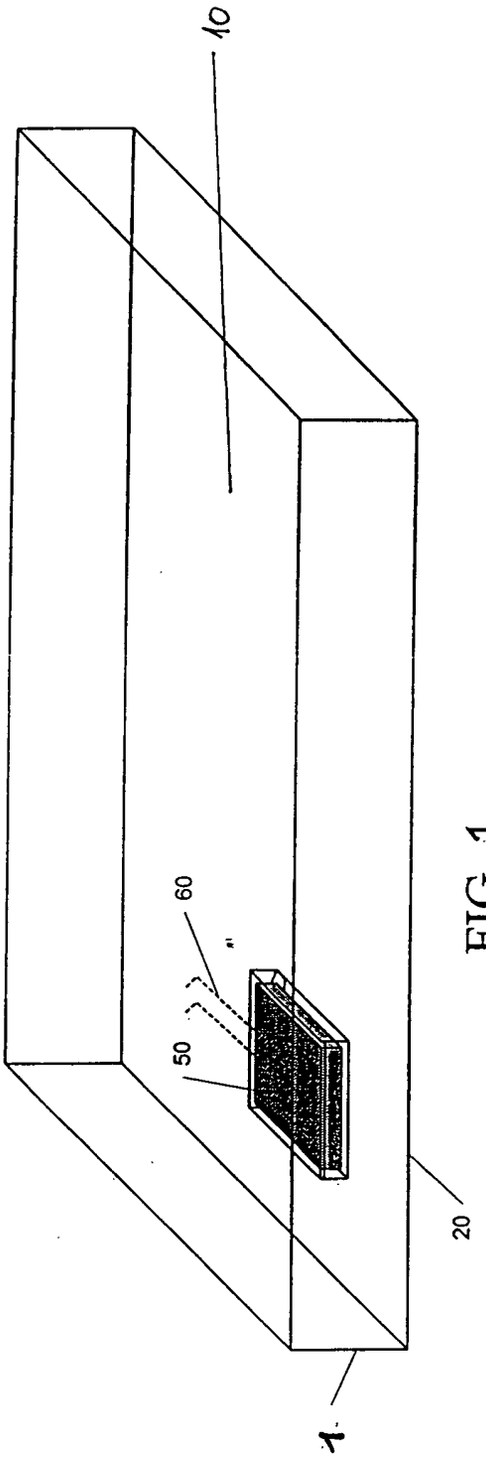

FIG. 1