Title: SINGLE SPACE WIRELESS PARKING WITH IMPROVED ANTENNA PLACEMENTS

Abstract: A wireless parking meter with an improved antenna location is described. The antenna may be located within a covering protruding from the top of the parking meter, allowing radio frequency (RF) signals to be transmitted through a portion of the parking meter with high permittivity to the RF signals. Alternatively, the antenna may be located within the parking meter housing above a lower parking meter mechanism housing so that RF signals can be transmitted through the dome covering of the parking meter, which may have a high permittivity to the RF signals.

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SINGLE SPACE WIRELESS PARKING WITH IMPROVED ANTENNA PLACEMENTS

FIELD OF THE INVENTION

[0001] The invention relates generally to parking meters, and in particular to single space wireless parking meters

BACKGROUND

[0002] Often, major cities deploy thousands of single-space parking meters throughout their jurisdiction. The management of such a deployment is labor intensive. Costs of overhead can be larger than necessary due to the normal inefficiencies in managing large distributed systems.

[0003] Wireless parking meters have been devised that enable the parking meter to communicate with enforcement officers to make parking enforcement more efficient, as well as to allow for payment using credit cards. The wireless parking meters may use a protocol such as ZigBee or SSIPCO for the wireless communication. The wireless systems may have disadvantages when used in single space parking meters, which may include, for example, shorter operating times due to increased power consumption, and communication latency due to the communication protocol used.

[0004] The wireless single space parking meters may include an antenna for transmitting radio frequency (RF) signals used for the wireless communication. However, the placement of the antenna has not provided efficient transmission of the RF signals, resulting in higher power consumption, lower communication range, or both.

SUMMARY

[0005] In one embodiment the current disclosure provides a parking meter comprising a mechanism housing comprising an upper mechanism housing enclosing a display module for displaying parking meter related information including an amount of parking meter time purchased; and a lower mechanism housing enclosing parking meter mechanism components for operating the parking meter. The parking meter further comprises a radio communication module coupled to at least one of the parking meter mechanism components for wirelessly communicating parking meter information and a parking meter housing enclosing at least the mechanism housing, the parking meter housing comprising: an upper housing enclosing the upper mechanism housing, the upper housing comprising an opening in the upper housing for
viewing at least a portion of the display module; and a lower housing enclosing the lower mechanism housing. The parking meter further comprises an antenna coupled to the radio communication module located above the mechanism housing to transmit and receive radio frequency (RF) signals through at least a portion of the parking meter that has a high emissivity to RF signals (the transmission path).

[0006] In another embodiment the current disclosure provides a parking meter comprising a mechanism housing comprising an upper mechanism housing enclosing a display module for displaying parking meter related information including an amount of parking meter time purchased; and a lower mechanism housing enclosing parking meter mechanism components for operating the parking meter. The parking meter further comprises a radio communication module coupled to at least one of the parking meter mechanism components for wirelessly communicating parking meter information and a parking meter housing enclosing at least the mechanism housing, the parking meter housing comprising: an upper housing enclosing the upper mechanism housing, the upper housing comprising an opening in the upper housing for viewing at least a portion of the display module; and a lower housing enclosing the lower mechanism housing. The parking meter further comprises an antenna coupled to the radio communication module located above the mechanism housing to transmit and receive radio frequency (RF) signals, the antenna having a shape selected from the group consisting of a 'T' shape; an 'F' shape; and an 'L' shape.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Embodiments of the novel technology are described herein, with reference to the drawings in which,

Figure 1A depicts a schematic of a typical single space parking meter;

Figure 1B depicts an exploded view of the single space parking meter of Figure 1A;

Figure 2A depicts a schematic of an embodiment of a single space parking meter with an improved antenna placement;

Figure 2B depicts an exploded view of the single space parking meter of Figure 2A;

Figures 3A - 3D depict various views of an illustrative upper housing of an illustrative parking meter;
Figure 4A - 4C depict various views of an illustrative dome covering of an illustrative parking meter;

Figure 5A - 5C depict schematics of various embodiments of an illustrative parking meter with improved antenna placement; and

Figures 6A - 6D depict schematics of illustrative antenna configurations;

Figures 7A - 7E depict results of radiation pattern simulations of a monopole antenna;

Figures 8A - 8E depict results of radiation pattern simulations of a T antenna;

Figures 9A - 9E depict results of radiation pattern simulations of an L antenna;

Figures 10A - 10E depict results of radiation pattern simulations of an F antenna;

Figure 11A - 11C depict schematics of an alternative antenna arrangement of an illustrative parking meter with improved antenna placement.

DETAILED DESCRIPTION

[0008] A wireless parking meter is described herein that provides for better placement of an antenna. The location of the antenna described herein allows the antenna to transmit and receive radio frequency (RF) signals through a portion of the parking meter that has a high permittivity to the RF signals. Advantageously, the location of the antenna described herein allows for a more power efficient wireless parking meter, a larger communication range, or both. Furthermore, current parking meters may be modified to make use of the improved antenna locations described herein, reducing the cost of implementing wireless parking meters.

[0009] Figures 1A and 1B depict a typical single space parking meter 100. A single space parking meter 100 typically comprises an outer housing 102, or simply a housing, comprising multiple components. The housing 102 typically comprises a two-part upper housing comprising of a removable upper housing cap 104 that is typically locked or otherwise secured to a meter housing 110 which in turn is attached to a lower vault housing 112. The upper housing cap 104 generally has a semi elliptical shape with an opening in the upper housing cap for viewing a display of the parking meter 100. It will be appreciated that the shape of the upper housing cap may be of other shapes. The upper housing cap 104 may include an opening on both sides in
order to allow viewing of the display from either side of the parking meter 100. The opening in the upper housing cap is sealed by a dome situated within the housing. The dome is typically made from a high strength transparent material, such as Lexan. The meter housing 110 may include space for holding a coin vault, or alternatively may have a further lower vault housing 112 that can be secured to the meter housing 110 to hold the coin vault. The outer housing 102 provides physical protection for the components of the parking meter. The outer housing 102 also protects the components of the parking meter from the exterior environment. The outer housing 102 is typically made from a high strength metal that provides sufficient protection against intentional vandalism.

[0010] The outer housing 102 encloses a parking meter mechanism housing and various parking meter mechanism components. The parking meter mechanism housing and parking meter mechanism components may be referred to collectively as the parking meter mechanism 105. The parking meter mechanism 105 provides for the various functionality of the wireless parking meter 100. For example, the mechanism components may include a coin chute 114 for detecting coins inserted into the parking meter 100, a card reader 116 for detecting magnetic stripe, or smart-chip cards inserted into the parking meter 100, a main processing board (not shown) including a processor and memory storing instructions that, when executed by the processor, control the operation of the parking meter 100 as well as a display 118, or display module, for displaying parking meter information, such as an amount of parking time purchased, parking meter error messages, expired time, etc.

[0011] The parking meter mechanism housing generally comprises two sections, an upper mechanism housing 106 that houses the display 118 and a lower mechanism housing 108 that houses the parking meter mechanism components. It will be appreciated that while the display 118 is a component of the parking meter, it is not referred to herein as a mechanism component as it is housed above the mechanism components, such as the coin chute 114, card reader 116 and main processing board. Furthermore, while the upper mechanism housing 106 is located above the lower mechanism housing 108 it will be appreciated that this refers to the assembled mechanism 105. That is, the mechanism housing may be assembled from a back frame that includes a portion of the upper mechanism housing and the lower mechanism housing. The mechanism components and the display 118 may be attached to the back frame. A front frame may be secured over the mechanism components to provide the lower mechanism housing 108 of the assembled mechanism housing.
[0012] The parking meter outer housing 102, and the parking meter mechanism housing, present a problem when transmitting and receiving RF signals. The materials of the parking meter outer housing 102 and the mechanism housing are opaque to RF signals, or at least attenuate the transmitted RF signals. As a result the RF signals need to be transmitted with a higher power, consuming more power from a battery powering the parking meter 100. Alternatively, the same power may be used to transmit the RF signal; however, this will result in a reduced communication range and possibly require additional infrastructure to provide the wireless communication with the parking meter 100.

[0013] In order to increase the transmission efficiency of the RF signals from the parking meter 100, improved locations for the placement of the antenna are described herein. The improved wireless parking meter provides an antenna within the parking meter housing that locates the antenna such that the antenna can transmit and receive RF signals through a portion of the parking meter housing that has a high permittivity to RF signals. To further increase the transmission efficiency, improved shapes of antennas are described.

[0014] Figures 2A and 2B depict an illustrative embodiment of an antenna placement for a wireless parking meter 200. Figures 2A and 2B do not depict the lower vault housing or the meter housing of the wireless parking meter. The wireless parking meter 200 includes a fin cover 216 that protrudes through a second opening in the upper housing cap 202. The fin cover 216 encloses the antenna 210. The fin cover 216 is constructed from a material with a high permittivity to RF signals. The protruding fin cover 216 allows the antenna 210 to be located above the upper housing cap 202. As depicted in Figure 2B the fin cover 216 may house the antenna 210 which is located on a radio board 206. The radio board 206 may include a radio control module 208 for controlling the transmission, and reception, of the RF signals. The radio control module 208 may be coupled to a parking meter mechanism component housed in the lower mechanism housing 108, such as the main control board, via an appropriate cable 212 with an appropriate connector 214. It will be appreciated that while the radio control module 208 is depicted as being located on the radio board 206, it may be located within the parking meter mechanism housing, or other convenient locations. If the radio control module 208 is not located on the radio board, the cable 212 and connector 214 may be used to connect the antenna to the radio control module 208. Additionally, it will be appreciated that, while the radio control module 208 has been described as being a separate component, it may be included as a component of the main control board or other parking meter mechanism components.
[0015] As described above, the fin cover 216 protrudes upwardly through a second opening in the upper housing cap 202. The second opening, or fin opening, is sized to allow a portion of the fin cover 216 to pass through. However a base portion 217 of the fin cover is enlarged so that it does not pass through the fin opening of the upper housing cap 202. This base portion 217 of the fin cover may also seal the fin opening in the upper housing. It will be appreciated that other means of securing the fin cover 216 to the upper housing cap 202 are possible, and will be apparent to those skilled in the art.

[0016] The fin cover 216 allows the antenna 210 to be located above the upper housing cap 202 of the parking meter 200. The fin cover 216 is constructed from a material with a higher permittivity to RF signals than the housings of the parking meter. As such, the fin cover 216 provides an improved antenna placement in which the antenna 210 can transmit and receive RF signals through a portion of the parking meter 200 that has a high permittivity to RF signals.

[0017] Figures 3A - 3D depict various views of an illustrative embodiment of an upper housing for a parking meter 200. The upper housing cap 202 may be modified from an upper housing cap as used in previous parking meter housings. The upper housing cap 202 includes first openings 306, which may be referred to as dome openings. The dome openings 306 provide an opening through which the parking meter display may be viewed. If the display of the parking meter 200 is a dual sided display, dome openings 306 may be provided on each side of the upper housing cap 202. The upper housing cap 202 includes a central portion 308 located between the two dome openings; or alternatively located about a center of the upper housing cap 202 if only a single dome opening 306 is provided. The central portion 308 of the parking meter housing cap generally has a semi elliptical, or an actuate, shape. A second opening, or fin opening 310, is provided in the upper housing cap 202. As depicted in the Figures, the fin opening 310 is located centrally in the central portion 308 of the upper housing cap 202. It will be appreciated that the fin opening 310 is located centrally within the central portion 308 of the upper housing cap 202 for aesthetic reasons, and for the simplicity of forming the opening within the central portion 308. The fin opening 310 may be located at any suitable location of the upper housing cap 202 that allows the fin cover 216, and so the antenna housed within, to protrude away from the upper housing cap 202. Additionally, although the fin opening 310 has been described as being positioned within the upper housing cap 202, it is possible to locate the fin opening 310, and the fin cover 216, within any portion of the parking meter outer housing, for example within the meter housing. It will be appreciated that positioning the fin opening 310 within the upper housing cap 202 has the advantage of being relatively easy to replace if
required. If the fin opening 310 is located within the meter housing, the upper housing cap 202 would be required to be removed, as well as possibly the parking meter mechanism housing in order to replace or service the fin cover 216 located within the fin opening 310. Removing the parking meter mechanism housing may require further disassembly of the parking meter 200 than would be required if simply placing the fin opening 310 in the upper housing cap 202.

[0018] Figures 4A - 4C depict various views of an illustrative dome cover 404. The dome cover 404 may be used with the upper housing cap 202 of Figures 3A - 3D. The dome cover 404 includes a radio board opening 406 that is located to correspond with the fin opening 310 of the upper housing cap 202 of Figures 3A - 3D. The radio board opening 406 of the dome cover 404 allows the radio board 206 to be situated above the dome cover 404 while having a portion of the radio board 206 pass through the dome cover 404. The radio board opening 406 may register the radio board 206 within the parking meter housing in order to securely position the radio board 206 within the fin cover. The size of the radio board opening 406 may vary. The radio board opening 406 may be sized to accommodate the radio control module 208 located on the radio board 206. Alternatively, the radio board opening 406 may be sized to accommodate only the board portion of the radio board 206, while the radio control module 208, if present, is situated above or below the dome cover 404. Alternatively, the dome cover 404 may not have a radio board opening 406 at all, and the radio board 206 may be wholly located above the dome cover 404.

[0019] If the dome cover 404 includes a radio board opening 406, it may be used to route the connection cable 212 from the radio board 206 to the appropriate location of the parking meter mechanism. If the radio board opening 406 is not present, the cable 212 may be routed along the dome cover 404 to a position where the dome cover 404 meets the parking meter housing and then routed to the appropriate connection location on the parking meter mechanism.

[0020] Figures 5A - 5C depict various arrangements of the radio board 206 and fin cover 216 within the upper housing cap 202 and dome cover 404. Figure 5A depicts a dome cover 404 that does not include a radio board opening. The radio board 206, which may include a radio control module 208, is wholly located above the dome cover 404. The fin cover 216 is located between the dome cover 404 and the upper housing cap 202. A main portion of the fin cover 216 protrudes through the fin opening in the upper housing cap 202. A base portion of the fin cover 216 extends past the fin opening in the upper housing cap 202 and captures the fin cover 216 between the dome cover 404 and the upper housing cap 202, helping to ensure that the fin
cover 216 is not easily removed through the fin opening of the upper housing cap 202.

[0021] Figure 5B depicts an alternative embodiment of the arrangement of the radio board 206 and fin cover 216 within the upper housing cap 202 and dome cover 404. The dome cover 404 of Figure 5B includes a radio board opening 502 that is sized to allow the radio board 206 to pass through but not a radio control module 208, if present. The fin cover 216 is located between the dome cover 404 and the upper housing cap 202 in a similar manner as in the embodiment of Figure 5A. If the radio control module 208 is present on the radio board 206, it may be located above or below the dome cover 404. If it is located above the dome cover 404, a bottom surface of the radio control module 208 may rest on an upper surface of the dome cover 404, and position the radio board 206 within the fin cover 216. If the radio control module 208 is positioned below the dome cover 404, it may be held between the upper mechanism housing (not shown) and the dome cover 404.

[0022] Figure 5C depicts a further alternative embodiment of the arrangement of the radio board 206 and fin cover 216 within the upper housing cap 202 and dome cover 404. The radio board opening 502 in the dome cover 404 is expanded to allow the main portion of the fin cover 216 to pass through. The base portion of the fin cover 216 is captured by the dome cover 404, preventing the fin cover 216 from passing through the radio board opening 502. The fin cover 216 and the radio board 206, is held in position between the upper mechanism housing and the dome cover 404.

[0023] The radio board 206 may be further held in position within the fin cover 216, of any of the described embodiments, by a radio board clip or other suitable means. Although not required to locate the radio board 206 within the fin cover 216, the radio board clip may hold the radio board 206 within the fin cover 216, which may facilitate assembly or disassembly of the parking meter.

[0024] As is apparent from the above description of various embodiments, the antenna 210, and possibly the radio control module 208, is housed at the top of the parking meter within the fin cover 216. The fin cover 216 provides the required physical strength to prevent, or reduce, the likelihood that the antenna 210 can be broken off from the parking meter.

[0025] The fin cover 216 is constructed from a material with a high permittivity to RF signals and in particular to the RF signals used by the radio control module 208 of the parking meter. The fin cover 216 may be made from a plastic or similar material. The following table provides a listing of possible suitable materials for the fin cover 216, as well as their RF characteristics.
The fin cover 216 may house the radio control module 208 and the antenna 210. The antenna 210 may be formed on the radio board 206. Although the arrangement of the antenna 210 within the parking meter 200 as described above allows RF signals to be transmitted, and received, through a portion of the parking meter 200 with a high permittivity to RF signals and so provides a more efficient wireless parking meter 200, further efficiency may be gained by the type, or shape, of antenna 210 used.

Figures 6A - 6D depict various shapes of antennas 210A-D that can be used within wireless parking meters. The antennas 210A-D may be formed on the radio board by a metal trace or other techniques known to one skilled in the art. Figures 6A - 6D also depict the characteristics of connection to the antennas 210A-D that may provide improved impedance matching between the antenna and the RF signal source. It will be appreciated that the

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Table 1: Table showing RF properties of various materials
characteristics of the connection, including components connected to the antenna and their values may vary depending upon the specific characteristics of the antenna used. One skilled in the art will appreciate that the values of components may be readily determined through experimentation, simulation, or through theoretical calculations.

[0028] Figure 6A depicts a monopole antenna 210A. The monopole antenna 210A is coupled to the source through an inductor with a value of 29 nH. A 7.5 pF capacitor is connected in parallel with the source. Figure 6B depicts a T antenna 210B. A base of the T is coupled to the RF source through a 10.5 nH inductor. A 6.0 pF capacitor is connected in parallel with the source. Figure 6C depicts an L antenna 210C. A short leg of the antenna 210C is connected to the source with a 4.7 pF capacitor connected in parallel. Figure 6D depicts an F antenna 210D. A short arm of the F is coupled to the source. No additional capacitors or inductors are required for impedance matching in the arrangement of Figure 6D. Various specific antenna arrangements have been described with reference to Figures 6A - 6D. It will be appreciated that these antenna shapes are merely illustrative, and other antennas may be used in a wireless parking meter in accordance with the present disclosure.

[0029] Figures 7A - 7E depict characteristics of the monopole antenna 210A of Figure 6A. The characteristics were determined through a simulation of the antenna located above the upper housing of a parking meter housing. Figure 7A depicts the impedance matching characteristics of the monopole antenna 210A. Figures 7B - 7E depict the transmission characteristics of the simulated monopole antenna 210A along different planes.

[0030] Figures 8A - 8E depict characteristics of the T antenna 210B of Figure 6B. The characteristics were determined through a simulation of the antenna located above the upper housing of a parking meter housing. Figure 8A depicts the impedance matching characteristics of the T antenna 210B. Figures 8B - 8E depict the transmission characteristics of the simulated antenna along different planes.

[0031] Figures 9A - 9E depict characteristics of the L antenna 210C of Figure 6C. The characteristics were determined through a simulation of the antenna located above the upper housing of a parking meter housing. Figure 9A depicts the impedance matching characteristics of the L antenna 210C. Figures 9B - 9E depict the transmission characteristics of the simulated antenna along different planes.

[0032] Figures 10A - 10E depict characteristics of the F antenna 210D of Figure 6D. The
characteristics were determined through a simulation of the antenna located above the upper housing of a parking meter housing. Figure 10A depicts the impedance matching characteristics of the F antenna 210D. Figures 10B - 10E depict the transmission characteristics of the simulated antenna along different planes.

[0033] An improved location for an antenna of a wireless parking meter has been described above. The antenna is located above the upper housing of the parking meter housing within a fin cover that is constructed from a material with high permittivity to the RF signals used by the wireless parking meter. Although the fin cover provides for the desirable placement of the antenna above the upper housing of the parking meter, the antenna may be located in other positions. For example, as described above, the fin cover may be located on a portion of the parking meter housing. Furthermore, as described below, the antenna may also be located within the housing of the parking meter.

[0034] Figure 11A - 11C depict various views of an alternative embodiment of a wireless parking meter 1100. As seen in Figure 11C, an antenna 1102 can be located within the housing 1104, above the lower mechanism housing 1106. The antenna 1102 is positioned within the opening of the upper housing 1108. A dome cover, such as dome cover 404, provides a transmission path, which has a high permittivity to RF signals. The upper housing 1108 may include a radio board holder 1110 for securing the radio board 1112, which may include the radio control module. The antenna 1102 may be positioned in front of the display as depicted, or may be located to one side of the display.

[0035] Unlike the antennas described above with reference to Figures 6A-D, which are formed on the radio board, the antenna 1102 is made from a self supporting wire that allows the antenna 1102 to be positioned vertically within the dome opening in the upper housing 1108, above the lower mechanism housing 1106. The self supported wire allows the antenna 1102 to be positioned in front of the display without blocking, or interfering with, the visibility of the display. The self supported antenna 1102 may be formed into various shapes. A T antenna is depicted in Figure 11C.

[0036] Although the fin cover locates the antenna above the upper housing, it may require that the upper housing be modified to include a fin cover opening to allow the fin cover to protrude from the upper housing. While the self supported antenna may be positioned within the housing, and so avoid modification of the upper housing, it may not have as advantageous transmission
characteristics as the fin cover placement. The display and the upper mechanical housing may provide a transmission path on one side of the antenna with low permittivity to the RF signals. Although one side of the antenna may be blocked by the relatively low permittivity of the display and upper mechanism housing, the transmission path from the other side of the antenna will advantageously pass through the opening in the upper housing through the dome cover. The dome cover is made from a transparent material with high permittivity to the RF signals.

[0037] As described herein, locating the antenna of the wireless parking meter so that the RF signals will have a transmission path that passes at least partly through a portion of the parking meter with high permittivity to RF signals, allows for more efficient transmission of RF signals. The more efficient transmission of RF signals from the wireless parking meter may provide either a more power efficient wireless parking meter, a wireless parking meter with extended communication range, or both.

[0038] Furthermore, the transmission efficiency can also be improved by improving the shape of the antenna. As described herein, a T' shaped antenna has superior transmission characteristics than previous antennas used in wireless parking meters. Although, the T' shape provides the best transmission characteristics according to the simulations and calculations performed, the 'L' shaped and 'F' shaped antennas also provided superior transmission characteristics for use in a wireless parking meter over a typical monopole antenna.

[0039] The embodiments described above are intended to be illustrative only. The scope of the invention is therefore intended to be limited solely by the scope of the appended claims.
WHAT IS CLAIMED IS:

1. A parking meter comprising:
   a mechanism housing comprising:
   an upper mechanism housing enclosing a display module for displaying parking
   meter related information including an amount of parking meter time purchased;
   and
   a lower mechanism housing enclosing parking meter mechanism components for
   operating the parking meter;
   a radio communication module coupled to at least one of the parking meter mechanism
   components for wirelessly communicating parking meter information;
   a parking meter housing enclosing at least the mechanism housing, the parking meter
   housing comprising:
   an upper housing enclosing the upper mechanism housing, the upper housing
   comprising an opening in the upper housing for viewing at least a portion of the
   display module; and
   a lower housing enclosing the lower mechanism housing; and
   an antenna coupled to the radio communication module located above the mechanism
   housing to transmit and receive radio frequency (RF) signals through at least a
   portion of the parking meter that has a high emissivity to RF signals (the
   transmission path).

2. The parking meter as claimed in claim 1, further comprising:
   a dome located within the upper housing sealing the opening of the upper housing, the
   dome constructed from a material with a high emissivity to the RF signals of the
   antenna to provide the transmission path of the antenna.

3. The parking meter as claimed in claim 2, wherein:
   the antenna is located adjacent the dome and extends from proximate a top surface of
   the lower mechanism housing upwards towards a top of the opening in the upper
   housing.

4. The parking meter as claimed in claim 2, wherein:
   the antenna comprises a self supporting wire and is connected to the radio
   communication module; and
the radio communication module is coupled to the at least one parking meter mechanism components through an electrical cable.

5. The parking meter as claimed in claim 2, wherein the dome is constructed from a material selected from the group consisting of:
   LEXAN;
   CYCOLOY;
   GELOY;
   XENOY;
   XYLEX;
   NORYL;
   ULTEM; and
   VALOX.

6. The parking meter as claimed in claim 1, wherein:
   the upper housing further comprises a second opening, the second opening located above the upper mechanism housing;
   the antenna is located within the second opening and extends outward from an interior side of the upper housing past the upper housing; and
   the parking meter further comprising:
      a fin cover located within the second opening of the upper housing, extending outward and enclosing the antenna, the fin cover constructed from a material with a high emissivity to the RF signals of the antenna to provide the transmission path of the antenna.

7. The parking meter as claimed in claim 6, wherein:
   the antenna is connected to the radio communication module; and
   the radio communication module is coupled to the at least one parking meter mechanism components through an electrical cable.

8. The parking meter as claimed in claim 7, further comprising:
   a dome located within the upper housing sealing the opening in the upper housing, the dome comprising an opening coincident with the second opening of the upper housing,
   wherein the fin cover passes through the opening in the dome, locating a base portion of
   the fin cover between a top surface of the upper mechanism housing and the dome.

9. The parking meter as claimed in claim 7, further comprising:
a dome located within the upper housing sealing the opening in the upper housing, wherein a base portion of the fin cover is located between a top surface of the dome and the upper housing.

10. The parking meter as claimed in claim 7, further comprising:
a dome located within the upper housing sealing the opening in the upper housing, the dome comprising an opening coincident with the second opening of the upper housing, wherein the antenna passes through the opening in the dome, and a base portion of the fin cover is located between a top surface of the dome and the upper housing.

11. The parking meter as claimed in claim 6, wherein the fin cover is constructed from a material selected from the group consisting of:
LEXAN;
CYCOLOY;
GELOY;
XENOY;
XYLEX;
NORYL;
ULTEM; and
VALOX.

12. The parking meter as claimed in claim 7, wherein the radio communication module is located on a radio board and the antenna comprises a trace of a configuration of the antenna on the radio board.

13. The parking meter as claimed in claim 12, wherein the configuration of the antenna is a monopole antenna.

14. The parking meter as claimed in claim 13, wherein a RF source and a capacitor connected in parallel with the RF source are coupled to the monopole antenna through an inductor.

15. A parking meter comprising:
a mechanism housing comprising:
an upper mechanism housing enclosing a display module for displaying parking meter related information including an amount of parking meter time purchased; and
a lower mechanism housing enclosing parking meter mechanism components for operating the parking meter;
a radio communication module coupled to at least one of the parking meter mechanism components for wirelessly communicating parking meter information;
a parking meter housing enclosing at least the mechanism housing, the parking meter housing comprising:
an upper housing enclosing the upper mechanism housing, the upper housing comprising an opening in the upper housing for viewing at least a portion of the display module; and
a lower housing enclosing the lower mechanism housing; and
an antenna coupled to the radio communication module located above the mechanism housing to transmit and receive radio frequency (RF) signals, the antenna having a shape selected from the group consisting of:
a T shape;
an 'F' shape; and
an 'L' shape.

16. The parking meter as claimed in claim 15, wherein the antenna is T' shaped and wherein a RF source and a capacitor connected in parallel with the RF source are coupled to a base of the T antenna through an inductor.

17. The parking meter as claimed in claim 15, wherein the antenna is 'F' shaped and wherein a RF source is coupled to an arm of the F antenna.

18. The parking meter as claimed in claim 15, wherein the antenna is 'L' shaped and wherein a RF source and a capacitor connected in parallel with the RF source are coupled to a leg of the L antenna.

19. The parking meter as claimed in claim 15, wherein the antenna is formed as a metal trace on a radio board.
Figure 7A

Azimuthal (x-y) plane, Theta component:

Frequency = 915 MHz
Main lobe magnitude = -6.1 dB
Main lobe direction = 100.0 deg.
Angular width [3 dB] = 59.3 deg.
Side lobe level = -4.5 dB

Figure 7B
Azimuthal (x-y) plane, Phi component:

*Figure 7C*

Elevation (x-z) plane, Theta component:

*Figure 7D*
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Elevation (x-z) plane, Phi component (non-existent):

Figure 7E

Frequency = 916
Main lobe magnitude = 42.1 dB
Main lobe direction = 196.0 deg.
Angular width (3 dB) = 81.0 deg.

Figure 8A
Azimuthal (x-y) plane, Theta (vertical) component:

Farfield \( t_{930,0000} \) [1] Realized Gain, Theta(\( \Phi \)): Theta= 90.0 deg.

Frequency = 930 MHz
Main lobe magnitude = -2.3 dB
Main lobe direction = 180.0 deg.
Angular width (3 dB) = 76.2 deg.
Side lobe level = -3.9 dB

Figure 8B

Azimuthal (x-y) plane, Phi (horizontal) component (note scale change):

Farfield \( t_{930,0000} \) [1] Realized Gain, Phi(\( \Phi \)): Theta= 90.0 deg.

Frequency = 930 MHz
Main lobe magnitude = -20.5 dB
Main lobe direction = 220.0 deg.
Angular width (3 dB) = 45.7 deg.

Figure 8C
Elevation (x-z) plane, Theta component (note scale change):

Frequency = 930
Main lobe magnitude = 4.8 dB
Main lobe direction = 135.0 deg.
Angular width (3 dB) = 46.0 deg.
Side lobe level = -6.8 dB

Figure 8D

Elevation (x-z) plane, Phi component (non-existent):

Frequency = 930
Main lobe magnitude = -60.8 dB
Main lobe direction = 50.0 deg.
Angular width (3 dB) = 163.2 deg.

Figure 8E
Figure 9A

Azimuthal (x-y) plane, Theta (vertical) component:

Farfield `{\phi|_{915.0000}} \{\Psi}\) Realized Gain, \(\text{Theta}(\Phi)\) Theta= 90.0 deg.

Figure 9B

Frequency = 915
Main lobe magnitude = -2.2 dB
Main lobe direction = 205.0 deg.
Angular width (3 dB) = 207.0 deg.
Azimuthal (x-y) plane, Phi (horizontal) component:

Farfield 'ff_915.0000 [1]' Realized Gain Phi(Phi); Theta= 90.0 deg.

Frequency = 915 MHz
Main lobe magnitude = 9.4 dB
Main lobe direction = 160.0 deg.
Angular width (3 dB) = 73.2 deg.

Figure 9C

Elevation (x-z) plane, Theta component (note scale change):

Farfield 'ff_915.0000 [1]' Realized Gain Theta(Theta)

Frequency = 915 MHz
Main lobe magnitude = 3.8 dB
Main lobe direction = 135.0 deg.
Angular width (3 dB) = 46.0 deg.
Side lobe level = -6.0 dB

Figure 9D
Elevation (x-z) plane, Phi component:

Frequency = 915 MHz
Main lobe magnitude = -4.2 dB
Main lobe direction = 40.0 deg.
Angular width (3 dB) = 151.0 deg.

Figure 9E

Figure 10A
Azimuthal (x-y) plane, Theta (vertical) component:

Farfield W_915.0000 [1] Realized Gain_Theta(Phi); Theta= 90.0 deg.

Frequency = 915
Main lobe magnitude = -2.2 dB
Main lobe direction = 200.0 deg.
Angular width (3 dB) = 214.0 deg.

Figure 10B

Azimuthal (x-y) plane, Phi (horizontal) component:

Farfield W_915.0000 [1] Realized Gain_Phi(Phi); Theta= 90.0 deg.

Frequency = 915
Main lobe magnitude = -10.3 dB
Main lobe direction = 160.0 deg.
Angular width (3 dB) = 69.9 deg.

Figure 10C
Elevation (x-z) plane, Theta component (note scale change):

Frequency = 915 MHz
Main lobe magnitude = 4.2 dB
Main lobe direction = 135.0 deg.
Angular width (3 dB) = 46.3 deg.
Side lobe level = -6.7 dB

Figure 10D

Elevation (x-z) plane, Phi component:

Frequency = 915 MHz
Main lobe magnitude = -5.1 dB
Main lobe direction = 35.0 deg.
Angular width (3 dB) = 148.5 deg.

Figure 10E
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC: **G07C 1/30** (2006.01), **G07F 1/24** (2006.01), **H01Q 1/38** (2006.01), **H01Q 1/42** (2006.01), **H01Q 9/04** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**G07C 2006.01**, **G07F** (2006.01), **H01Q** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)

WEST, Epoque, and Canadian Patent Database

keywords used: parking, meter, antenna, above, top, head, emissivity, housing, wireless, T-shaped, F-shaped, L-shaped

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>CA 2 414 132 A1 (Chauvin et al.) 14 June 2003 (14-06-2003) see the abstract, page 2, line 23, page 5, lines 2-6, and Figure 1</td>
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<td>US 2004/0264302 A1 (Ward, II) 30 December 2004 (30-12-2004) see page 1, paragraph [0010], page 2, paragraph [0025], page 3, paragraphs [0035]-[0035], and Figures 1, 3 and 4</td>
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<td>EP 1 376 491 A1 (Smulders) 2 January 2004 (02-01-2004) see whole document</td>
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<td>WO 97/12345 (Jacobs) 3 April 1997 (03-04-1997) see whole document</td>
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[X] See patent family annex.

Date of the actual completion of the international search

12 February 2010 (12-02-2010)

Date of mailing of the international search report

17 February 2010 (17-02-2010)

Name and mailing address of the ISA/CA

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<td>28-02-1995</td>
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<td>03-10-1995</td>
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<td>24-06-1997</td>
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<td>09-02-1995</td>
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