[0003] Radio frequency identification (RFID) systems, however, have used RF energy that is emitted from a reader device to power tags. The tags may affect the emitted signal to invoke a change in the emitted signal that is detectable by the reader device or the tags may transmit an RF signal that is detectable by the reader device. In the former case, the reader may be able to determine that a tag is within an operable range of the reader device. In the later case, the reader may be able to extract a code that uniquely identifies the tag from the signal output by the tag. The range of RFID systems is severely limited. Also, the capabilities of the tags are limited due to the small amount of useable energy that may be derived from the RF signal emitted by the reader device.

SUMMARY OF INVENTION

[0003a] An aspect of the present invention provides an object identification system, comprising:

a guided surface waveguide probe comprising a charge terminal elevated over a terrestrial medium that produces an electromagnetic guided surface wave along a surface of a lossy conducting medium by generating at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence of the lossy conducting medium, from which object identification tags obtain electrical power to operate, each tag associated with an object; and

a plurality of receivers deployed at strategic locations to receive return signals from one or more of the tags as the tags move with the associated objects during a lifecycle of the objects.

[0003b] Another aspect of the present invention provides a method of tracking an object, comprising:

producing an electromagnetic guided surface wave along a surface of a lossy conducting medium with a guided surface waveguide probe comprising a charge terminal elevated over a terrestrial medium by generating at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence) of the lossy conducting medium, the electromagnetic guided surface wave having sufficient energy density to power object identification tags across an area of interest;

receiving return signals from a tag of interest at plural receivers, the tag of interest associated with an object and the receivers that receive the return signals change over time as the tag moves with the associated object in the area of interest; and

identifying a series of geolocations at which the object was present as a function of time according to the received reply signals from the tag.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Aspects of the present disclosure are better understood with reference to the following drawings. The drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the disclosure. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

[0005] FIG. 1 is a chart that depicts field strength as a function of distance for a guided electromagnetic field and a radiated electromagnetic field.

[0006] FIG. 2 is a drawing that illustrates a propagation interface with two regions employed for transmission of a guided surface wave according to various embodiments of the present disclosure.

[0007] FIG. 3 is a drawing that illustrates a guided surface waveguide probe disposed with respect to a propagation interface of FIG. 2 according to various embodiments of the present disclosure.

[0008] FIG. 4 is a plot of an example of the magnitudes of close-in and far-out asymptotes of first order Hankel functions according to various embodiments of the present disclosure.

CLAIMS

Therefore, the following is claimed:

1. An object identification system, comprising:

a guided surface waveguide probe comprising a charge terminal elevated over a terrestrial medium that produces an electromagnetic guided surface wave along a surface of a lossy conducting medium by generating at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence of the lossy conducting medium, from which object identification tags obtain electrical power to operate, each tag associated with an object; and

a plurality of receivers deployed at strategic locations to receive return signals from one or more of the tags as the tags move with the associated objects during a lifecycle of the objects.

2. The system of claim 1, wherein the electromagnetic guided surface wave has an illumination area in which sufficient energy to power tags is present, a size of the illumination area corresponding to a region in which the tags are expected to be present during at least a part of the lifecycle of the objects.

3. The system of claim 1, wherein the electromagnetic guided surface wave is produced at a frequency and sufficient energy density to illuminate the tags located throughout the entire planet.

4. The system of any of claims 1-3, wherein the receivers are deployed along product supply routes to track objects travelling in commerce.

5. The system of claim 4, wherein the system further comprises a computer system that logs data associated with detection of the return signals from the tags by the receivers in a database.

6. The system of any of claims 1-5, wherein the system further comprises a computer system that identifies geolocation of the tags according to return signals from the tags that are received by the receivers.

7. The system of claim 6, wherein geolocation for at least one tag is determined by triangulation using a corresponding return signal that is received at two receivers.

8. The system of claim 6, wherein a geolocation of at least one receiver that receives a return signal from a tag serves as a proxy for location of the tag.

9. The system of any of claims 1-8, wherein a shape of an illumination area for the electromagnetic guided surface wave in which sufficient energy density is present for the object identification tags to obtain electrical power to operate is controlled by varying the electromagnetic guided surface wave output by the guided surface waveguide probe as a function of a direction that the guided surface waveguide probe launches the electromagnetic guided surface wave.

10. The system of any of claims 1-9, wherein the tags are addressable and the electromagnetic guided surface wave includes an addressed message for at least one of the tags.

11. The system of any of claims 1-10, wherein the tags are addressable and the receivers are configured to send addressed message for at least one of the tags.

12. The system of any of claims 10-11, wherein the message is a query for data stored by an addressed tag.

13. The system of any of claims 10-11, wherein the message contains data to be stored by an addressed tag.

14. The system of claim 13, wherein the data corresponds to least one event associated with a history of the addressed tag.

15. The system of claim 13, wherein the data corresponds to least one detected location of the addressed tag.

16. The system of any of claims 10-11, wherein the message is a command for an addressed tag to not transmit a return signal for at least a period of time.

17. The system of any of claims 1-16, wherein the electromagnetic guided surface wave illuminates the tags at a first frequency and at least a first set of the tags emit return signals at a second frequency nominally different than the first frequency.

18. The system of claim 17, wherein at least a second set of the tags emit return signals at a third frequency nominally different than the first and second frequencies.

19. The system of claim 17, wherein the probe operates in an environment in which another electromagnetic guided surface wave is present, the another electromagnetic guided surface wave having a frequency nominally different than the first frequency and the first set of tags unresponsive to the frequency of the another electromagnetic guided surface wave.

20. The system of any of claims 1-19, wherein the production of the electromagnetic guided surface wave is continuous over a period of time.

21. The system of claim 20, wherein during the period of time each tag repeats emission of the return signal with no delay or a slight delay between each return signal instance.

22. The system of any of claims 1-21, wherein the system further comprises a computer system that tracks and logs events related to the tags in a database according to return signals from the tags that are received by the receivers.

23. The system of claim 22, wherein the events correspond to one or more of association of a tag with an object, manufacture of the object, movement of the object, departure or arrival of the object at a predetermined location, or sale or transfer of possession of the object.

24. The system of any of claims 1-23, wherein one or more of the receivers have fixed geolocations.

25. The system of claim 24, wherein the geolocations are selected from one or more of a doorway at a site, a payment area at a site, a receiving or shipping portal at a site, or a port of entry.

26. The system of any of claims 1-25, wherein one or more of the receivers move with a vehicle configured to carry one or more objects during a portion of a lifecycle of the carried objects.

27. The system of any of claims 1-26, wherein the system further comprises a computer system that tracks the tags over time, the computer system configured to allow a person associated with one or more of the objects to opt out of further tracking of the tags associated with the one or more of the objects.

28. A method of tracking an object, comprising:

producing an electromagnetic guided surface wave along a surface of a lossy conducting medium with a guided surface waveguide probe comprising a charge terminal elevated over a terrestrial medium by generating at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence) of the lossy conducting medium, the electromagnetic guided surface wave having sufficient energy density to power object identification tags across an area of interest;

receiving return signals from a tag of interest at plural receivers, the tag of interest associated with an object and the receivers that receive the return signals change over time as the tag moves with the associated object in the area of interest; and

identifying a series of geolocations at which the object was present as a function of time according to the received reply signals from the tag.