SUMMARY

[0005] Embodiments of the present disclosure are related to the transmission of modulated guided surface waves. According to one embodiment, a system is provided that comprises a guided surface waveguide probe which includes at least one charge terminal elevated over a lossy conducting medium, modulation circuitry coupled to the guided surface waveguide probe, where the modulation circuitry is configured to generate a modulated signal, the modulated signal being applied to the guided surface waveguide probe. The guided surface waveguide probe is adjusted to launch a Zenneck surface wave embodying the modulated signal by generating at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence along the lossy conducting medium.

[0006] According to various embodiments, the modulation circuitry further comprises amplitude modulation circuitry, and the modulated signal further comprises an amplitude modulation signal. Also, the guided surface waveguide probes as described herein may be polyphase waveguide probes, each having at least two charge terminals. According to other embodiments, the guided surface waveguide probes described herein may comprise a charge terminal elevated over the terrestrial medium configured to generate at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence ($\theta_{i,B}$) of the terrestrial medium at a vicinity of the guided surface waveguide probe.

[0007] In various embodiments, the guided surface waveguide probes described herein may be single phase probes having a single charge terminal.

[0008] In various embodiments, the guided surface waveguide probes described herein may comprise a feed network electrically coupled to the single charge terminal, where the feed network providing a phase delay (Φ) that matches a wave tilt angle (Ψ) associated with a complex Brewster angle of incidence ($\theta_{i,B}$) associated with the terrestrial medium in a vicinity of the guided surface waveguide probe. Also, according to the various embodiments, the guided surface waveguide probe may include a compensation terminal.

[0009] According to the various embodiments, the guided surface wave generated by a given guided surface waveguide probe decays exponentially as a function of a distance from the guided surface waveguide probe.

[0010] Also, according to the various embodiments, the guided surface waveguide probes described herein further comprise an anti-skywave structure.

[0011] According to the various embodiments of the present disclosure, amplitude modulation circuitry described herein may be directly coupled or inductively coupled to a circuit component of the surface waveguide probe.

[0012] According to various embodiments, the modulation circuitry described herein further comprises amplitude modulation circuitry, and a modulation type of the modulation performed by the amplitude modulation circuitry is taken from a group consisting of a double-

sideband full carrier, a single-sideband reduced-carrier, a single-sideband full-carrier, single-sideband suppressed-carrier, an independent-sideband emission, a vestigial-sideband, or a linked compressor and expander.

[0013] According to various embodiments, a method is provided comprising the steps of coupling an amplitude modulated signal to a guided surface waveguide probe; and launching a guided surface wave embodying the amplitude modulated signal via the guided surface waveguide probe, a field strength of the guided surface wave decaying exponentially as a function of a distance from the guided surface waveguide probe and launching the guided surface wave comprises generating at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence (θ_(i,B)) of the terrestrial medium at a vicinity of the guided surface waveguide probe. According to various embodiments, the method further comprises the step of launching the guided surface wave while minimizing creation of a skywave.

[0014] In the various embodiments, the guided surface wave propagates along an interface of an atmospheric medium and a terrestrial medium. Also, according to the various embodiments described herein, the guided surface waveguide probe further comprises a single phase waveguide probe having a charge terminal and a feed network electrically coupled to the charge terminal, and the launching of a guided surface wave via a guided surface waveguide probe as described herein further comprises generating a resultant field that matches a wave tilt angle (Ψ) associated with a complex Brewster angle of incidence ($\theta_{i,B}$) associated with a terrestrial medium in a vicinity of the guided surface waveguide probe.

[0015] According to the various embodiments, the guided surface waveguide probe comprises at least one charge terminal elevated over a terrestrial medium, and the launching of the guided surface wave via the guided surface waveguide probe further comprises generating at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence ($\theta_{i,B}$) of the terrestrial medium at a vicinity of the guided surface waveguide probe.

[0016] According to the various embodiments, the methods further comprise generating the amplitude modulated signal.

[0017] In addition, the various embodiments of the present disclosure include an apparatus comprising a guided surface waveguide probe having a charge terminal and a feed network coupled to the charge terminal, the feed network including a phase delay circuit positioned adjacent to the charge terminal. The apparatus further comprises modulation circuitry coupled to the guided surface waveguide probe, the modulation circuitry being configured to generate a modulated signal, the modulated signal being applied to the guided surface waveguide probe. The apparatus further comprises the guided surface waveguide probe being adjusted to launch a guided surface wave along a terrestrial medium, the guided surface wave embodying the modulated signal, and wherein launching the guided surface wave comprises generating a resultant field that matches a wave tilt angle (Ψ) associated with a complex Brewster angle of incidence ($\theta_{i,B}$) of the terrestrial medium.

CLAIMS

Therefore, the following is claimed:

1. A system, comprising:

a guided surface waveguide probe comprising at least one charge terminal elevated over a lossy conducting medium;

modulation circuitry coupled to the guided surface waveguide probe, the modulation circuitry being configured to generate a modulated signal, the modulated signal being applied to the guided surface waveguide probe; and

the guided surface waveguide probe being adjusted to launch a Zenneck surface wave embodying the modulated signal by generating at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence along the lossy conducting medium.

2. The system of claim 1, wherein the modulation circuitry further comprises amplitude modulation circuitry, and the modulated signal further comprises an amplitude modulation signal.

3. The system of claims 1 or 2, wherein the guided surface waveguide probe is a polyphase waveguide probe having at least two charge terminals.

4. The system of claims 1 or 2, wherein the guided surface waveguide probe is a single phase probe having a single charge terminal.

5. The system of claim 4, wherein the guided surface waveguide probe further comprises a feed network electrically coupled to the single charge terminal, the feed network providing a phase delay (Φ) that matches a wave tilt angle (Ψ) associated with the complex Brewster angle of incidence ($\theta_{i,B}$) of the lossy conducting medium.

6. The system of claim 4, wherein the guided surface waveguide probe further comprises a compensation terminal.

7. The system of claims 1, 2, 3, 4, 5, or 6, wherein a field strength of the guided surface wave decays exponentially as a function of a distance from the guided surface waveguide probe.

8. The system of claims 1, 2, 3, 5, 6, 7, or 8, wherein the guided surface waveguide probe further comprises an anti-skywave structure.

9. The system of claims 1, 2, 3, 4, 5, 6, 7, or 8, wherein the modulation circuitry is directly coupled to a circuit component of the guided surface waveguide probe.

10. The system of claims 1, 2, 3, 4, 5, 6, 7, or 8, wherein the modulation circuitry is inductively coupled to a circuit component of the guided surface waveguide probe.

11. The system of claims 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10, wherein a modulation type of the modulation performed by the modulation circuitry is taken from a group consisting of a double-sideband full carrier, a single-sideband reduced-carrier, a single-sideband full-carrier, single-sideband suppressed-carrier, an independent-sideband emission, a vestigial-sideband, or a linked compressor and expander.

12. A method, comprising:

coupling an amplitude modulated signal to a guided surface waveguide probe; and

launching a guided surface wave embodying the amplitude modulated signal via the guided surface waveguide probe, a field strength of the guided surface wave decaying exponentially as a function of a distance from the guided surface waveguide probe, and launching the guided surface wave comprises generating at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence ($\theta_{i,B}$) of the terrestrial medium at a vicinity of the guided surface waveguide probe.

13. The method of claim 12, wherein the guided surface wave is launched while minimizing creation of a skywave.

14. The method of claims 12 or 13, wherein the guided surface wave propagates along an interface of an atmospheric medium and a terrestrial medium.

15. The method of claims 12, 13, or 14, wherein the guided surface waveguide probe further comprises a single phase waveguide probe having a charge terminal and a feed network electrically coupled to the charge terminal.

16. The method of claims 12, 13, or 14, wherein the guided surface waveguide probe comprises at least one charge terminal elevated over a terrestrial medium.

17. The method of claims 12, 13, 14, 15, or 16, further comprising generating the amplitude modulated signal.

18. An apparatus, comprising:

a guided surface waveguide probe having a charge terminal and a feed network coupled to the charge terminal, the feed network including a phase delay circuit positioned adjacent to the charge terminal;

modulation circuitry coupled to the guided surface waveguide probe, the modulation circuitry being configured to generate a modulated signal, the modulated signal being applied to the guided surface waveguide probe; and

the guided surface waveguide probe being adjusted to launch a guided surface wave along a terrestrial medium, the guided surface wave embodying the modulated signal, and wherein launching the guided surface wave comprises generating a resultant field that matches a wave tilt angle (Ψ) associated with a complex Brewster angle of incidence ($\theta_{i,B}$) of the terrestrial medium.

19. The apparatus of claim 18, wherein the feed network further comprises a shielded conductor having an inner conductor, a first end of the inner conductor being coupled to the phase delay circuit, and a second end of the inner conductor being coupled to an output of the modulation circuitry.

20. The apparatus of claim 19, wherein the feed network further comprises a feed line coupling the phase delay circuit to the charge terminal, wherein a length of the feed line is less than a length of the shielded conductor.

21. The apparatus of claim 19, wherein the phase delay circuit further comprises a coil, and the inner conductor is coupled to a tap on the coil.

22. The apparatus of claim 19, wherein the phase delay circuit further comprises a coil, and the inner conductor is coupled to an end of the coil.

23. The apparatus of claim 19, wherein at least one choke is positioned on the shielded conductor.

24. The apparatus of claim 18, wherein the phase delay circuit further comprises an active component.

25. The apparatus of claim 18, wherein:

the feed network further comprises a shielded conductor having an inner conductor, a first end of the inner conductor being coupled to a ground stake, and a second end of the inner conductor being coupled to the modulation circuitry; and

an output of the modulation circuitry is coupled to the phase delay circuit.