CLAIMS

Therefore, the following is claimed:

1. An electromagnetic hybrid phased array system, comprising:

a guided surface waveguide probe, wherein the guided surface waveguide probe comprises a charge terminal elevated over a ground;

a contrawound toroidal helix antenna collocated with the guided surface waveguide probe, wherein the contrawound toroidal helix comprises ring elements spaced from each other and wrapped around the guided surface waveguide probe; and

a signal source applied to at least the guided surface waveguide probe, wherein the guided surface waveguide probe and the contrawound toroidal helix contribute individual vertical electric fields that form a radiation pattern based on the phase and amplitude characteristics of the individual vertical electric fields.

2. The electromagnetic hybrid phased array system of claim 1, wherein the guided surface waveguide probe is configured to generate at least one resultant field that synthesizes a wave front incident at a complex Brewster angle of incidence of a lossy conducting medium comprising the ground.

3. The electromagnetic hybrid phased array system of claim 1, wherein the ring elements comprise a plurality of closed, interconnected ring elements.

4. The electromagnetic hybrid phased array system of claim 1, wherein the contrawound toroidal helix antenna is positioned above the ground.

5. The electromagnetic hybrid phased array system of claim 1, wherein the ring elements comprise a plurality of half-circle ring elements that are positioned in the ground.

6. The electromagnetic hybrid phased array system of claim 1, wherein the radiation pattern comprises a vertical electrical field having a low angle radiation.

7. The electromagnetic hybrid phased array system of claim 1, wherein the signal source operates at a low frequency within a range 30 kHz–300 kHz.

8. The electromagnetic hybrid phased array system of claim 1, further comprising at least one additional collocated guided surface wave guide probe and contrawound toroidal helix antenna.

9. The electromagnetic hybrid phased array system of claim 1, wherein the signal source generates an amplitude modulation signal.

10. The electromagnetic hybrid phased array system of claim 1, wherein the signal source is applied to the contrawound toroidal helix antenna.

11. A method comprising:

conducting a first electrical current through a contrawound toroidal helix structure comprising interconnected conducting ring elements spaced from each other;

establishing, in response to a flow of the first electrical current, a first vertical electric field;

conducting a second electrical current through a guided surface waveguide probe;

establishing, in response to a flow of the second electrical current, a second vertical electric field; and

forming a radiation pattern based on phase and amplitude characteristics of the first and second vertical electric fields.

12. The method of claim 11, wherein the radiation pattern comprises a vertical electrical field having a low angle radiation.

13. The method of claim 11, further comprising applying a signal source to the guided surface waveguide probe, wherein application of the signal source generates the second electrical current.

14. The method of claim 13, wherein the signal source generates an amplitude modulation signal.

15. The method of claim 13, wherein the signal source operates at a low frequency within a range 30 kHz–300 kHz.

16. The method of claim 13, wherein the contrawound toroidal helix is collocated with the guided surface waveguide probe.

17. The method of claim 13, wherein the contrawound toroidal helix structure is positioned above a ground.

18. The method of claim 13, wherein the contrawound toroidal helix structure comprises a plurality of half-circle ring elements that are positioned in the ground.

19. An electromagnetic hybrid phased array system, comprising:

a guided surface waveguide probe, wherein the guided surface waveguide probe comprises a charge terminal elevated over a ground;

a contrawound toroidal helix antenna located to a side of the guided surface waveguide probe, wherein the contrawound toroidal helix comprises ring elements spaced from each other; and

a signal source applied to at least the guided surface waveguide probe, wherein the guided surface waveguide probe and the contrawound toroidal helix contribute individual vertical electric fields that form a radiation pattern based on the phase and amplitude characteristics of the individual vertical electric fields.

20. The electromagnetic hybrid phased array system of claim 19, wherein the signal source operates at a low frequency within a range 30 kHz–300 kHz.