DEPARTMENT OF THE NAVY
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NAVAL UNDERSEA WARFARE CENTER DIVISION
1176 HOWELL STREET NEWPORT RI 02841-1708

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NAVAL UNDERSEA WARFARE CENTER
1176 HOWELL ST.
CODE 00T2, BLDG. 102T
NEWPORT, RI 02841

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Inventor	David F. Rivera

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WIDEBAND LOW VISIBILITY ANTENNA

STATEMENT OF GOVERNMENT INTEREST

[0001] The invention described herein was made in the performance of official duties by employees of the United States Department of the Navy and may be manufactured, used, or licensed by or for the Government of the United States of America for any governmental purpose without payment of any royalties thereon.

BACKGROUND OF THE INVENTION

1) Field of the Invention

[0002] The present invention is directed to a portable and lightweight tactical communications antenna that can receive and transmit over a wide band of frequencies without the antenna requiring tuning adjustments.

2) Description of the Related Art

[0003] Antennas for line-of-sight tactical communications in the frequency range of 30 MHz to 88 MHz are vertically-orientated dipoles or monopoles (whips) that are deployed and used in numerous ways.

[0004] In one type of deployment, a rear or side panel mounted whip is attached to a vehicle. This method of antenna mounting is common as the whip antenna permits communication when the vehicle is in transit. The counterpoise or return path for currents to close the electromagnetic circuit of the antenna includes the metal body of the vehicle and the terrain beneath the vehicle.

[0005] In another deployment, a pole or mast-mounted dipole and wideband antenna is hoisted above the ground (typically 30 feet) to establish a stationary communications base. The antenna also can be a man-pack whip antenna in which the antenna is a thin metal blade connected to a radio frequency of a portable transceiver. The transceiver/antenna combination permits on-the-move communication.

[0006] The antenna can also be tripod-mounted at a short distance above the terrain. The tripod-mounted antenna is a dipole antenna encompassed by a protective dielectric shell (radome) with the bottom end of the antenna mechanically attached to a tripod. The tripod-mounted antenna is a low-profile alternative to the mast-mounted dipole with the advantage of being transportable.

[0007] The above-identified antennas are typical in that the antennas are used for routine in-the-field radio traffic. However, improvements to durability, portability, reception clarity and transmission clarity are always being sought.

SUMMARY OF THE INVENTION

[0008] It is therefore a primary object and general purpose of the present invention to provide a portable and lightweight tactical communications antenna that can be rapidly deployed by a single operator.

[0009] To attain the object of the invention, an antenna is provided with geometric shaping and materials to produce a lightweight device with enhanced performance.

[0010] The antenna includes a vertically-orientated rectangular loop section with a taper which faces a base plate. Two rods extending from the base plate lock the loop section in the vertical orientation. At least eight thin wire radials extend horizontally from the base plate to a circumference surrounding the base plate. The other end of each wire connects to a metal stake. The stakes secure the wire radials and the base plate to the terrain of the Earth.

[0011] The base plate provides a stable and low center-of-gravity for mounting the antenna on an uneven terrain; acts as a connection hub for the wire radials; and acts as the lower half of a transmission line assembly for energizing the vertical loop section. The upper half of the transmission line assembly to the loop section includes a metal clamp, an S-shaped metal plate and an L-shaped standoff insulator. The plate is soldered to an input jack and the clamp secures the loop section to the transmission line assembly.

[0012] The radiating portion of the antenna is the closed metal loop section. The loop width and taper angle proportions present an antenna impedance at the input jack to a level that matches to a transceiver.

[0013] In a transmitting or receiving operation, the antenna beam pattern is generated by currents and voltages set up over the loop section, the base plate, the wire radials and the Earth. The interaction between these elements form a closed circuit that the transceiver recognizes as an electrical load with a complex-valued impedance that changes with frequency.

[0014] When the circuit is applied with the antenna mounted on the Earth; deviation depends on the soil properties of the terrain of the Earth. After examining the feed point impedance of the antenna over other types of soil; a baseline equivalent circuit can be modified.

[0015] The equivalent circuit illustrates the manner in which a feed point impedance of the antenna is seen by a transceiver. In order to transfer maximum power to and from the transceiver when the antenna is mounted on terrain with unknown dielectric properties; a compensation network is needed. To provide this network; the limits of the dielectric properties of soil must be known.

[0016] A matching network can connect between the antenna and the transceiver to electrically match the antenna and the transceiver in order to transfer maximum power in the presence of any soil type. If the matching circuit were not there, the antenna would still work, but not consistently because the soil would alter the antenna impedance (R + j X) characteristics.

[0017] For example, the antenna without the matching circuit might work better in wet soil and worse over rocky soil (by better or worse, the antenna might radiate more power when over wet soil and less over rocky soil, which translates to communication range). By using the circuit, power transfer between antenna and transceiver is maximized so that communication range becomes more consistent regardless of soil type.

[0018] The influence of soil on feed point impedance generates a series of impedance compensation (or matching) networks. The compensation network comprises a resistor and co-axial transmission lines having different lengths and impedances. The network helps match the antenna to the transceiver with comparatively low Voltage Standing Wave Ratio results.

[0019] Voltage Standing Wave Ratio (VSWR) is a number that describes how well matched the antenna is to the transceiver for maximum power transfer. A value of one (1) is a perfect match but this is an idealization. Since the antenna is to be used over any soil type, the circuit that matches the antenna to the transceiver within a certain limit.

[0020] In operation, the antenna is deployed and activated with a transceiver. Either as a standalone or with an operator, the antenna is lightweight, easily deployed, simple to construct and not easily visible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Features of illustrative embodiments may be understood from the accompanying drawings in conjunction with the detailed description. The elements in the drawings may not be drawn to scale. Some elements and/or dimensions are enlarged or minimized for the purpose of illustration and the understanding of the disclosed embodiments.

[0022] **FIG. 1** depicts a side view of a rapid-deployment antenna of the present invention;

[0023] **FIG. 2** depicts a top view of the antenna of the present invention;

[0024] **FIG. 3** depicts an isometric view of the antenna with a mounting base and loop energizing-feed subassembly shown;

[0025] **FIG. 4** depicts a base plate of the antenna;

[0026] **FIG. 5** depicts the feed assembly of the antenna;

[0027] **FIG. 6** depicts a breakout view of the feed assembly of the antenna;

[0028] **FIG. 7** is a view of the vertical loop section of the antenna;

[0029] **FIG. 8** is a dimensioned view of the vertical loop section;

[0030] **FIG. 9** is a graphical representation of a feed point impedance of the antenna suspended at an infinite distance from the Earth;

[0031] **FIG. 10** depicts an equivalent circuit of the antenna of the present invention when the antenna is suspended at an infinite distance from the Earth;

[0032] **FIG. 11** is a graphical representation of a feed point impedance of an antenna far removed from Earth in comparison with impedance determined with the equivalent of **FIG. 10**;

[0033] **FIG. 12** is a graphical representation of the feed point impedance of the antenna in dry soil;

[0034] **FIG. 13** is a graphical representation of the feed point impedance of the antenna in wet soil;

[0035] **FIG. 14** depicts an antenna equivalent circuit seen by a transceiver when placed on real earth;

[0036] **FIG. 15** depicts the United States Department of Agriculture soil texture triangle;

[0037] **FIG. 16** depicts an antenna matching/soil-type compensation network;

[0038] **FIG. 17** is a graphical representation of an antenna matching/soil-type compensation network with the antenna of the present invention on dry earth without ground stakes;

[0039] **FIG. 18** is a graphical representation of an antenna matching/soil-type compensation network with the antenna of the present invention on dry earth with ground stakes;

[0040] **FIG. 19** is a graphical representation of an antenna matching/soil-type compensation network with an envelope of VSWR curves obtained with an un-staked antenna mounted over various soil types;

[0041] **FIG. 20** is a graphical representation of an antenna matching/soil-type compensation network with an envelope of VSWR curves obtained with a staked antenna mounted over various soil types;

[0042] **FIG. 21** depicts beam patterns over dry soil at a lower band edge of 30 MHz;

[0043] **FIG. 22** depicts beam patterns over rich soil at a lower band edge of 30 MHz;

[0044] **FIG. 23** depicts beam patterns over wet soil at a lower band edge of 30 MHz;

[0045] **FIG. 24** depicts beam patterns over dry soil at the geometric mean frequency of 52 MHz;

[0046] **FIG. 25** depicts beam patterns over rich soil at the geometric means frequency of 52 MHz;

[0047] **FIG. 26** depicts beam patterns over wet soil at the geometric mean frequency of 52 MHz;

[0048] **FIG. 27** depicts beam patterns over dry soil at the upper band edge of 88 MHz;

[0049] **FIG. 28** depicts beam patterns over rich soil at the upper band edge of 88 MHz; and

[0050] **FIG. 29** depicts beam patterns over wet soil at the upper band edge of 88 MHz.

DETAILED DESCRIPTION OF THE INVENTION

[0051] The invention summarized above is better understood by referring to the following description, which is read in conjunction with the accompanying drawings in which like reference numbers are used for like parts. This description of an embodiment, set out below to enable one to practice an implementation of the invention, is not intended to limit the preferred embodiment, but to serve as a particular example thereof.

[0052] **FIG. 1-3** depict an antenna **10** of the present invention. The antenna **10** includes a vertically-orientated and rectangular loop section **12** with a semi-triangular taper at a bottom end of the loop section. The loop section **12** is formed with round wire. A semi-rectangular metal base plate **14** energizes the loop section **12** while also providing mechanical stability and a low center of gravity when the base is mounted on a terrain. At least two rods **16** made from insulating material (such as FR-4 fiberglass) are supports that vertically lock the loop section **12** into place.

[0053] The antenna **10** also includes at least eight thin wire radials **18** attached by wing nuts **19** and extending from the base plate **14**. Another end of each of the thin wire radials **18** connects to a short metal stake (not shown). The metal stakes secure the wire radials **18** to the terrain of the Earth.

[0054] The metal components of the antenna **10** are aluminum, brass, copper and stainless steel. Depending on how the antenna **10** is used; the antenna can be made in several ways. For repeated and rough operator use; the metal parts of a rugged field version can be made from a nickel-titanium alloy (Nitinol). Nickel-titanium alloy is known for elastic and shape memory properties.

[0055] For standalone use, the metal parts may be made from magnesium alloys and the non-conducting (dielectric) parts from Chitosan or crystallized poly lactic acid (cPLA) composites. Employing these materials for the antenna **10** produces a biodegradable device that can break down into non-functional parts when exposed to the weather.

[0056] **FIG. 4** depicts a top view of the base plate **14** with hole-drilling details shown as apertures **22** as attachment points for the other components of the antenna **10.** These are hole drillings and are relevant to this particular base-plate design. The base plate **14** provides a low center-of-gravity for mounting the antenna **10** on an uneven terrain; acts as a connection hub for the wire radials **18;** and acts as the lower half of the transmission line assembly for energizing the vertical loop section **12.** Rectangular arms **24** protrude from the base plate **14** to further provide stability for the antenna **10.** A workable base plate **14** can be fabricated from 0.25 inch thick aluminum.

[0057] In **FIG. 5** and in **FIG. 6**, a feed assembly **26** is shown with a metal (brass) clamp **28**, an S-shaped metal (brass) plate **30** and an L-shaped standoff insulator **31.** Any low-loss insulator will work, but FR-4 flame retardant fiberglass is preferable because it is a hard and tough material. During assembly, the standoff insulator **31** is fastened to the base plate **14**; followed by the S-shaped plate **30.** Then, the S-shaped brass plate **30** is fastened to the opposite face; thereby, forming a parallel plate transmission line. One end of the S-shaped plate **30** is connected to the vertical loop to energize the. Standoff indicates that the upper S-shaped brass plate **30** was separated or “stood” off from the lower aluminum base plate by the insulator. One end of the S-shaped plate **30** is an up-turned tab that solders to a center pin of an input jack **32** for powering the antenna **10.**

[0058] The S-shaped plate **30,** the L-shaped standoff insulator **31** and the base plate **14** form a transmission line that carries power from the input jack **32** to the tapered region of the loop section **12.** The metal clamp **28** joins the loop section **12** with the transmission line or assembly. The transmission line is sized to produce a characteristic impedance (ZO) of 50 ohms.

[0059] As shown in **FIG. 7** and **FIG. 8,** the radiating portion of the antenna **10** is the closed metal loop section **12.** The wire material of the loop section **12** is preferably stainless steel with a diameter of 0.25 inches. In an example of an operable antenna **10;** a tall and wide antenna (68.5 and 13.25 inches respectively) would have the loop section **12** weighing approximately six ounces. The corner radii of the loop section **12** are large (in the example; 0.5 inches) to prevent breakage during fabrication.

[0060] The components of the antenna **10** are determined at the wavelength corresponding to the geometric mean frequency of the band (λ_o) as calculated by Equation **(1):**

$$\lambda_o = \frac{v_o}{f_o} \tag{1}$$

where v_o is the speed of light (3×10^8 meter/s) and where f_o is the geometric mean frequency (≈ 52 MHz).

[0061] The vertical loop section **12,** shown in **FIG. 8,** provides performance throughout a frequency band of interest. The height dimension is L ≈ $0.3\lambda_o$ at the geometric mean frequency. The loop width and taper are fractions of the height L. The height dimension is tall enough to yield a radiation pattern in the horizontal plane with significant power gain. The loop width and feed taper angle proportions present an antenna impedance (Z) at the input jack **32** to a level that can be matched to a transceiver in order to maximize power transfer.

[0062] The shape and size of the base plate **14** prevents the antenna **10** from toppling over when the antenna is mounted on an uneven terrain. The area of the base plate **14** is sufficiently large to permit proper spacing of the radials **18** as well as to mechanically stiffen the transmission line of the energizing feed to the vertical loop section **12.**

[0063] An operating example of the antenna **10** includes dimensions where the length of each radial wire **18** is 1.5 L and the radial wire diameter is L/200. The length of stakes that secure the radial wires **18** to the Earth have a length of L/5 and a diameter of L/540. The length of the radial wires **18** provides a stable radiation pattern, feed point impedance and diameter for flexibility. The ends of the radial wires **18** have alligator clips or other mechanical attaching devices to permit attachment to the ground stakes.

[0064] In a transmitting or receiving operation, the beam pattern of the antenna **10** is generated by currents and voltages set up over various length segments of the vertical loop section **12**, the base plate **14**, the wire radials **18** and the Earth. The interaction between these elements form a closed electromagnetic circuit that the transceiver recognizes as an electrical load with a complex-valued impedance ($Z = R + j X$, where $j = \sqrt{-1}$) that changes with frequency. The real part of the complex impedance, the resistance (symbol R), describes that portion of power that radiates into space with a small fraction being dissipated as heat. The imaginary part of the impedance, the reactance (symbol X), describes the non-radiative (or stored) portion of power flow.

[0065] To obtain information into what the transceiver electrically recognizes when connected; a hypothetical case is analyzed in which the antenna **10** is placed at an infinite distance from the Earth. The load impedance seen by the transceiver varies with frequency in the manner shown in **FIG. 9.**

[0066] The hypothetical case establishes a baseline for what occurs when the antenna **10** is brought back to Earth. This information can determine a matching circuit when placed between the transceiver and the antenna **10** and permits the maximum transfer of power in and out of the antenna to improve efficiency with any type of soil.

[0067] Circuit theory provides that a given impedance (Z) variation with frequency can be represented as a network of elements combining resistance (R), inductance (L) and capacitance (C). The difficulty is finding a particular circuit topology (configuration) that reproduces the given impedance. For the hypothetical antenna, a circuit is presented in **FIG. 10.** The circuit depicts the peaks and valleys in the resistance R as well as the inflection points in the reactance X as a function of frequency.

[0068] With the electrical values for the components of the circuit determined; a comparison plot is shown in **FIG. 11.** The impedance values produced by the equivalent circuit follow the shape and trend of the impedance curve of the antenna **10.**

[0069] **FIG. 11** depicts a feed point impedance of an antenna far removed from earth in comparison with the impedance determined with the equivalent of **FIG. 10.** The circuit component values are LS = 70nH, CS = 39pF, LP1 = 200nH, LP2 = 58 nH, CP1 = 48pF, CP2 = 79 pF, RP1 = 475 Ω, RP2 = 122 Ω. For the inductive (L) and capacitive (C) circuit element values, the units nH (nano-Henry) = 10^{-9} H and pF (pico-Farad) = 10^{-12}F.

[0070] When the circuit in **FIG. 10** is applied with the antenna **10** mounted on Earth; the element values differ significantly from those of the baseline (far from Earth). The deviation depends on the properties of the soil.

[0071] Examples of feed point impedances Z observed with the antenna **10** are shown in **FIG. 12** and **FIG. 13.** In **FIG. 12**, the feed point impedance observed with the antenna **10** is shown for dry soil and in **FIG. 13**, the feed point impedance observed with the antenna is shown for wet soil. The addition of ground stakes at the end of the radial wires **18** causes a shift in the maximum values of R and X to a lower frequency.

[0072] After examining the feed point impedance of the antenna **10** over other types of soil (between 30 MHz and 90 MHz); the baseline equivalent circuit of **FIG. 10** is modified and has the form shown in **FIG. 14**. The new circuit depicts the complicated paths taken by the currents and voltages as both are distributed around antenna conductors and through the Earth. The intention is to provide an equivalent circuit of the antenna.

[0073] **FIG. 14** depicts an approximate antenna equivalent circuit when placed on real earth (with or without ground stakes). The components comprising the baseline circuit (LS, CS, LP1, CP1, RP1, LP2, CP2 and RP2) are augmented by series and parallel circuit elements that represent additional electric and magnetic field flow paths through the Earth (ΔLS, ΔCS, ΔLP1, ΔCP1, ΔRP1, ΔLP2, ΔCP2, ΔRP2). The electrical values of the circuit components perturbing the baseline (ΔR, ΔL, ΔC) depend on soil dielectric properties (dielectric constant and bulk conductivity) and frequency.

[0074] The equivalent circuit shown in the figure illustrates the complicated manner in which the Earth modifies a feed point impedance of the antenna **10** is seen by a transceiver (not shown). In order to transfer maximum power to and from the transceiver when the antenna **10** is mounted on terrain with unknown dielectric properties; a compensation network that is able to electrically adjust itself without manual tuning is desirable. To assemble this network; the numerical limits of the dielectric properties of soil must be known.

[0075] Soil is generally a mixture of four components. Clay is the smallest particle in soil with a diameter of less 0.08 mil (one mil = 1/1000 inch) and a mass density of 0.77 oz/in^3. Clay contains various amounts of iron, magnesium, silicon dioxides and alkalai metals.

[0076] Silt has a diameter larger than 0.08 mil but less than 0.2 mil with a mass density of 0.80 oz/in^3. Silt is comprised of quartz and feldspar. Sand is the largest of the particles with a diameter greater than 0.2 mils but less than 8 mils. Sand has a mass density of 0.83 oz/in^3 and is made up of finely divided rock and mineral with added amounts of silicon dioxide. The water content of soil ranges from approximately three percent to as high as fifty percent by volume and may contain mineral salts.

[0077] The dielectric properties of soil also depend on other factors such as porosity, rocks and vegetation, that varies with depth and temperature. Soil is defined in **FIG. 15** in which the figure depicts a United States Department of Agriculture soil texture triangle.

[0078] The determination in dotted lines in **FIG. 15** was from a sample. The volume fractions of clay, silt and sand is determined by partially filling a glass jar with the soil sample, adding soapy water and then agitating the mixture. After a few days at rest, the constituents resettle in the jar in order of increasing mass density (heaviest at the bottom) to various thicknesses. The volume fraction of each constituent is the ratio of layer thickness to that of the total sample height. For the sample and at the geometric mean frequency of 52 MHz and an ambient temperature of 78 degrees Fahrenheit; the relative dielectric constant (ε') of the soil is twenty-two with a conductivity (σ) of 0.02S/m.

[0079] The relative dielectric constant of soil (Symbol: ε', no units) could have any value between approximately 3 (desert sand) and 27 (moist loamy soil) while the bulk connectivity (Symbol: σ, Units: Siemens per meter, S/m) is within the range of 10^{-5} to 0.05. **TABLE I** lists VHF dielectric properties of various soil types.

TABLE I

Soil Type	Dielectric Constant (ε')	Bulk Conductivity (σ), S/m
Dry	5	10^{-5}
Wet	10	10^{-3}
Rocky	10	$2x10^{-3}$
Forestation	13	$5x10^{-3}$
Rich	20	10^{-2}

[0080] The work on soils and their influence on feed point impedance generates a series of impedance compensation (or matching) networks with varying degrees of complexity. Out of this group, the network in **FIG. 16** is the simplest and most effective at matching the antenna **10** to a 50-ohm transceiver under soil conditions considered. **TABLE II** lists the parts of a matching network in support of **FIG. 16.**

TABLE II

Part	Description	Characteristic Impedance, Ω	Length, in.
R	Non-inductive, 470 Ω	---	---
ZO1	Transmission line	100	L1 = 18
ZO2	“	100	L2 = 10
ZO3	“	70	L3 = 9

[0081] **FIG. 16** depicts an antenna matching/soil-type compensation network with a resistor R and three co-axial transmission lines having different lengths (L1, L2, L3) and characteristic impedances (ZO1, ZO2, ZO3). The far-end transmission line length L2 terminates in an open circuit. Resistor R is a non-inductive type with a value between 330 and 680 ohms. A mass-production version of the antenna can have the network integrated into the mounting base.

[0082] The matching network operates when a parallel Za//R places an impedance locus in a Smith chart where the locus is stationary regardless of soil and staked/unstaked radials. A first transmission line rotates load impedance Za//R to a desirable position on the Smith chart (within 4:1 VSWR circle). An open circuit stub then adds a shunt capacitance between 12.5 pF (@30 MHz) and 14.7 pF (90 MHz). A last transmission line transforms a parallel combination of transformed load impedance Za//R and open stub capacitance to within desired limits. The function of resistor R is large enough so that negligible current goes to earth.

[0083] **FIG. 17** and **FIG. 18** demonstrate the behavior of the matching network on dry soil (worst case). As shown in the figures, the network presents a load to the transceiver with a Voltage Standing Wave Ratio (VSWR) of less than 4:1 over a substantial portion of the band. On other soil types, the network matches the antenna to the transceiver with similar or better (lower VSWR) results.

[0084] The differences are seen in the dashed line (with matching network) at the lower end of the frequency band, below about 40 MHz. In **FIG. 17**, the “with matching network” line is higher and in **FIG. 18**; the matching network is lower; thereby, indicating that for best results, the radials should be staked to obtain a better electrical match to the transceiver at frequencies below 40 MHz.

[0085] **FIG. 19** and **FIG. 20** depict the performance of the matching network over numerous soil types. **FIG. 19** is a graphical representation of an antenna matching/soil-type compensation network with an envelope of VSWR curves obtained with an un-staked antenna mounted over various soil types and **FIG. 20** is a graphical representation of an antenna matching/soil-type compensation network with an envelope of VSWR curves obtained with a staked antenna mounted over various soil types. There is a marked improvement in the match when the wire radials **18** are attached to ground stakes.

[0086] **FIG. 21-29** are the vertical or elevation plane beam patterns of the antenna **10** over selected soil types. The beam patterns in the horizontal (or azimuth) plane are omni-directional and are not shown. The figures also indicate that, particularly for dry soil, the attachment of ground stakes to the radials increases the power gain at frequencies below the geometric mean (the maximum increase being about 2 dB).

[0087] **FIG. 21** depicts beam patterns over dry soil at a lower band edge of 30 MHz; **FIG. 22** depicts beam patterns over rich soil at a lower band edge of 30 MHz and **FIG. 23** depicts beam patterns over wet soil at a lower band edge of 30 MHz.

[0088] **FIG. 24** depicts beam patterns over dry soil at the geometric mean of 52 MHz; **FIG. 25** depicts beam patterns over rich soil at the geometric mean of 52 MHz and **FIG. 26** depicts beam patterns over wet soil at the geometric mean of 52 MHz.

[0089] **FIG. 27** depicts beam patterns over dry soil at the upper band edge of 88 MHz; **FIG. 28** depicts beam patterns over rich soil at the upper band edge of 88 MHz and **FIG. 29** depicts beam patterns over wet soil at an upper band edge of 88 MHz.

[0090] Advantages of the antenna **10** are that the antenna is lightweight and portable with a negligible wind area. The antenna **10** has a novel radiator shape with a wide instantaneous operating bandwidth (3:1) yet the antenna is economical to build and maintain. The antenna **10** is able to electrically self-adjust to account for differing soil types resulting in consistent performance.

[0091] It should be recognized that, in the light of the above teachings, those skilled in the art could modify those specifics without departing from the invention taught herein. Having now fully set forth certain embodiments and modifications of the concept underlying the present disclosure, various other embodiments as well as potential variations and modifications of the embodiments shown and described herein will obviously occur to those skilled in the art upon becoming familiar with such underlying concept. It is intended to include all such modifications, alternatives, and other embodiments insofar as they come within the scope of the appended claims or equivalents thereof. It should be understood, therefore, that the invention might be practiced otherwise than as specifically set forth herein. Consequently, the present embodiments are to be considered in all respects as illustrative and not restrictive.

WIDEBAND LOW VISIBILITY ANTENNA

ABSTRACT OF THE DISCLOSURE

An antenna is provided with a wire loop having a tapered end with the antenna perpendicular to a base plate. Insulating rods extend from the plate to lock the loop. Wire radials are directed horizontally and circumferentially from the metal base plate to metal stakes secured in a terrain. The base plate is part of a transmission line assembly that also includes a clamp, an S-shaped plate, an input jack and an L-shaped standoff insulator. The antenna is powered from the input jack to the loop. A beam pattern is generated by the loop section, base plate, wire radials and the Earth. Deviation of the beam pattern depends on soil properties of the terrain. To transfer power when the antenna is mounted on a terrain with unknown dielectric properties; a compensation network is provided.

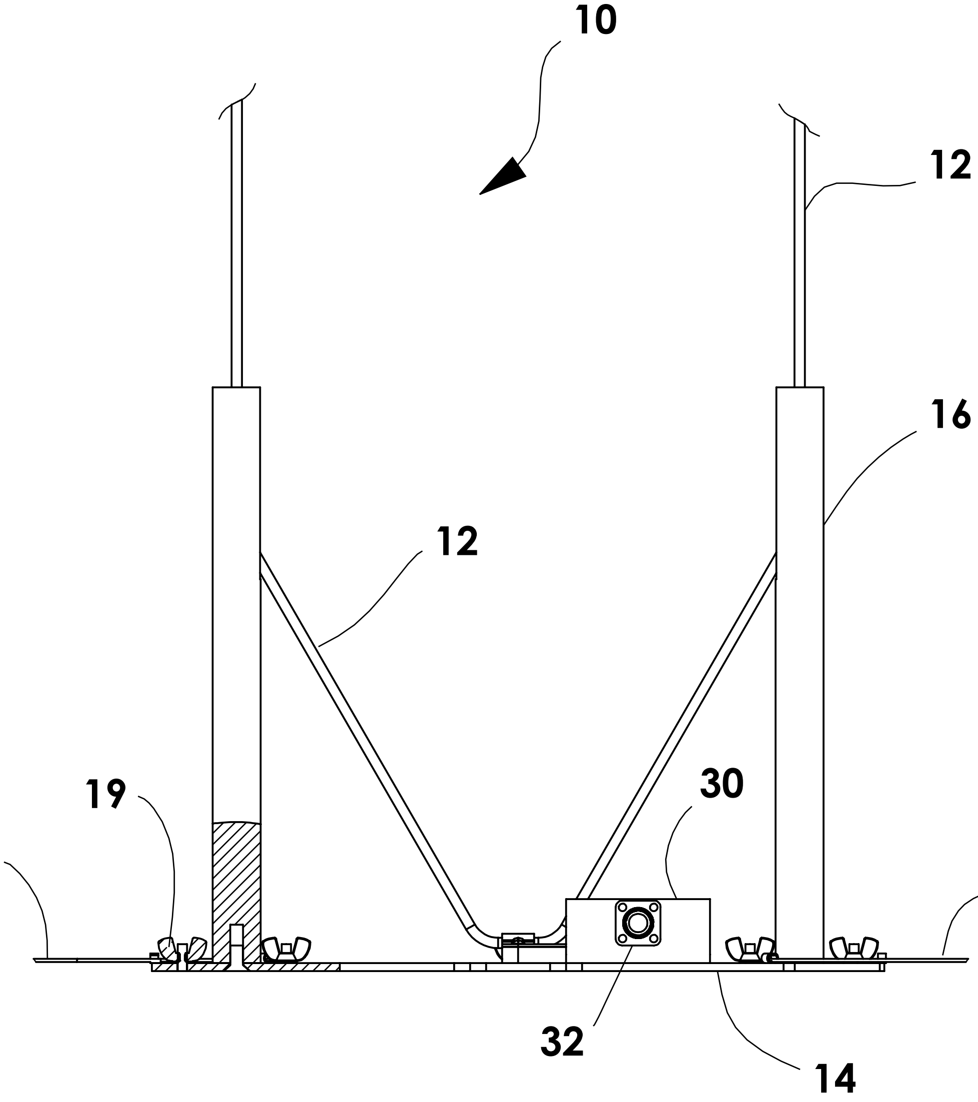


FIG. 1

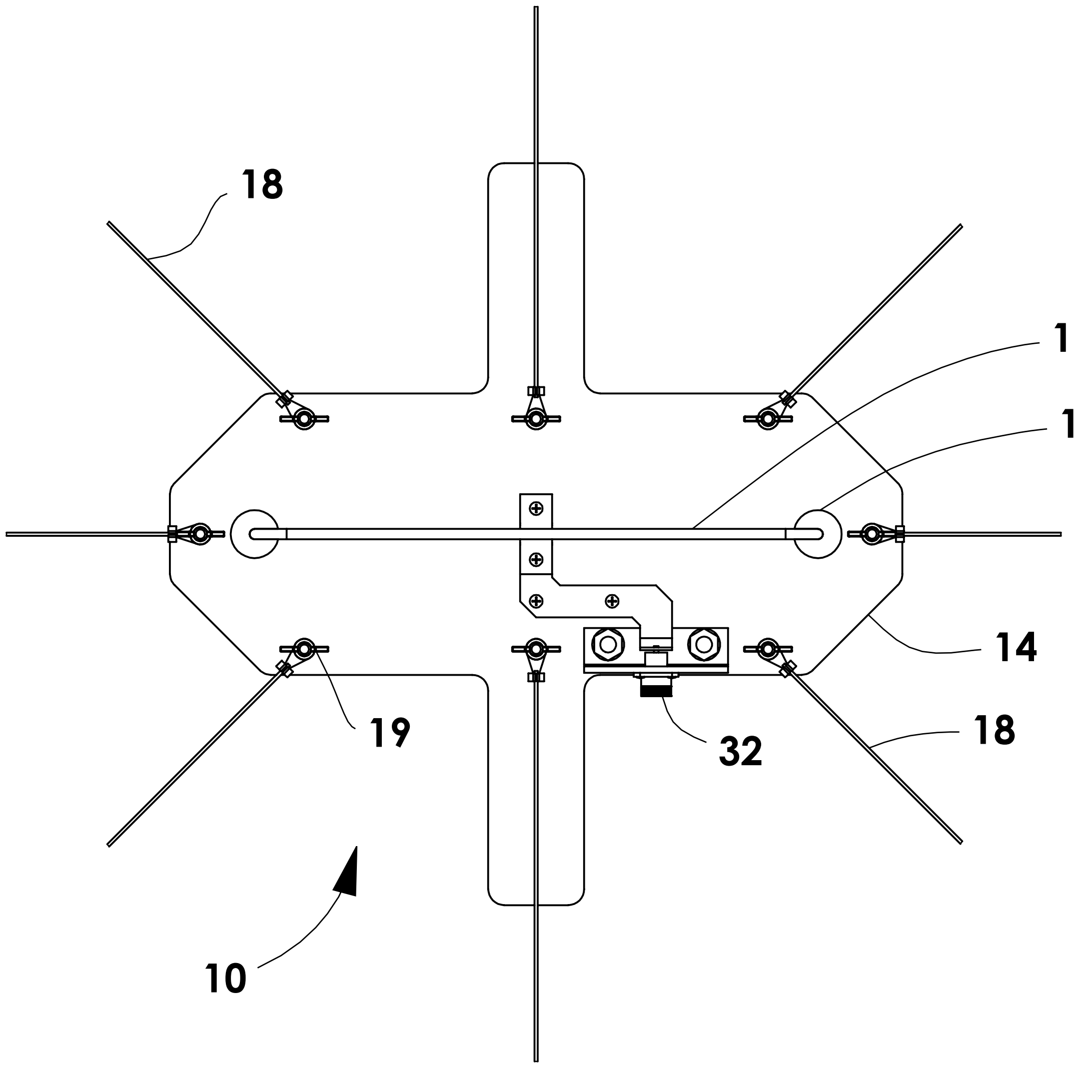


FIG. 2

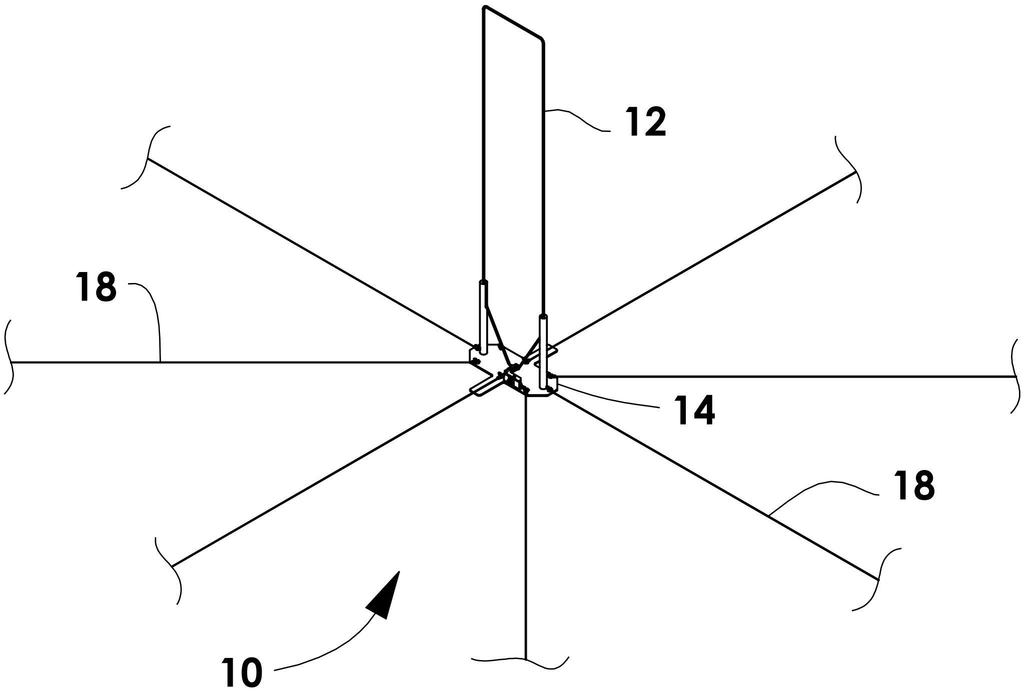


FIG. 3

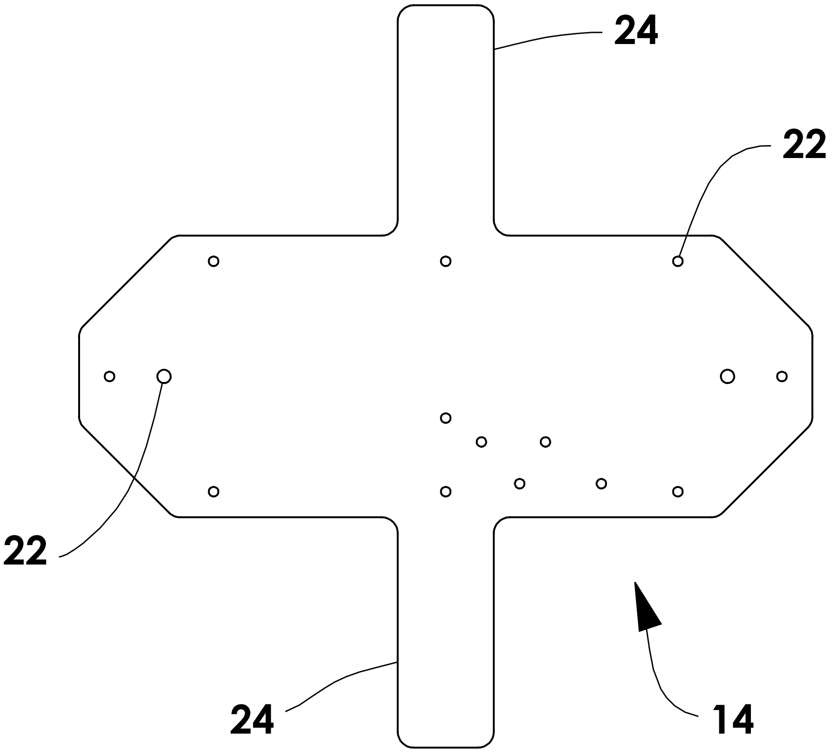


FIG. 4

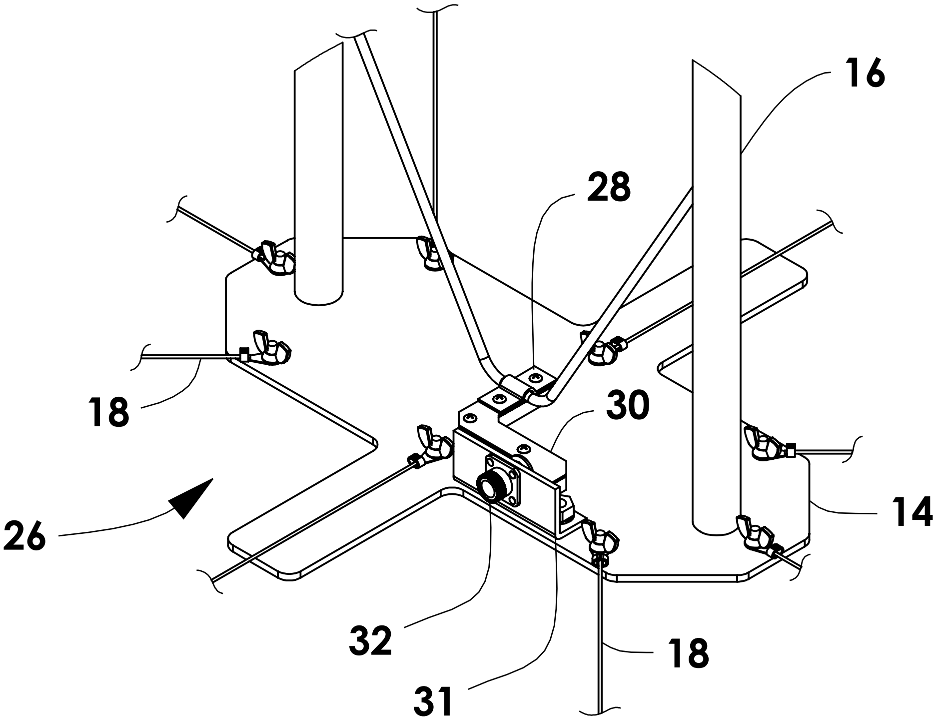


FIG. 5

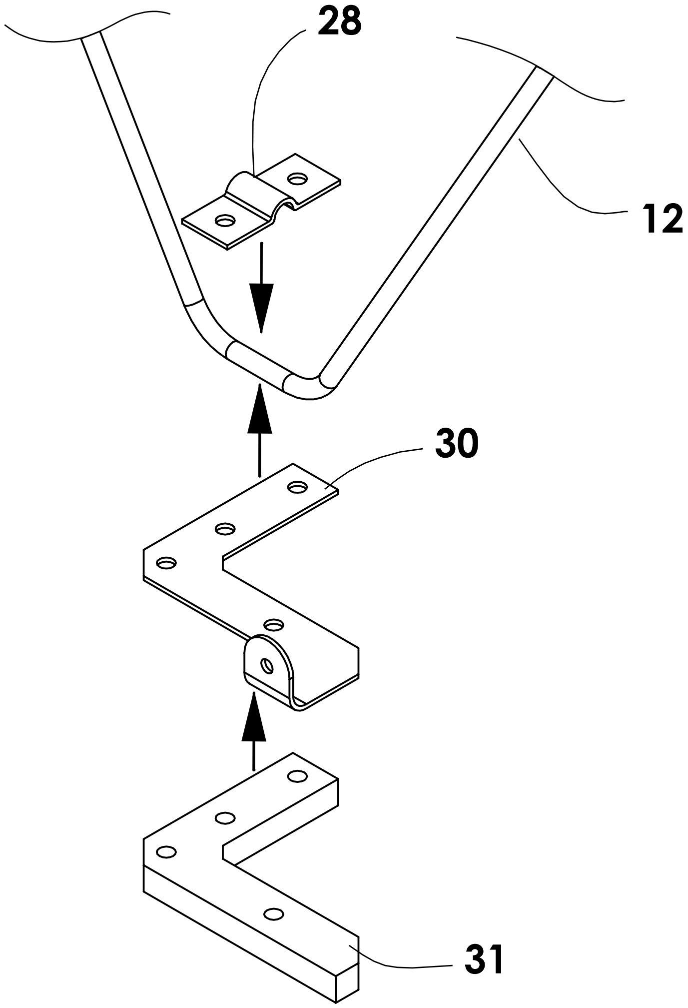


FIG. 6

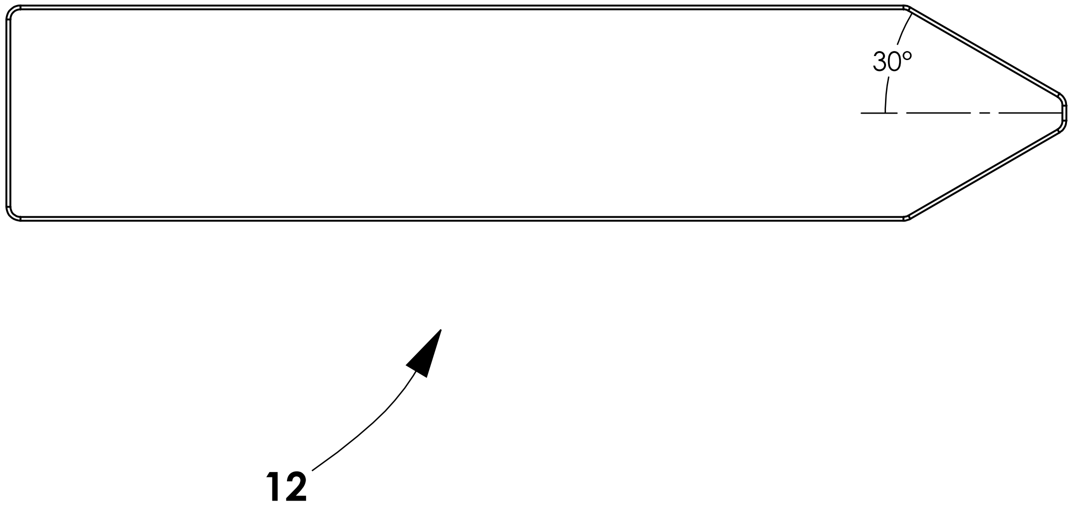


FIG. 7

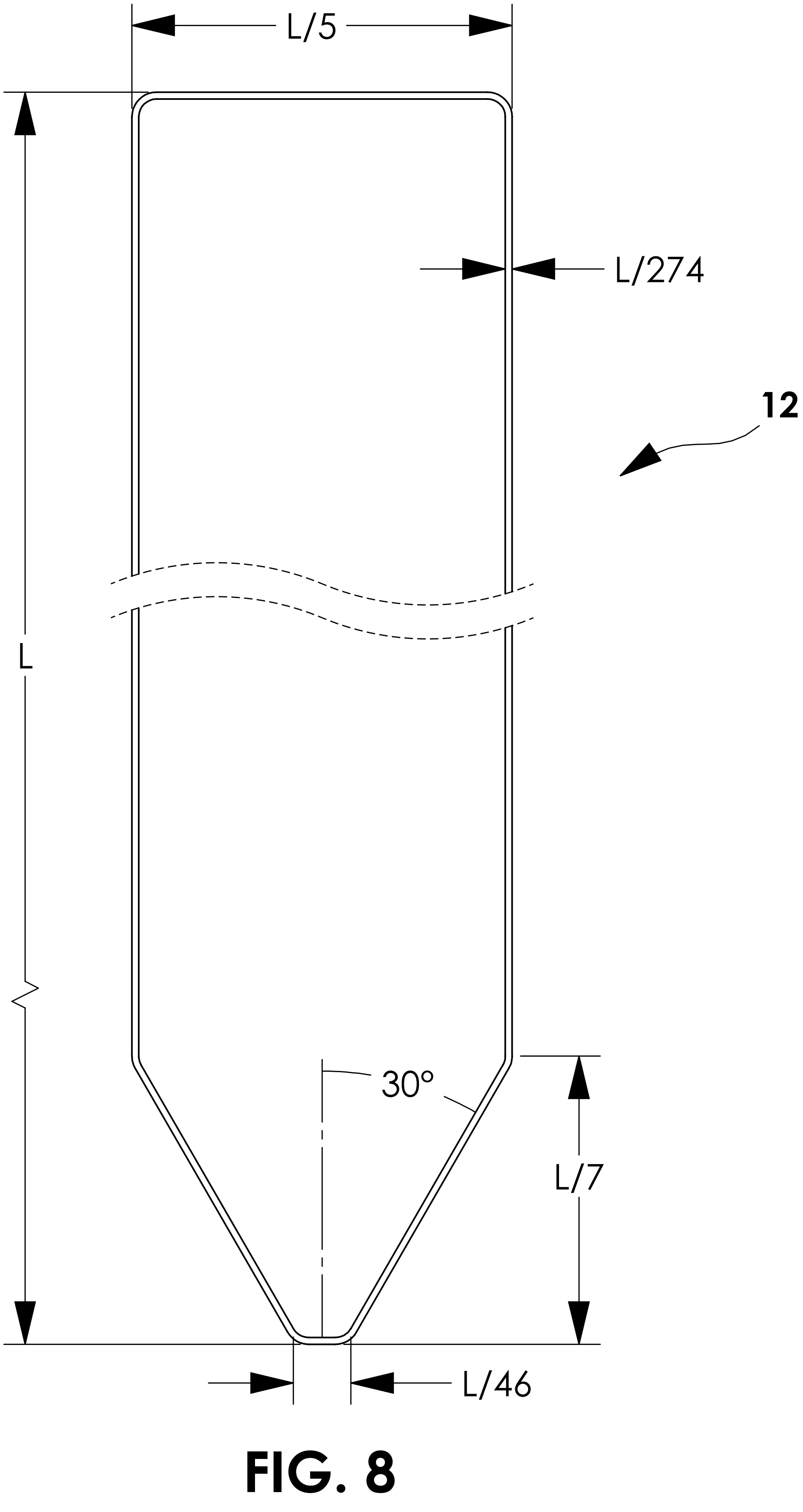


FIG. 8

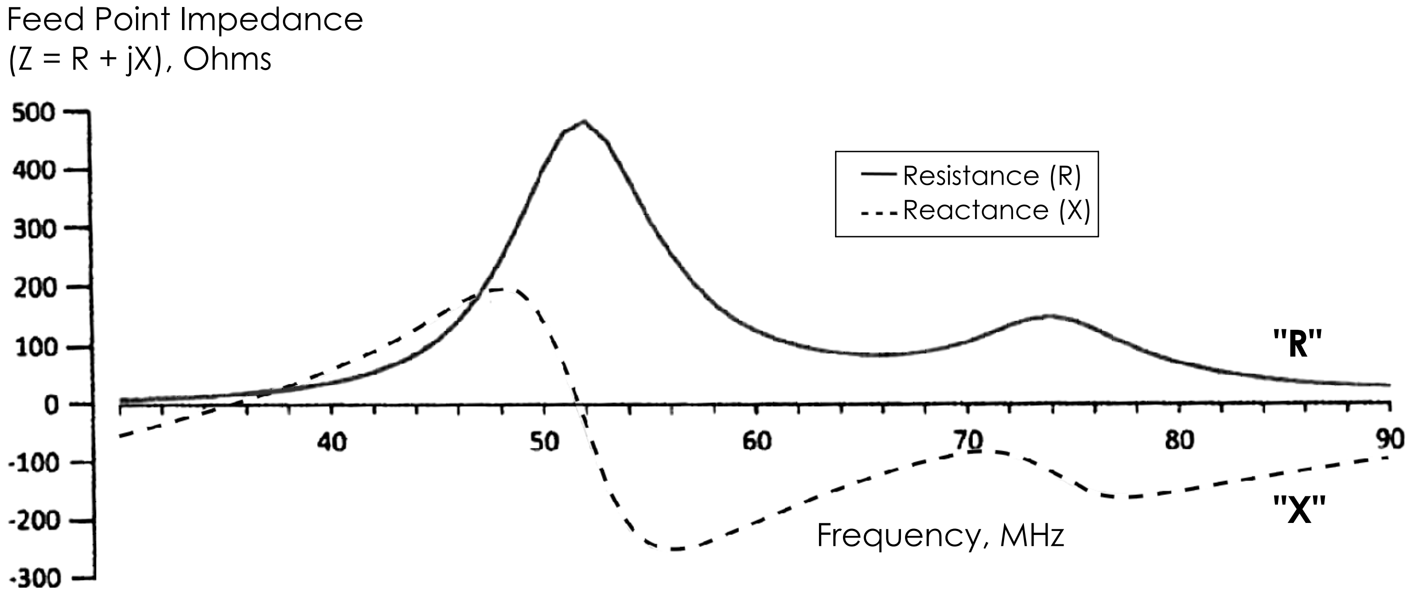

Feed Point Impedance
(Z = R + jX), Ohms
500
400
300
200
100
0
-100
-200
-300
40
50
60
70
80
90
Resistance (R)
Reactance (X)
"R"
"X"
Frequency, MHz

FIG. 9

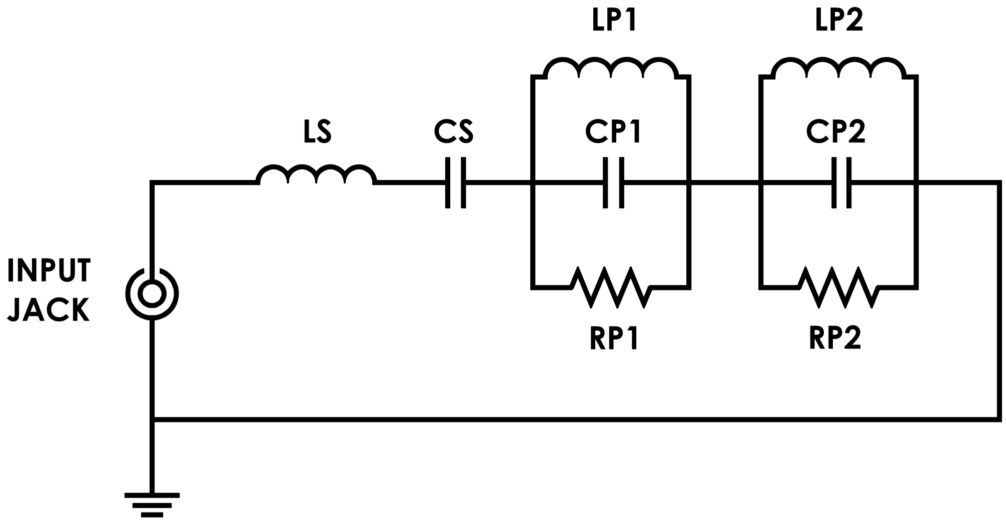


FIG. 10

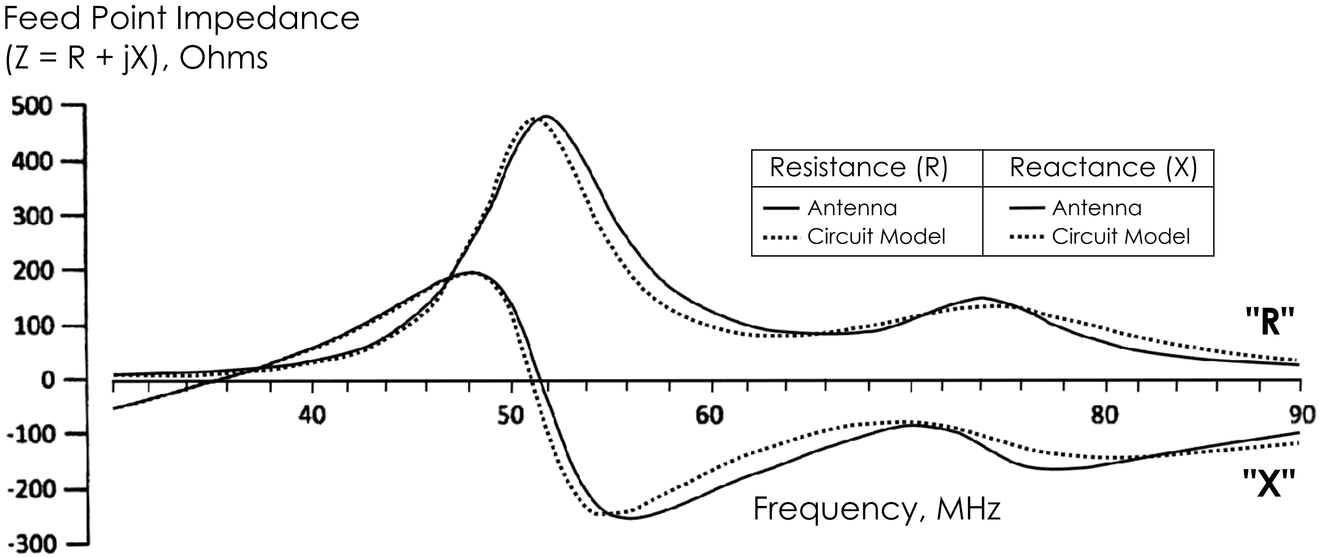

Feed Point Impedance
(Z = R + jX), Ohms
500
400
300
200
100
0
-100
-200
-300
40
50
60
80
90
Frequency, MHz
Resistance (R)
— Antenna
···· Circuit Model
Reactance (X)
— Antenna
···· Circuit Model
"R"
"X"

FIG. 11

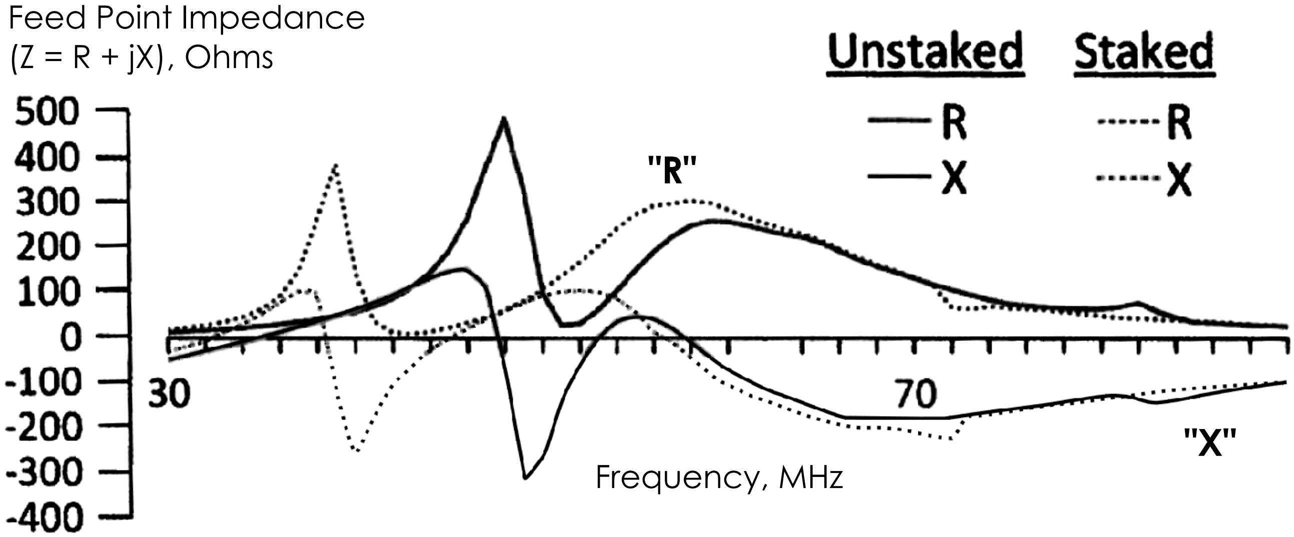

Feed Point Impedance
(Z = R + jX), Ohms
500
400
300
200
100
0
-100
-200
-300
-400
30
70
Frequency, MHz
"R"
"X"
Unstaked
Staked
R
X
R
X

FIG. 12

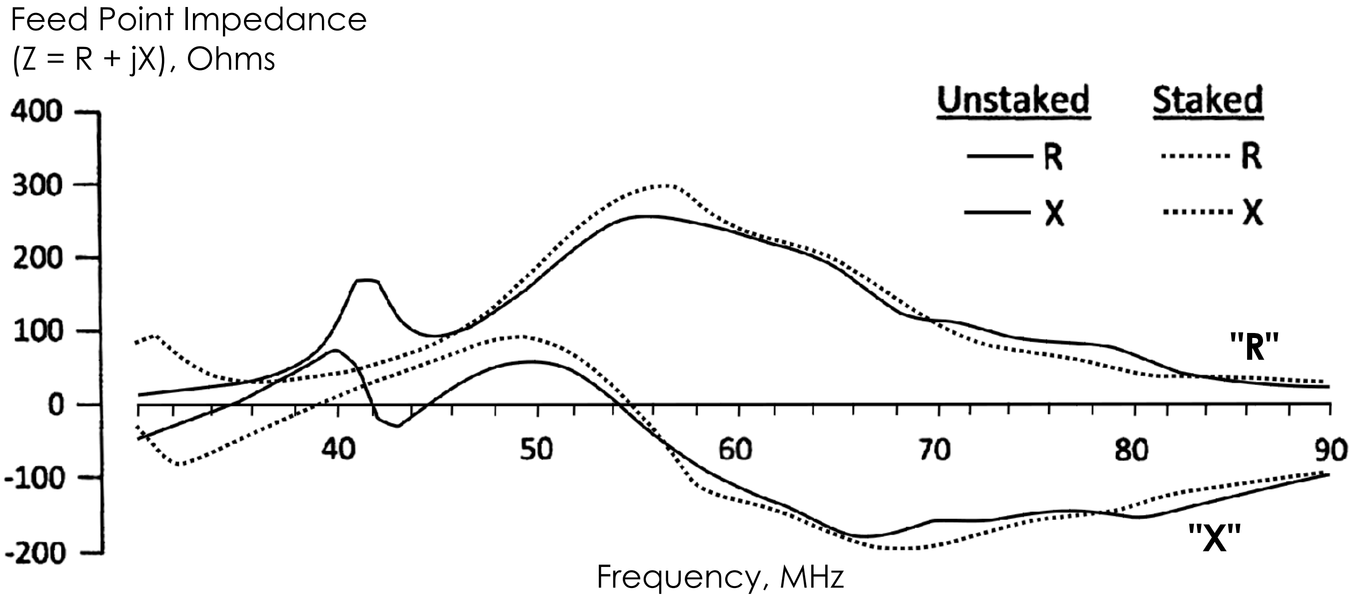

Feed Point Impedance
(Z = R + jX), Ohms
400
300
200
100
0
-100
-200
40
50
60
70
80
90
Frequency, MHz
Unstaked
Staked
R
X
R
X
"R"
"X"

FIG. 13

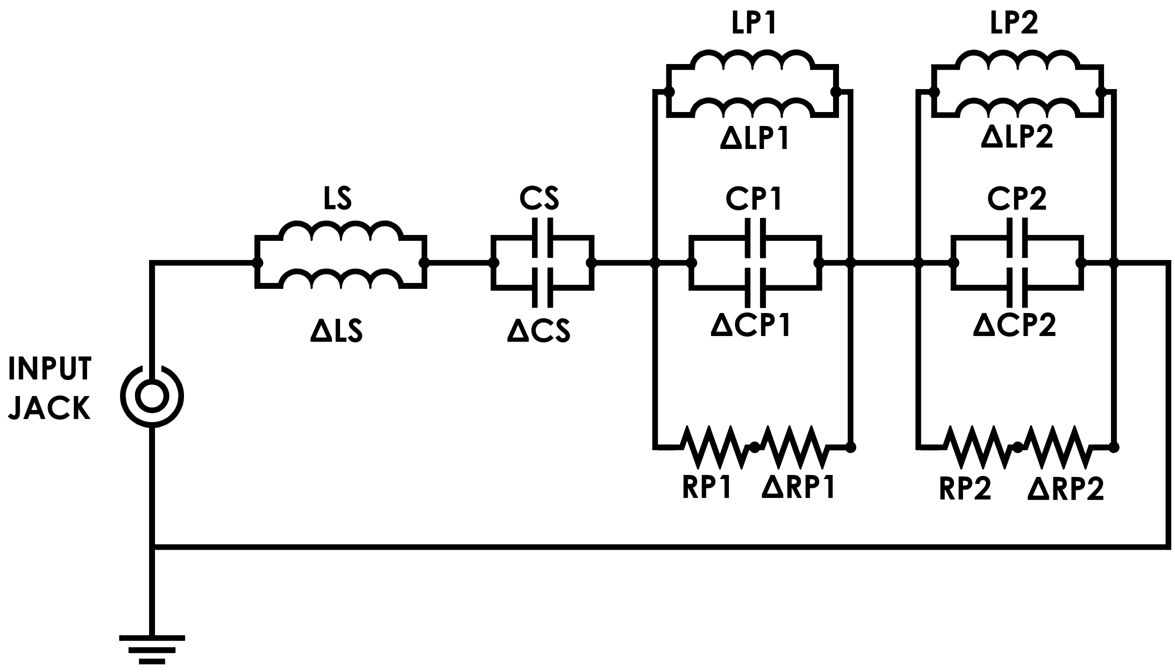

LP1
ΔLP1
LP2
ΔLP2
LS
ΔLS
CS
ΔCS
CP1
ΔCP1
CP2
ΔCP2
INPUT
JACK
RP1
ΔRP1
RP2
ΔRP2

FIG. 14

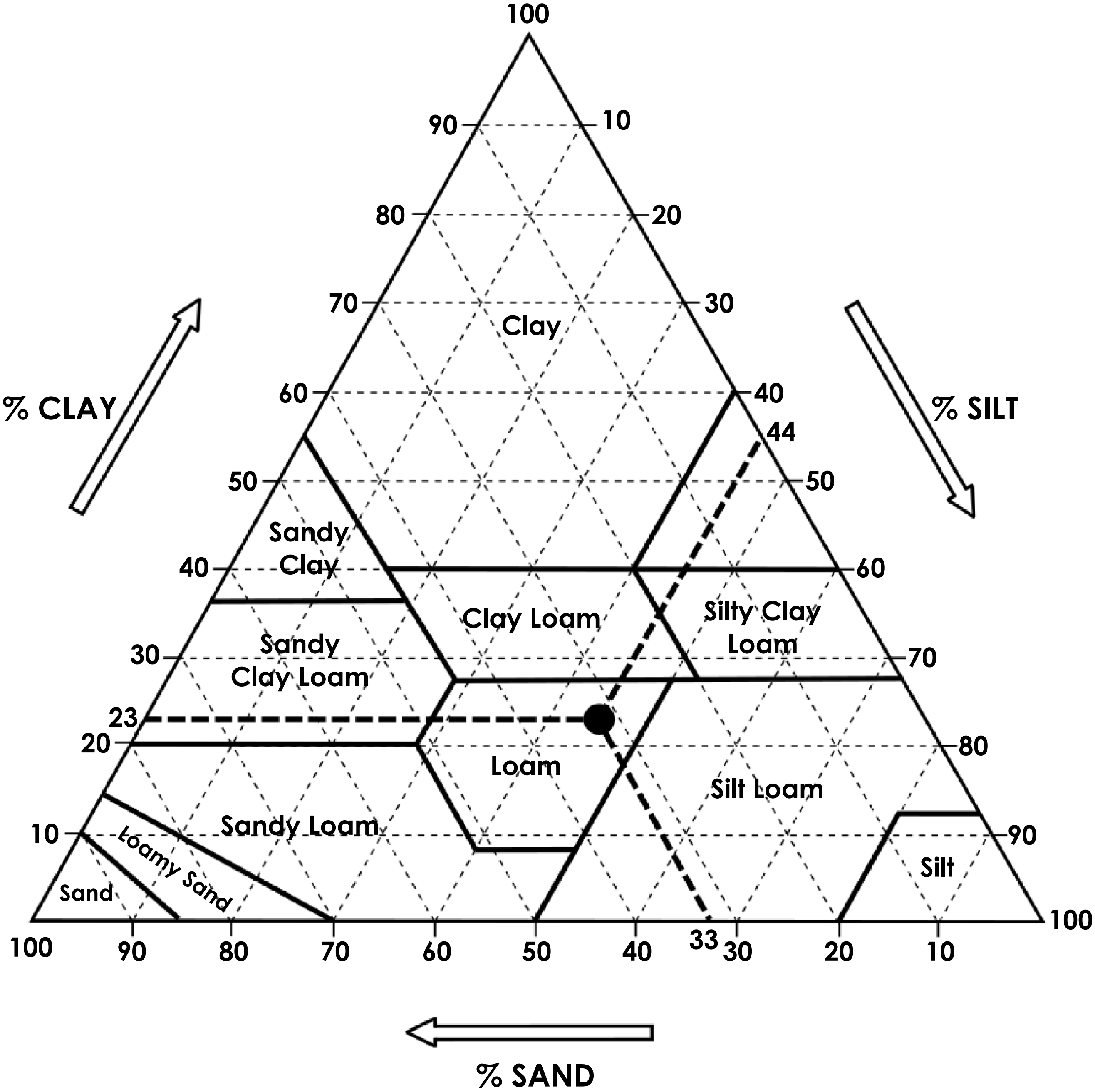

100
90
80
70
60
50
40
30
23
20
10
10
20
30
40
44
50
60
70
80
90
100
% CLAY
% SILT
% SAND
Clay
Sandy Clay
Clay Loam
Silty Clay Loam
Sandy Clay Loam
Loam
Silt Loam
Sandy Loam
Loamy Sand
Sand
Silt
100
90
80
70
60
50
40
33
30
20
10

FIG. 15

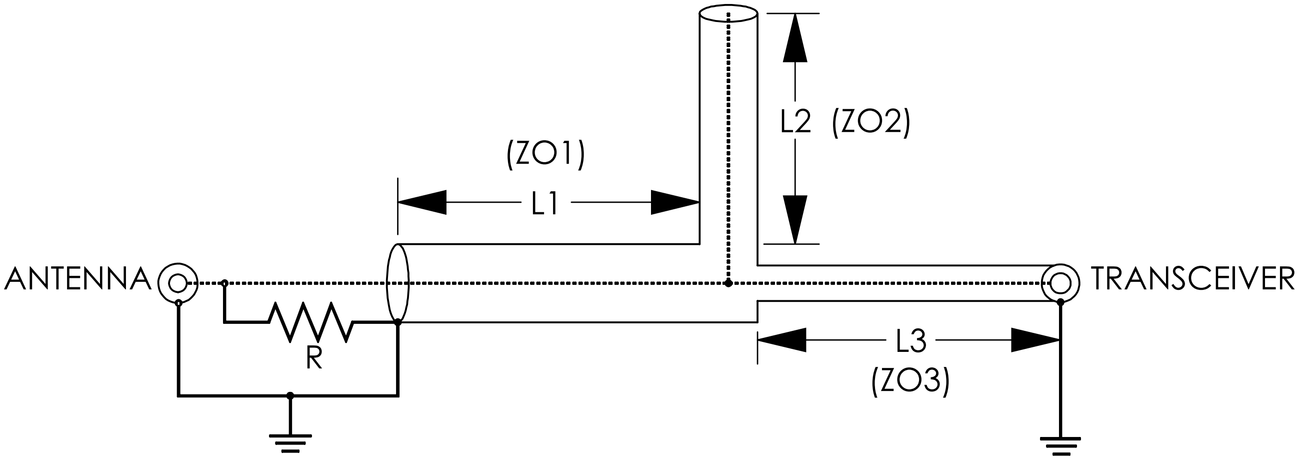


FIG. 16

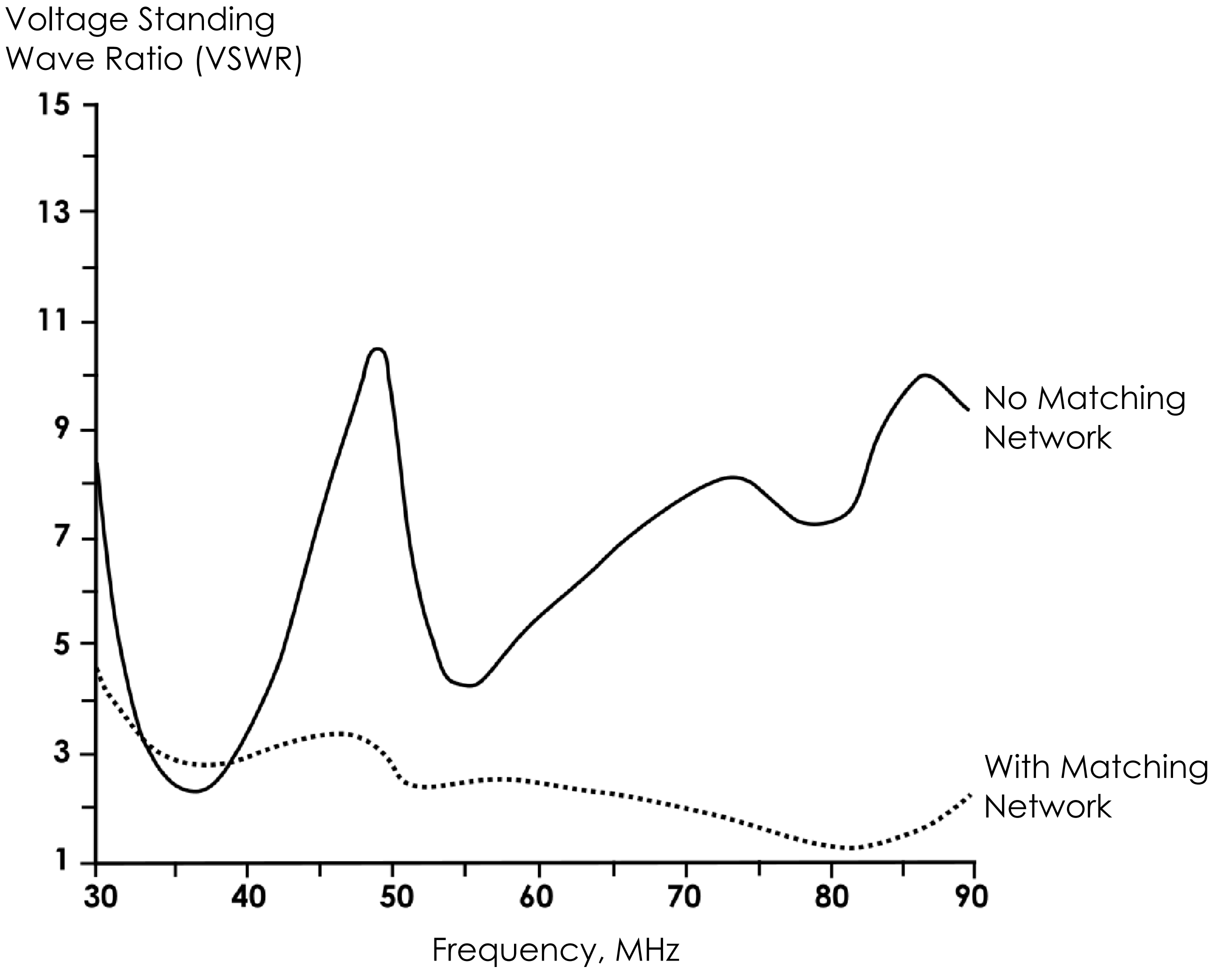

Voltage Standing
Wave Ratio (VSWR)
15
13
11
9
7
5
3
1
30
40
50
60
70
80
90
Frequency, MHz
No Matching
Network
With Matching
Network

FIG. 17

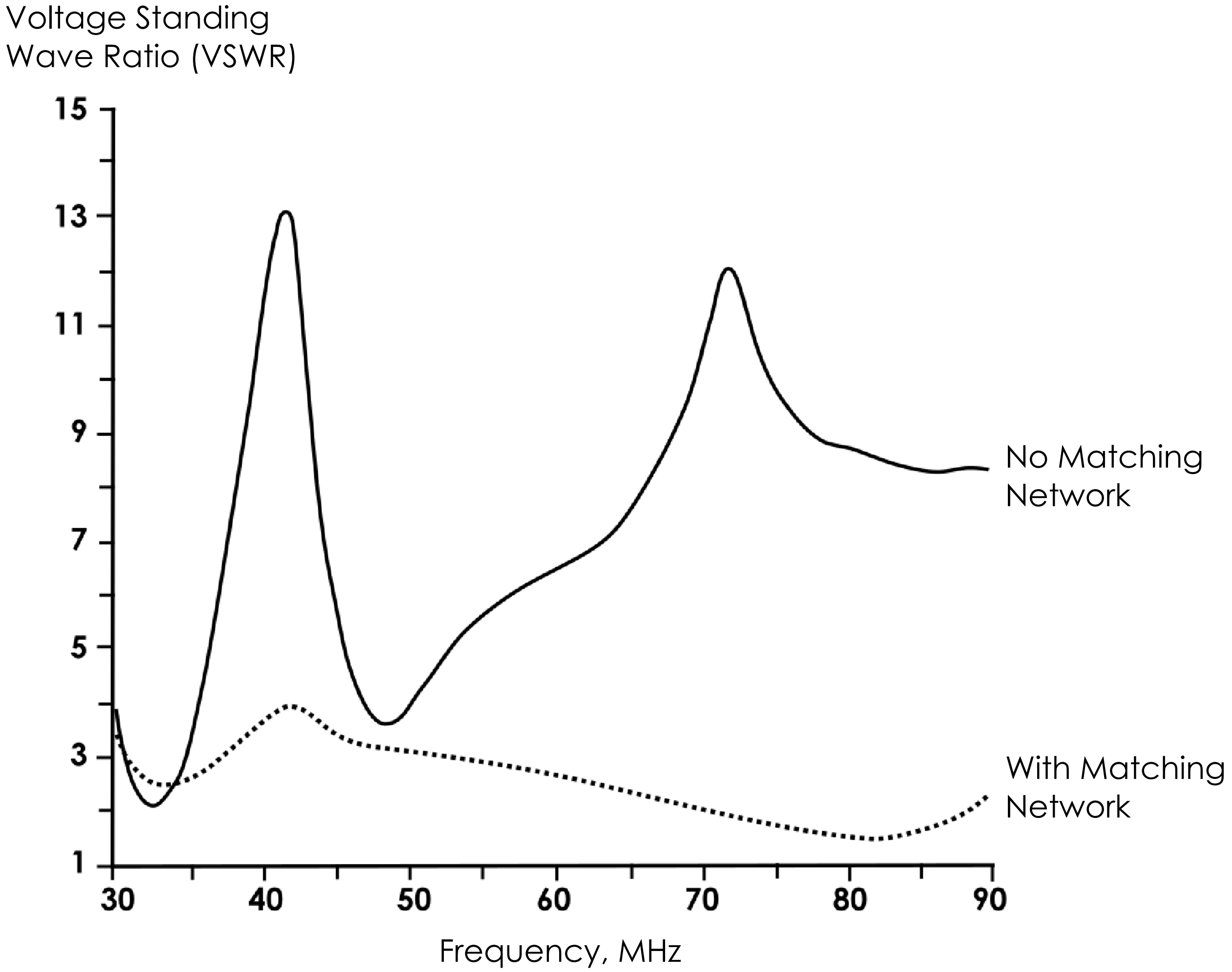

Voltage Standing Wave Ratio (VSWR)
15
13
11
9
7
5
3
1
30
40
50
60
70
80
90
Frequency, MHz
No Matching Network
With Matching Network

FIG. 18

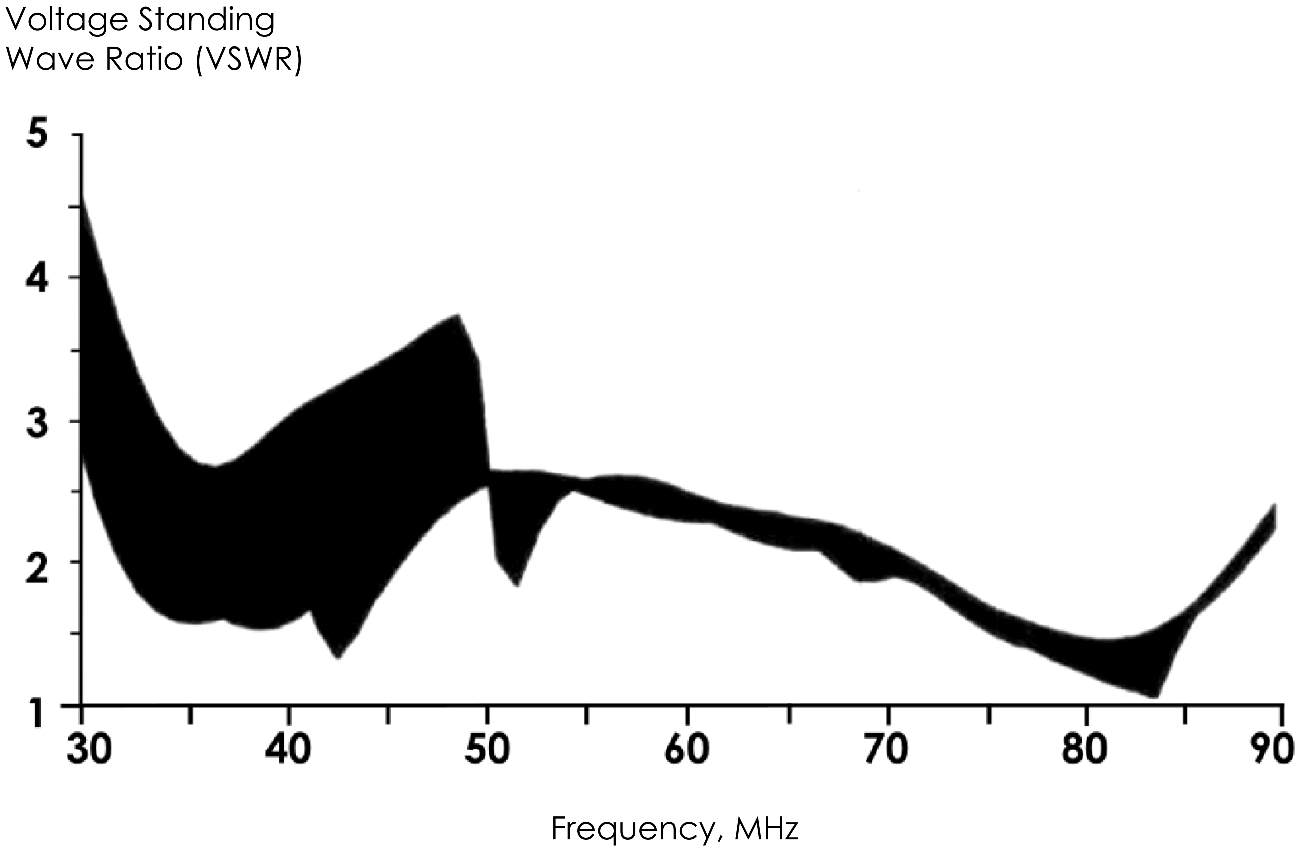

Voltage Standing
Wave Ratio (VSWR)
5
4
3
2
1
30
40
50
60
70
80
90
Frequency, MHz

FIG. 19

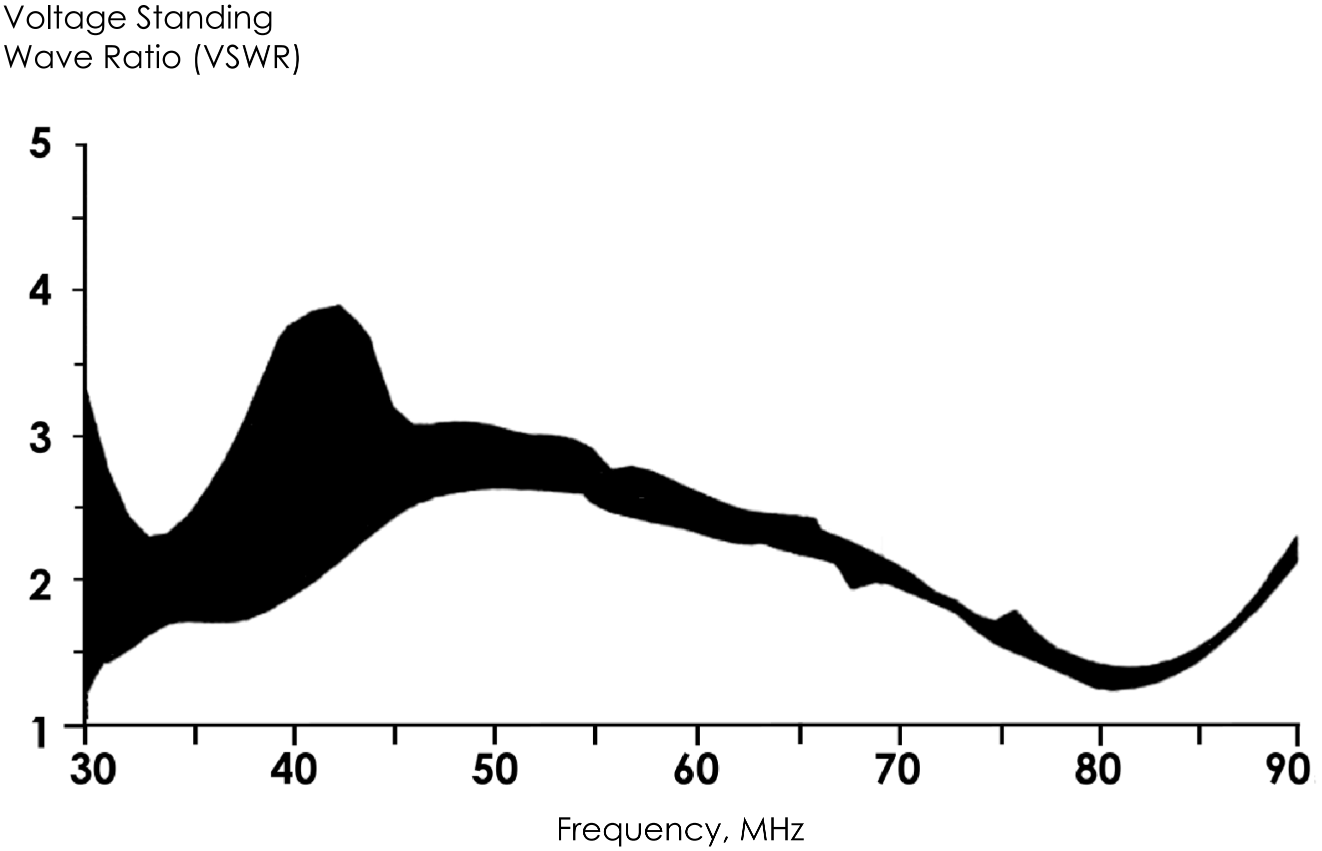
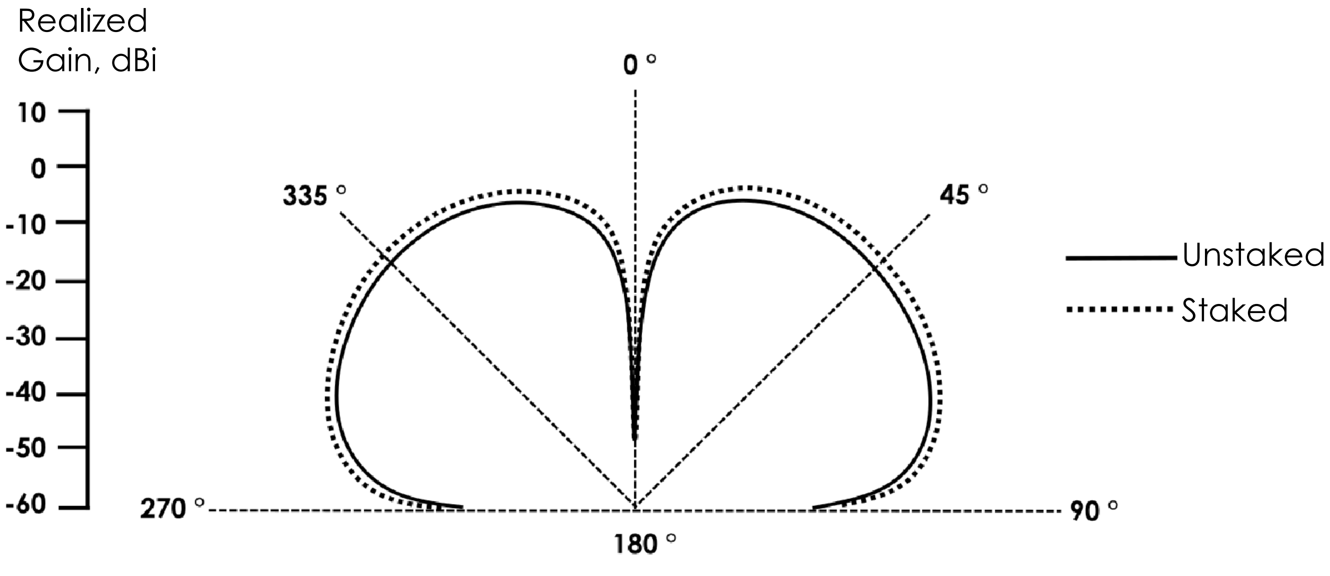

Voltage Standing Wave Ratio (VSWR)
5
4
3
2
1
30
40
50
60
70
80
90
Frequency, MHz

FIG. 20



Elevation Beam Pattern

FIG. 21

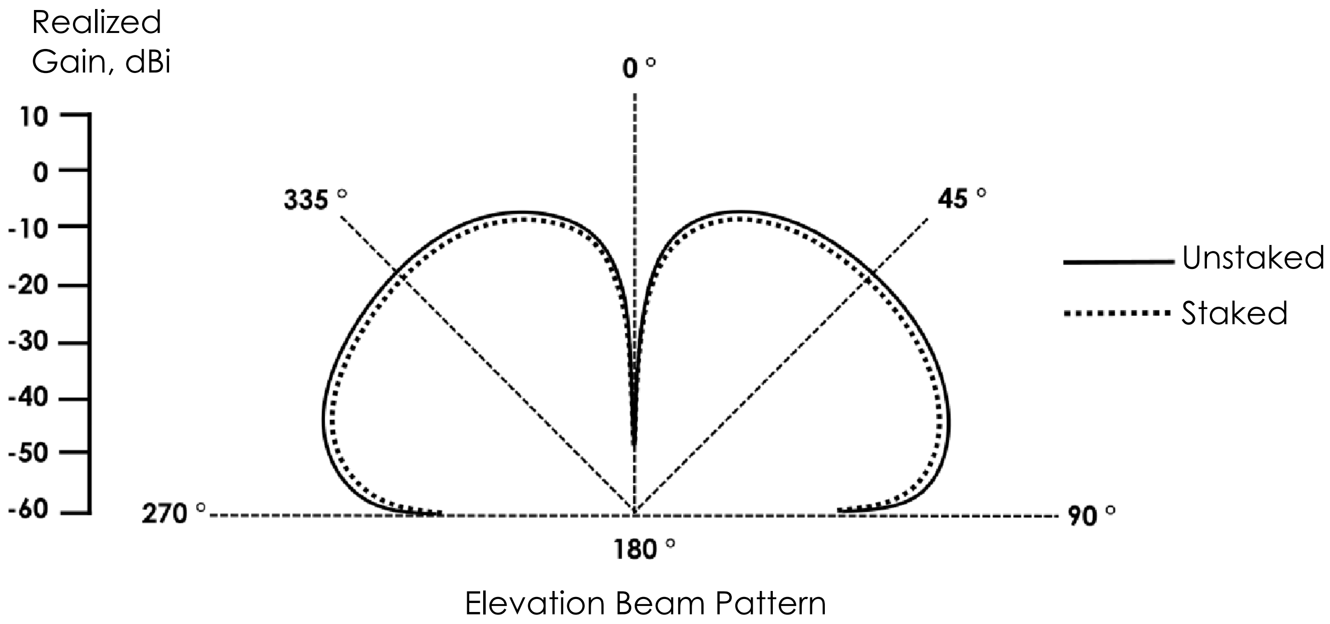

Realized
Gain, dBi
10
0
-10
-20
-30
-40
-50
-60
0 °
335 °
45 °
270 °
90 °
180 °
Unstaked
Staked
Elevation Beam Pattern

FIG. 22

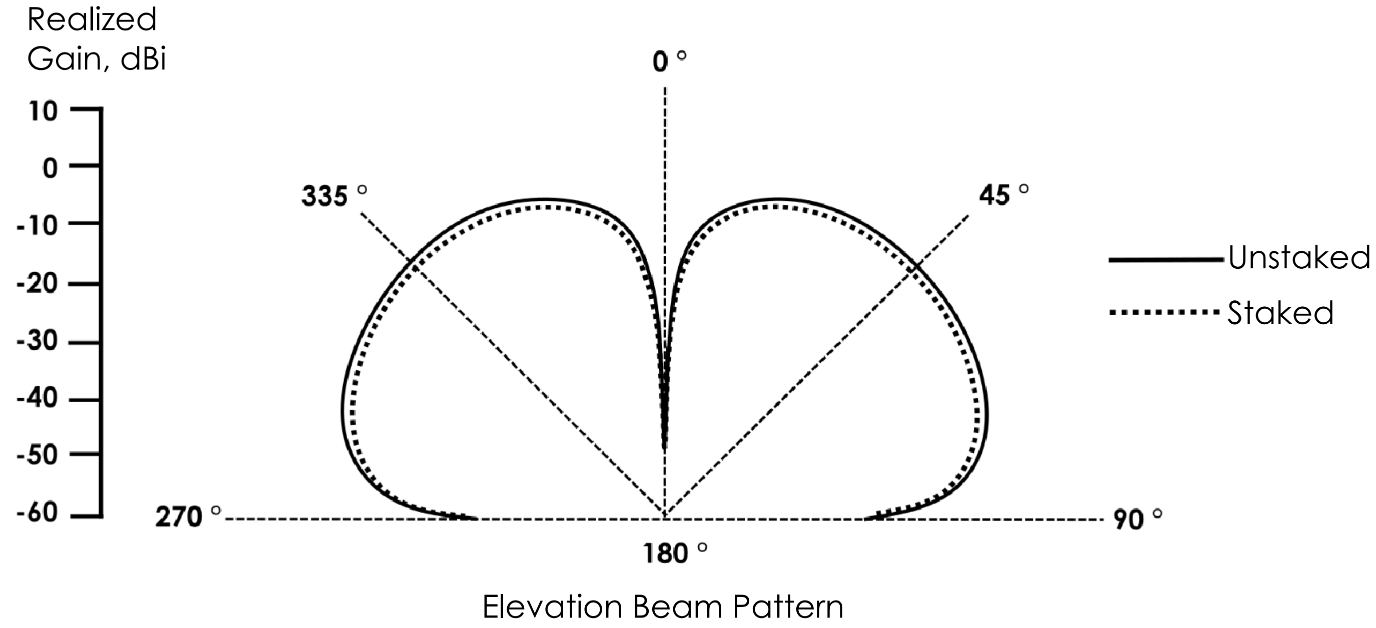
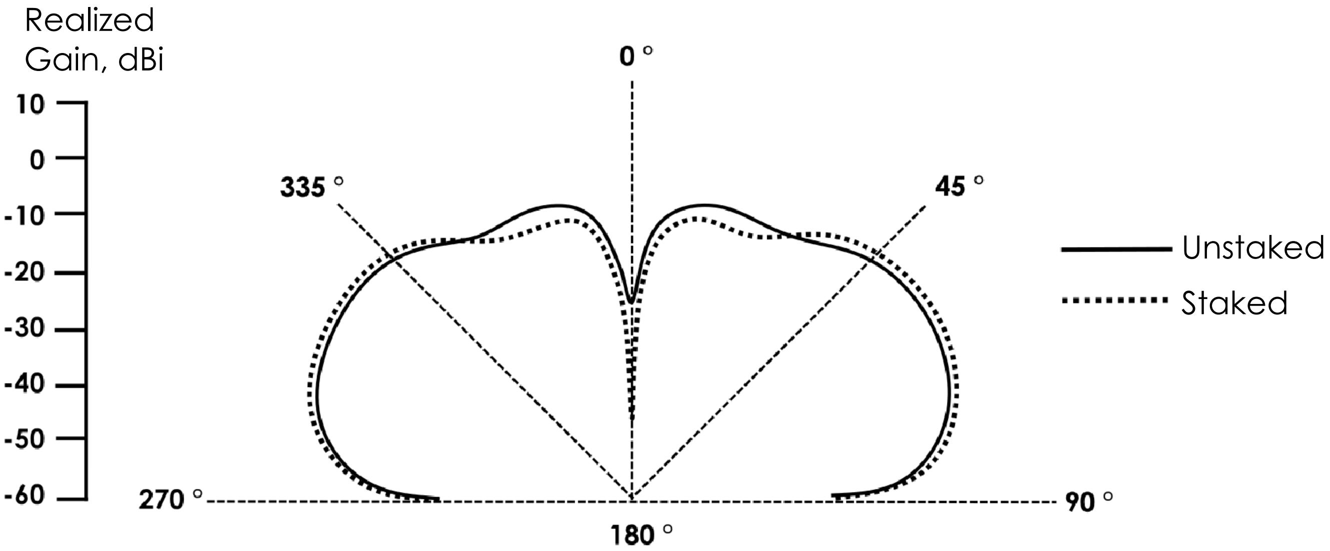

Realized
Gain, dBi
10
0
-10
-20
-30
-40
-50
-60
0 °
335 °
45 °
270 °
90 °
180 °
Unstaked
Staked
Elevation Beam Pattern

FIG. 23



Elevation Beam Pattern

FIG. 24

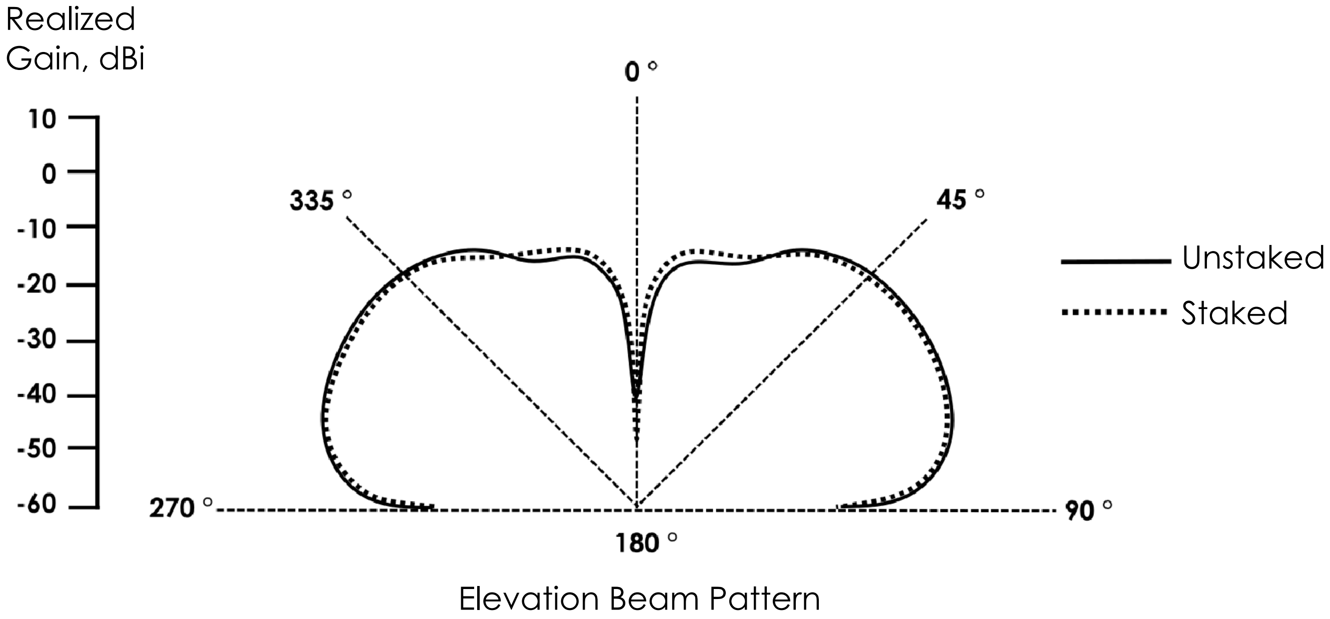
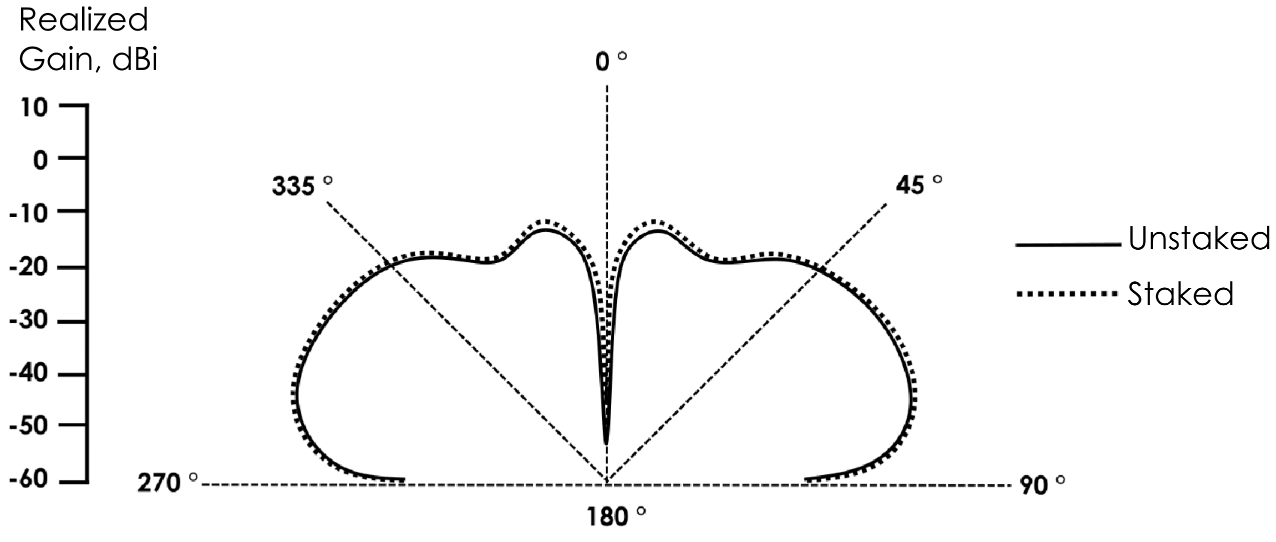

Realized
Gain, dBi
10
0
-10
-20
-30
-40
-50
-60
0 °
335 °
45 °
270 °
90 °
180 °
Unstaked
Staked
Elevation Beam Pattern

FIG. 25



Elevation Beam Pattern

FIG. 26

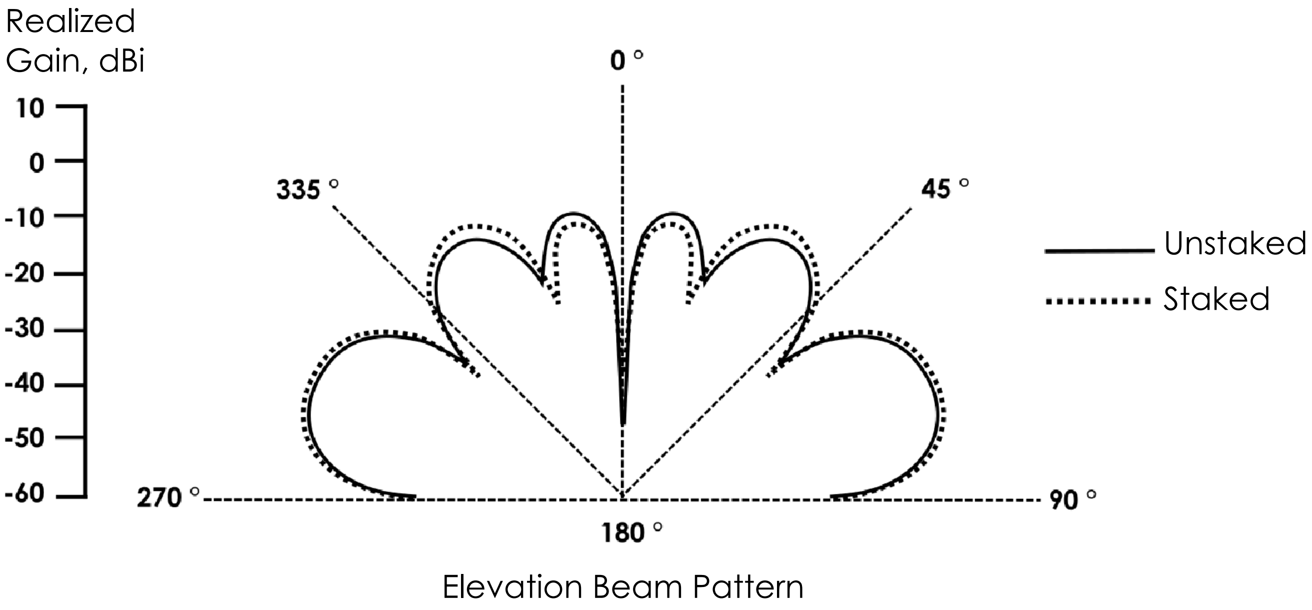

Realized
Gain, dBi
10
0
-10
-20
-30
-40
-50
-60
0 °
335 °
45 °
270 °
90 °
180 °
Unstaked
Staked
Elevation Beam Pattern

FIG. 27

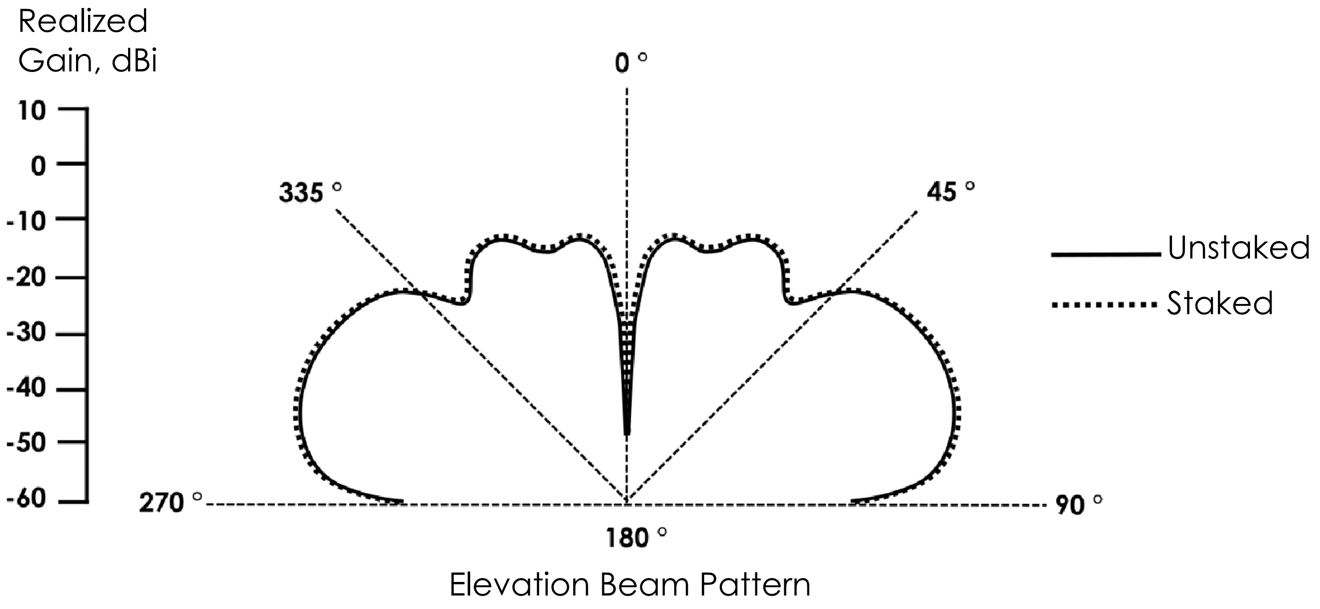

Realized
Gain, dBi
10
0
-10
-20
-30
-40
-50
-60
0 °
335 °
45 °
270 °
90 °
180 °
Unstaked
Staked
Elevation Beam Pattern

FIG. 28

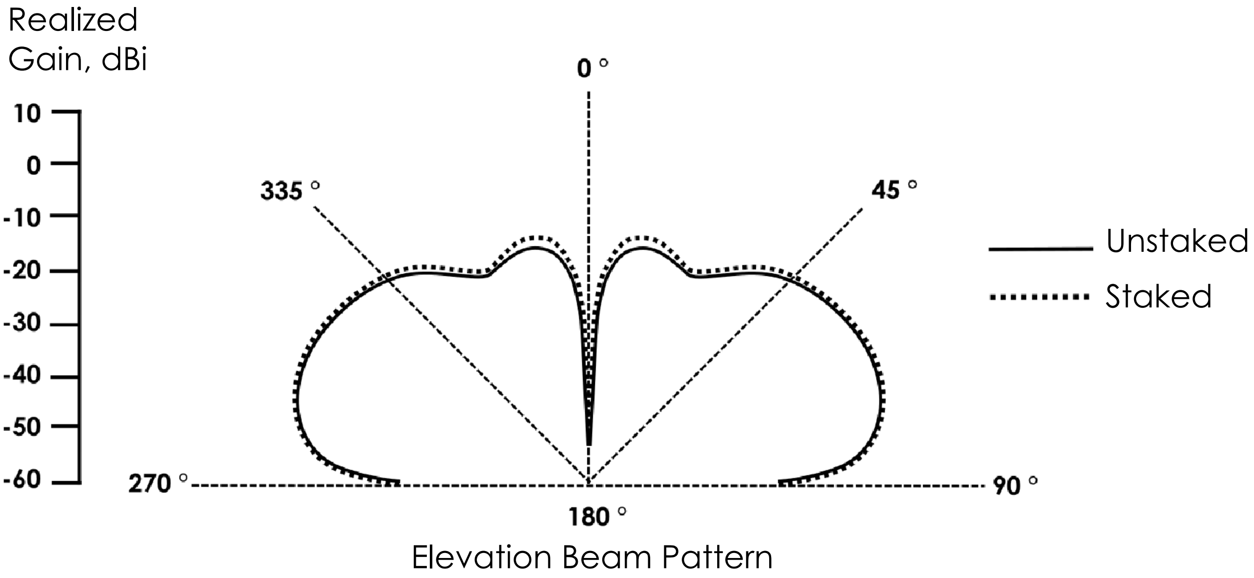

Realized
Gain, dBi
10
0
-10
-20
-30
-40
-50
-60
0 °
335 °
45 °
270 °
90 °
180 °
Unstaked
Staked
Elevation Beam Pattern

FIG. 29