ANTENNA THEORY

WAVE PROPAGATION

&

HF ANTENNAS

FREQUENCY SPECTRUM INFORMATION

Frequency range	American designator
below 300 Hz	ELF (extremely Low Frequency)
300-3000 Hz	ILF (Intermediate Low Frequency)
3 - 300 Khz	VLF (Very Low Frequency)
30-300 Khz	LF (Low Frequency)
300-3000 Khz	MF (Medium Frequency)
3 - 30 Mhz	HF (High Frequency)
30-300 Mhz	VHF (Very High Frequency)
300-3000 Mhz	UHF (Ultra High Frequency)
3 - 30 Ghz	SHF (Super High Frequency)
30-300 Ghz	EHF (Extremely High Frequency)

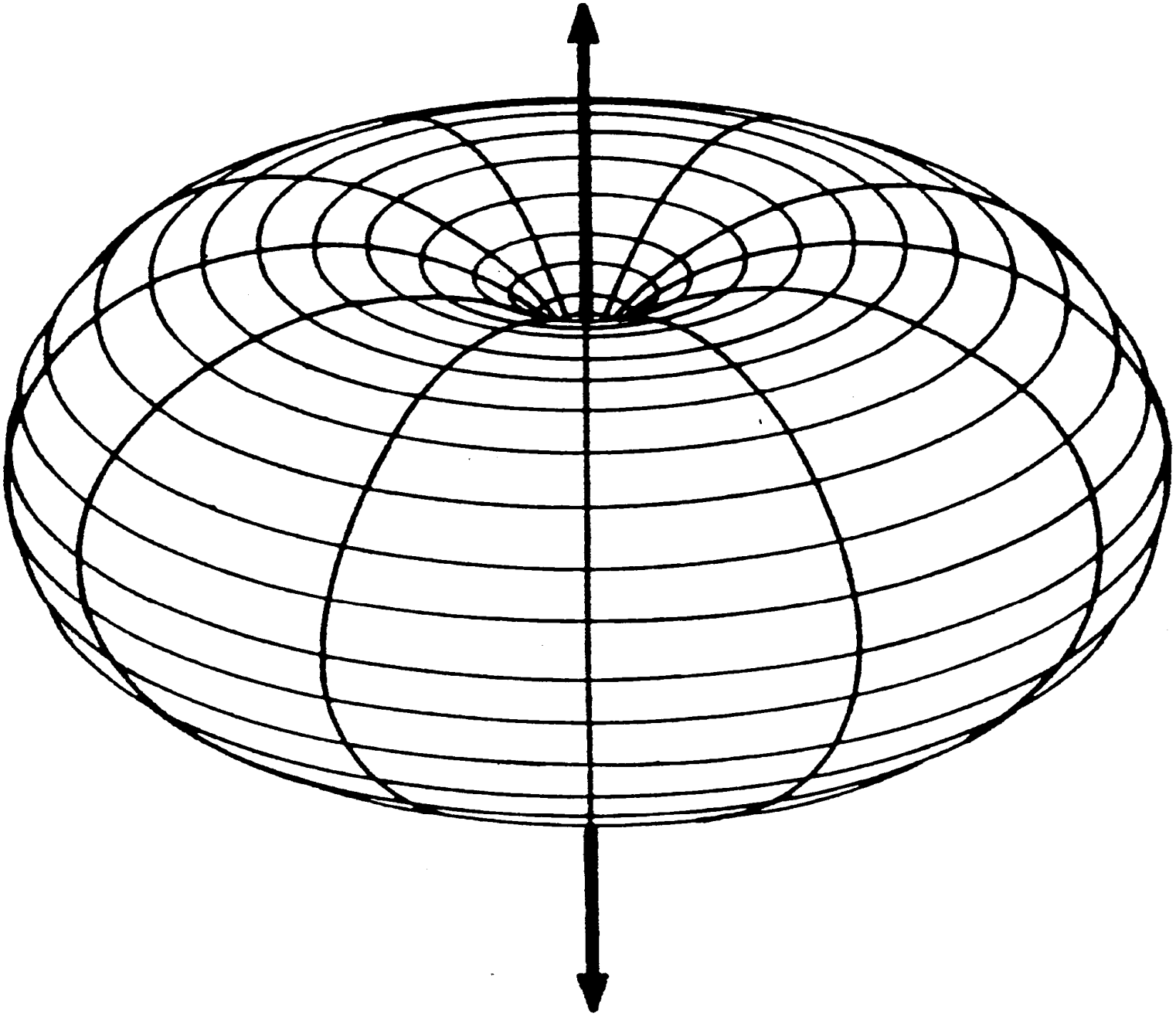
RADIO COMMUNICATIONS SYSTEM

Energy is generated by a radio transmitter by oscillating or vibrating at a given frequency, that energy is then fed to an antenna which radiates the energy into space at the speed of light about 186,000 miles per second. A receiving antenna sends the energy to a receiver which then modulates the frequency into audio to be heard by the human ear.

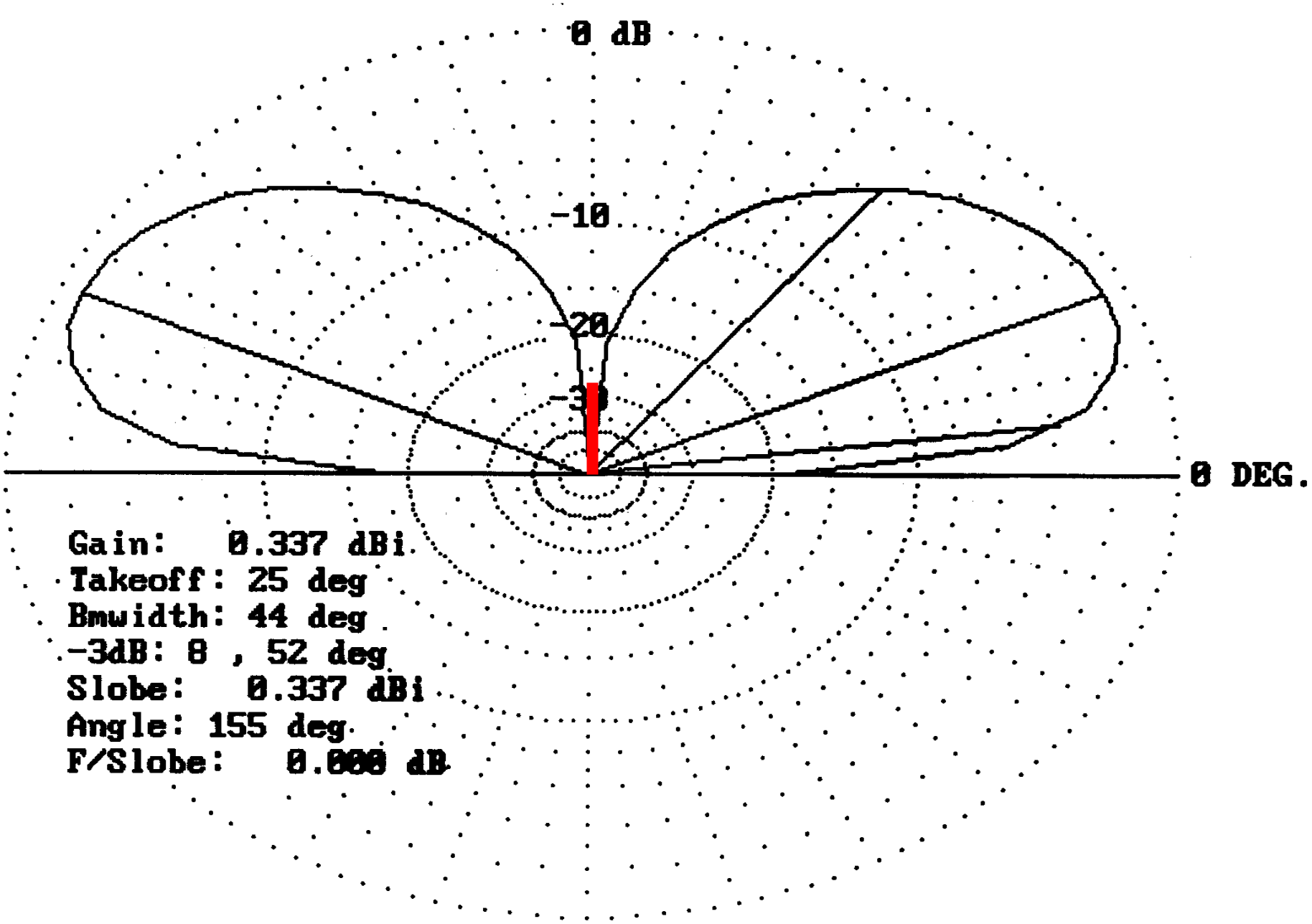
TRANSMITTING ANTENNA

Converts output energy from the radio transmitter into an electromagnetic field which the receiving antenna converts back to energy acceptable by the receiver. (A vertical whip antenna radiates or propagates in a 360 degree radius.

RADIATION PATTERN - WHIP ANTENNA



RADIATION PATTERN-WHIP ANTENNA (SIDE VIEW)



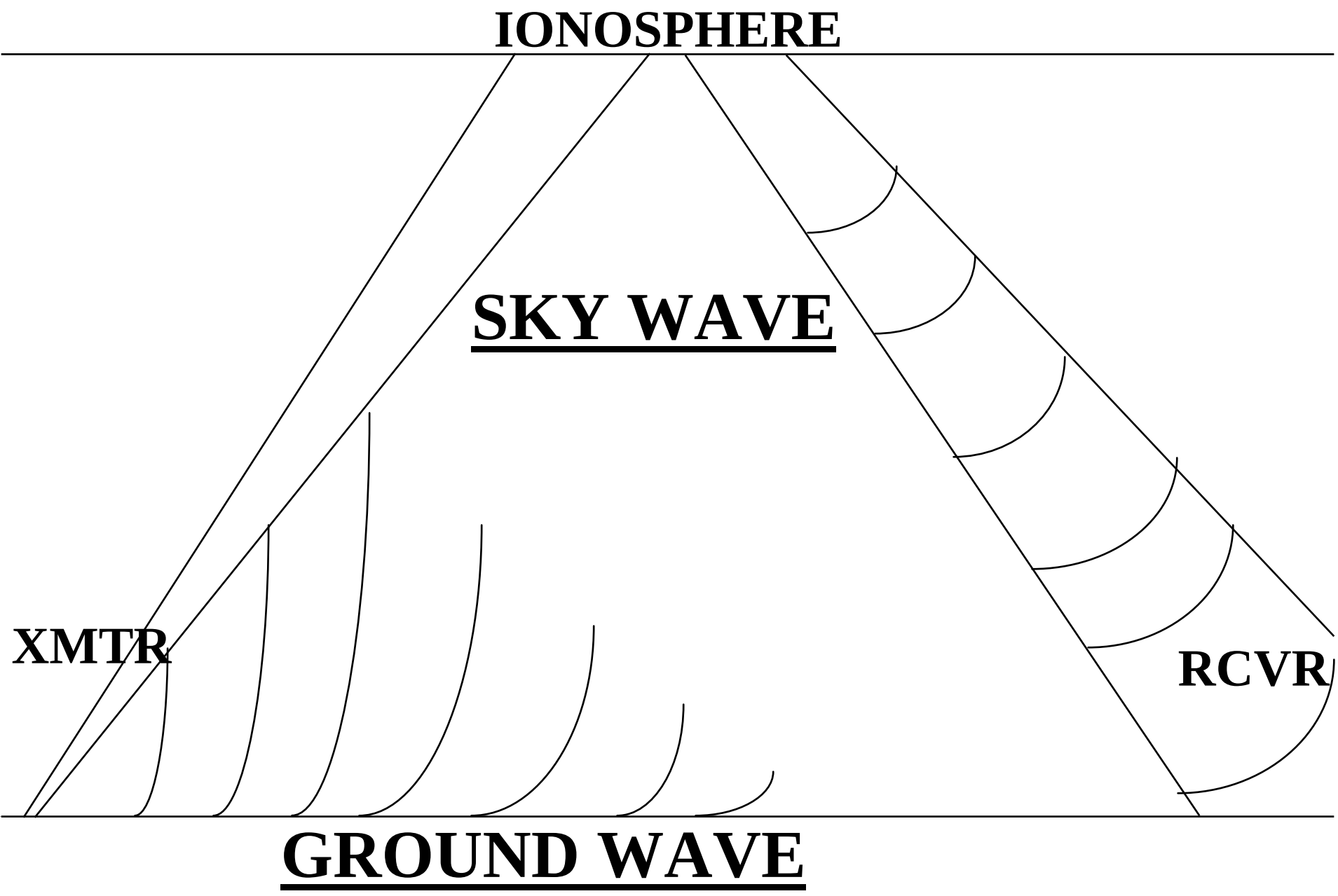
RADIO WAVE

Has 3 characteristics and they are: Speed which is the speed of light. Frequency which is the number of cycles completed by a radio wave in one second. Wavelength which is the distance from one point on a radio wave to the same point on the next radio wave.

TYPES OF RADIO WAVES

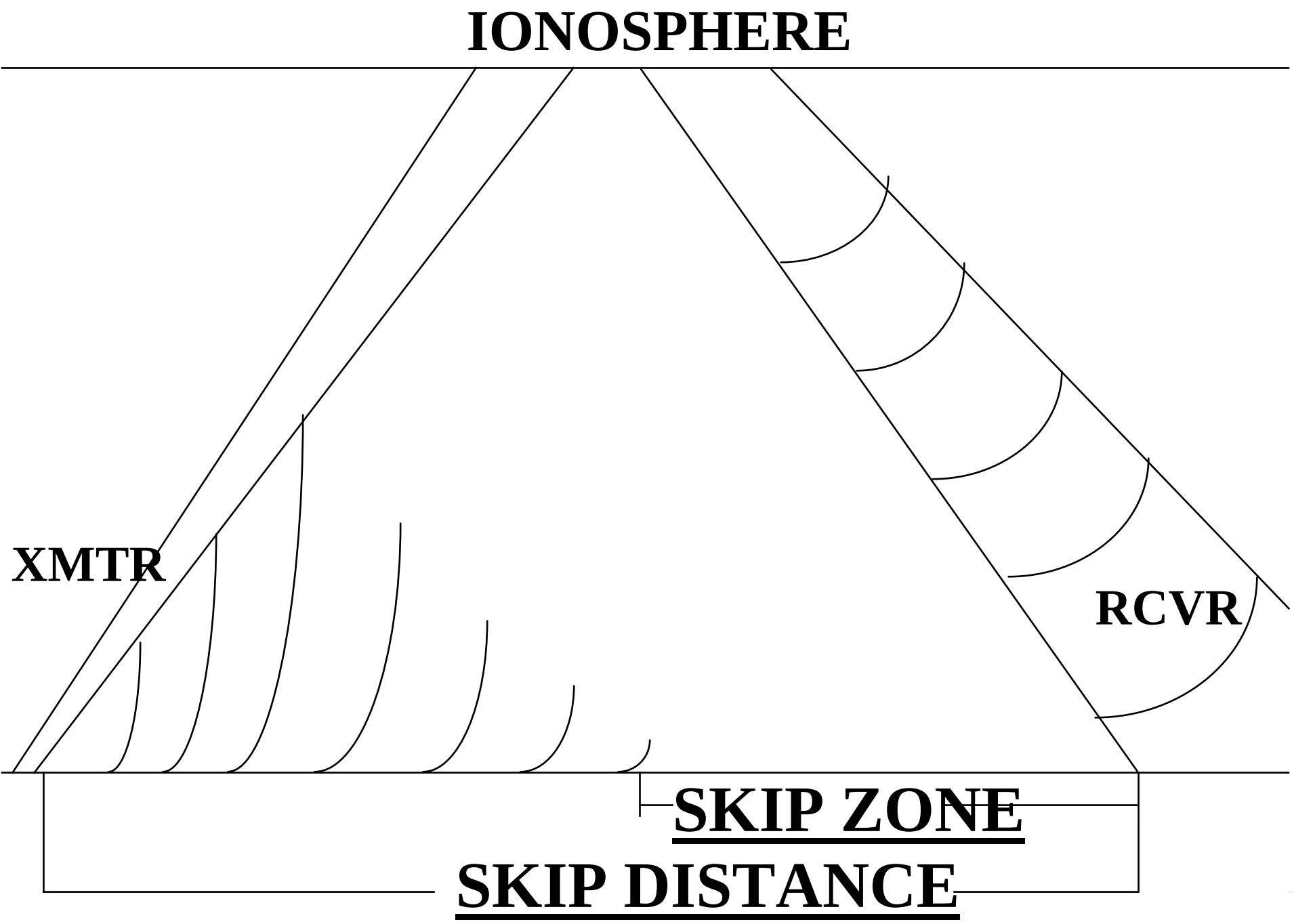
Ground waves- travel along the surface of the earth. It can be refracted off the ground or directly to the receiving antenna. It is used for short range communications because the radio waves can be absorbed by the earth and other objects such as a large electrical current. Ground waves are for very high frequencies (VHF) because they do not reflect off the ionosphere.

Sky waves- on the other hand make use of the ionosphere and reflect radio waves back to earth, and therefore will reach out to further distances. The reflected wave usually uses the lower F layer and may vary depending upon the ionospheric conditions, the frequency of the wave, and the angle at which it is reflected.


IONOSPHERE
SKY WAVE
XMTR
RCVR
GROUND WAVE

SKIP ZONE / SKIP DISTANCE

Skip zone is the zone of silence between the point where the ground wave is to weak for reception and where the sky wave is returned to earth. Skip distance is the total distance between the transmitter and where the radio wave is returned to earth. Both the skip zone and the skip distance is determined by the radiation takeoff angle and the angle at which the radio wave hits the ionosphere. The higher the angle, the shorter the distance and the lower the angle the longer the distance. The higher the antenna is off the ground the lower the take off angle, and the lower the antenna is off the ground, the higher the takeoff angle.

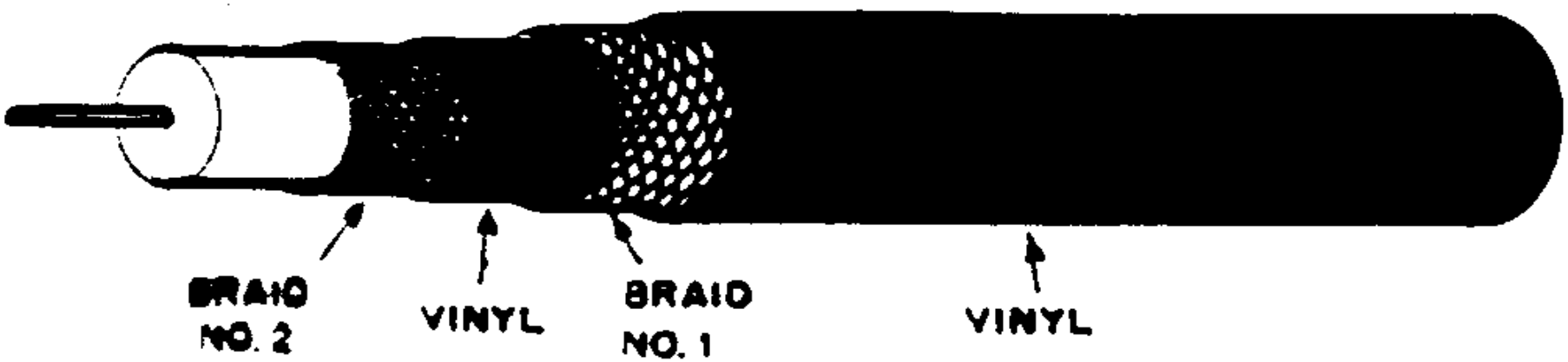

IONOSPHERE
XMTR
RCVR
SKIP ZONE
SKIP DISTANCE

TRANSMISSION LINES

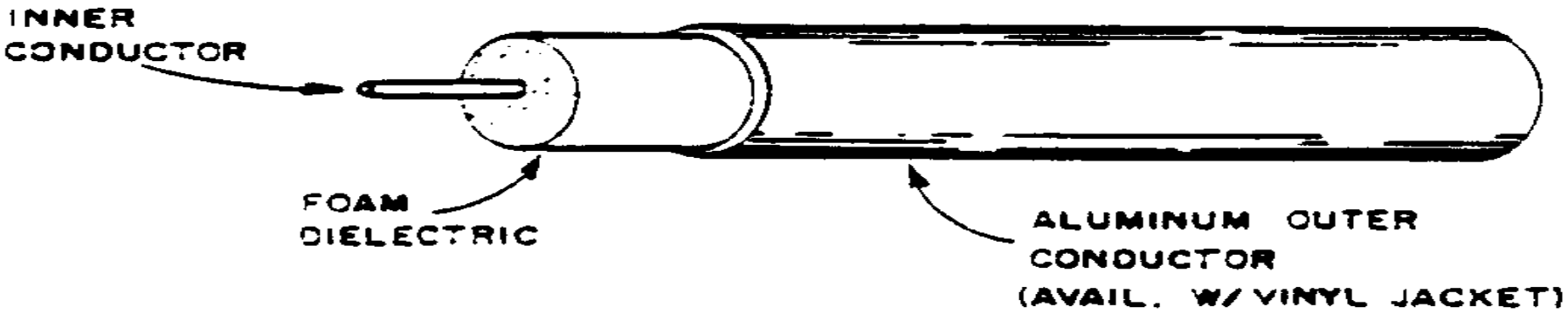
The connecting link between the transmitter and the antenna. There are several types, such as Coaxial cable, single wire, insulated 2 wire, ladder line, and twisted pair. Each transmission line has it's own characteristic impedence (resistance), and is either balanced or unbalanced. Unbalanced is when one part of the wire is at ground potential, such as coaxial cable. Feed Point is the point at which the transmission is connected to the antenna, usually with a Balun (balanced to unbalanced transformer), or an insulator of some sort.

FEEDLINES

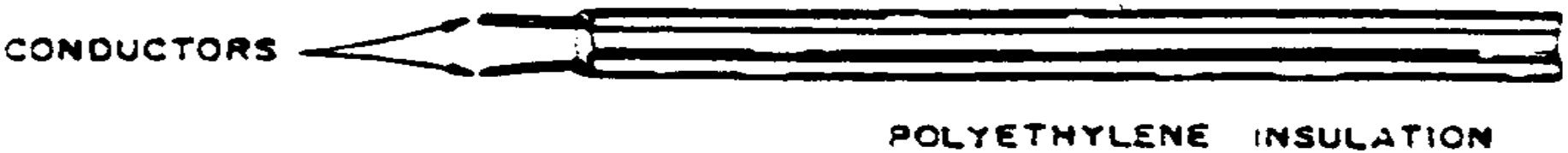
SINGLE – SHIELDED



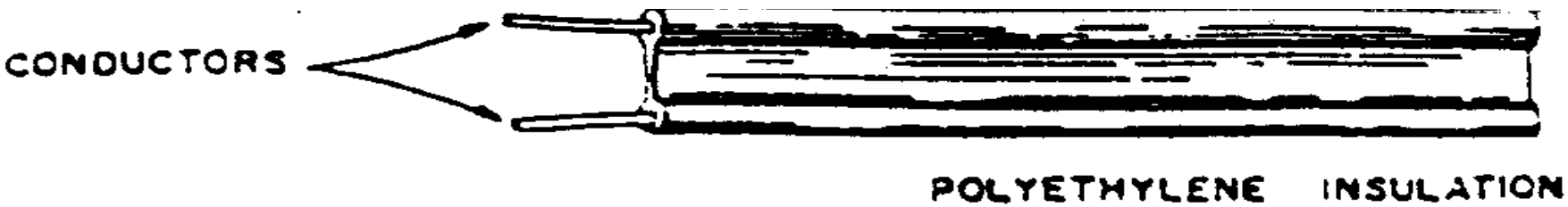
DOUBLE – SHIELDED



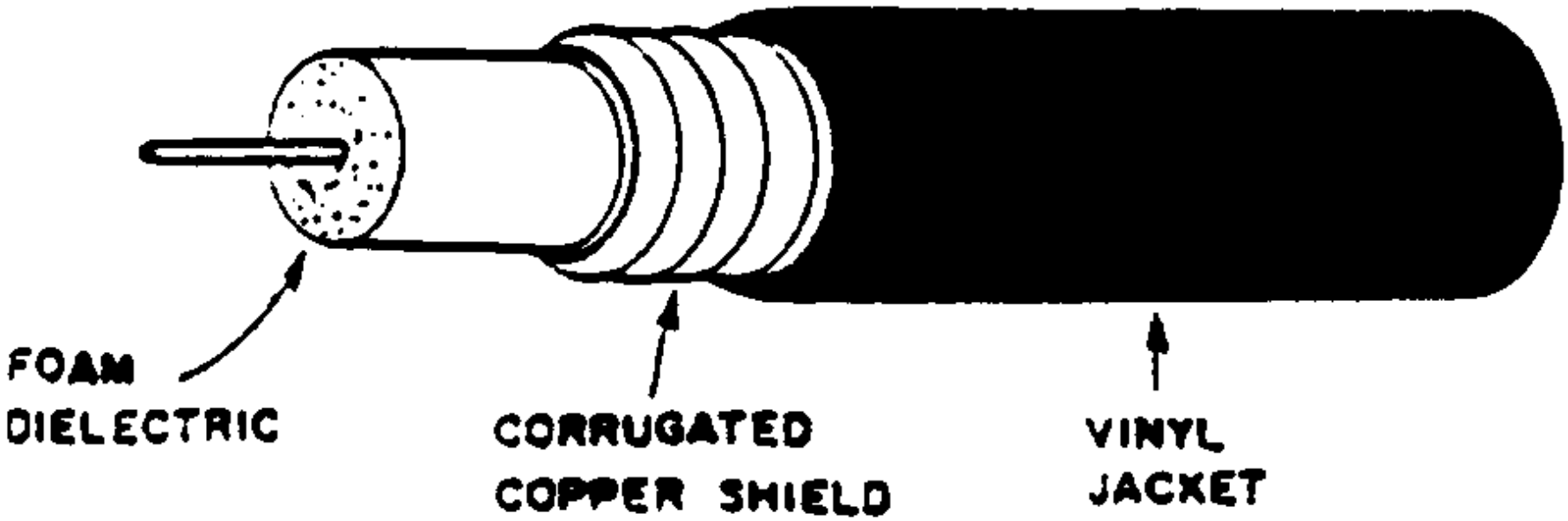
HARDLINE



75-OHM TWIN-LEAD

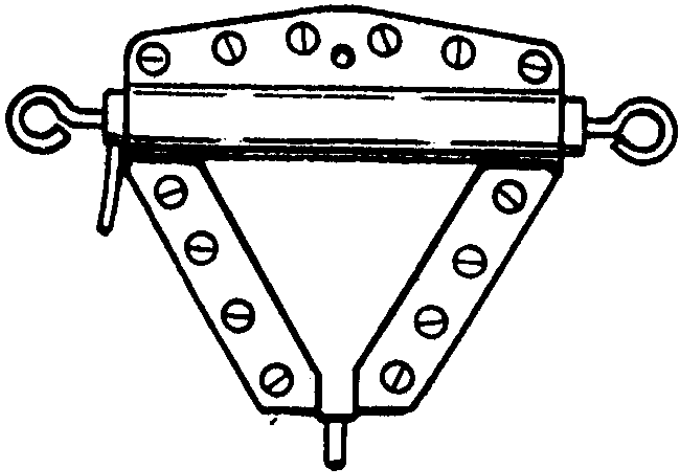


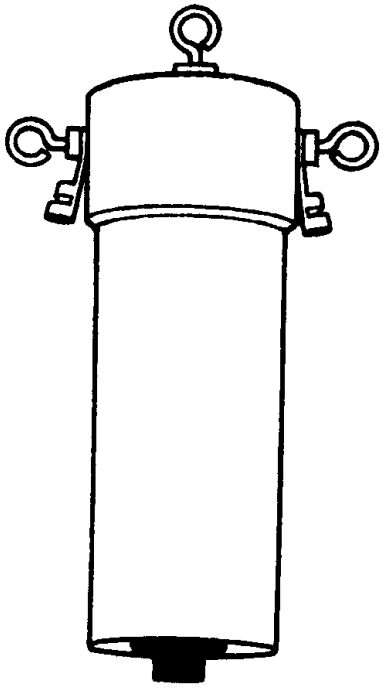
300-OHM TWIN-LEAD

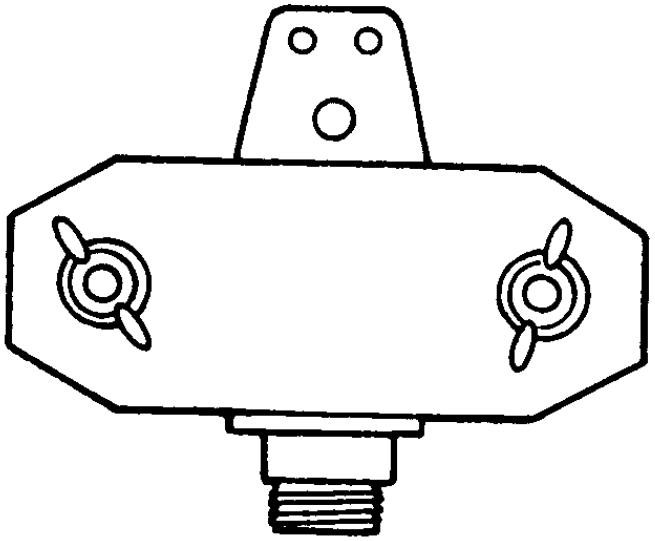


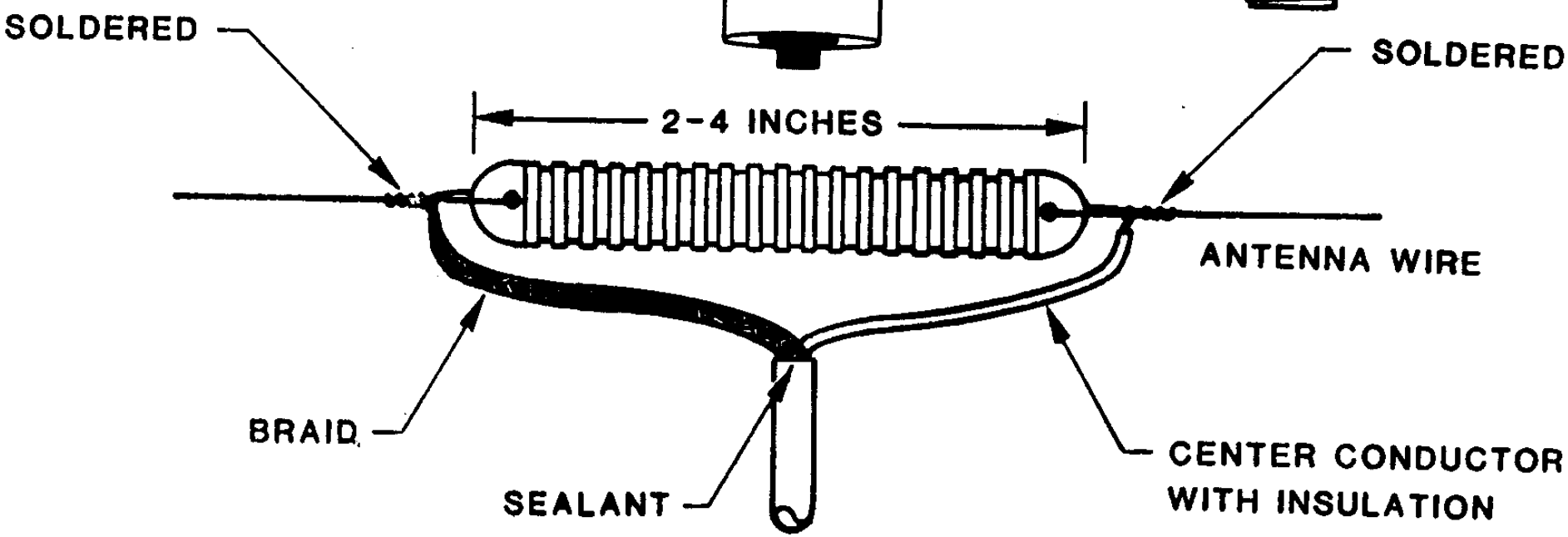
HELIAX

FEEDPOINTS / BALUNS









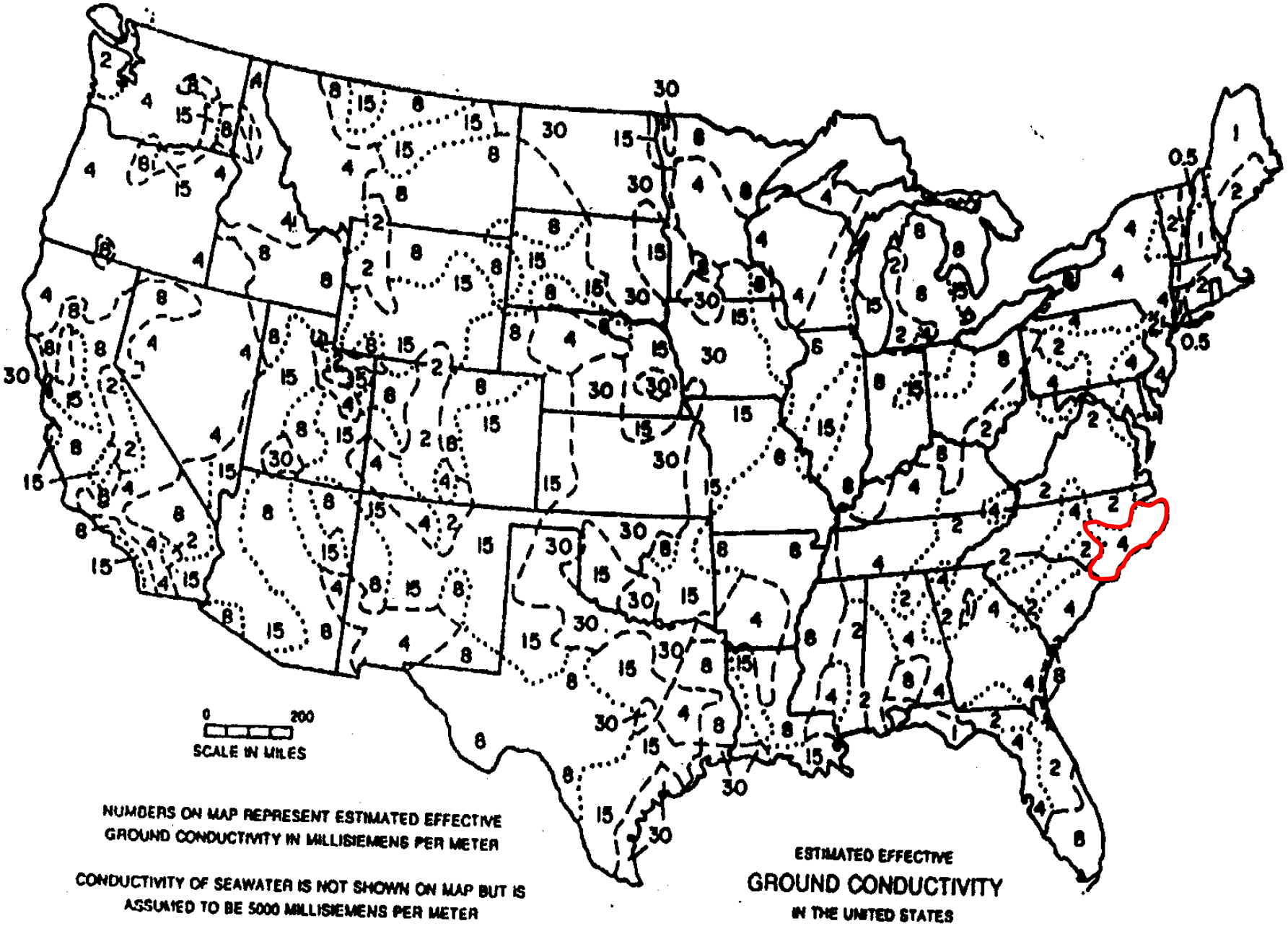
CONDUCTIVITY

Acts as a mirror for radiated energy and reflects or absorbs radio waves depending upon the type of materials that are contained in the ground. The best conductor is lots of moisture, such as oceans which contain salt. Dry, Rocky, and Mountainous areas are poor conductors because their lack of moisture. Jungle areas are also poor mainly because the large amounts of vegetation which can absorb or refract the radio waves.

Conductivities and Dielectric Constants for Common Types of Earth

Surface Type	*Dielectric constant*	*Conductivity (S/m)*	*Relative quality*
Fresh water	80	0.001	
Salt water	81	5.0	
Pastoral, low hills, rich soil typ Dallas, TX to Lincoln, NE areas	20	0.0303	Very good
Pastoral, low hills, rich soil typ OH and IL	14	0.01	
Flat country, marshy, densely wooded, typ LA near Mississippi River	12	0.0075	
Pastoral, medium hills and forestation, typ MD, PA, NY (exclusive of mountains and coastline)	13	0.006	
Pastoral, medium hills and forestation, heavy clay soil, typ central VA	13	0.005	Average
Rocky soil, steep hills, typ mountainous	12-14	0.002	Poor
Sandy, dry, flat, coastal	10	0.002	
Cities, industrial areas	5	0.001	Very Poor
Cities, heavy industrial areas, high buildings	3	0.001	Extremely poor

GROUND CONDUCTIVITY FOR U.S.



COUNTERPOISE

This is a false ground to help provide conductivity in the event the real ground is a poor conductor. If a counterpoise is used, it should be the same length as the operating antenna or larger. It can also be used to make an antenna unidirectional by reflecting the radio wave in the desired direction.
For example (Slant, Inverted L, and longwire)

RESONANT

When the physical length of an antenna matches the electrical length or frequency wavelength. This will make the antenna more efficient for both receiving and transmitting (theory of reciprocity) When an antenna is not resonant it will have a high Standing Wave Ratio, which means the capacitive reactance is not equal or opposite the inductive reactance. Which in simple terms means that the antenna is either too long or too short.

STANDING WAVE RATIO (SWR)

Sometimes called voltage standing wave ratio (VSWR), a measure of the impedence match between the feedline and the antenna. Also, with a transmatch in use, a measure of the match between the feedline from the transmitter (tx) and the antenna system. The system includes the transmatch (tuner box) and the line to the antenna. VSWR is the ratio of maximum voltage to minimum voltage along the feedline. It is also the ratio of antenna impedence to feedline impedence when the antenna is a purely resistive load. Impedence is the opposition to electric current that an antenna feedline presents.

Percentage of propability

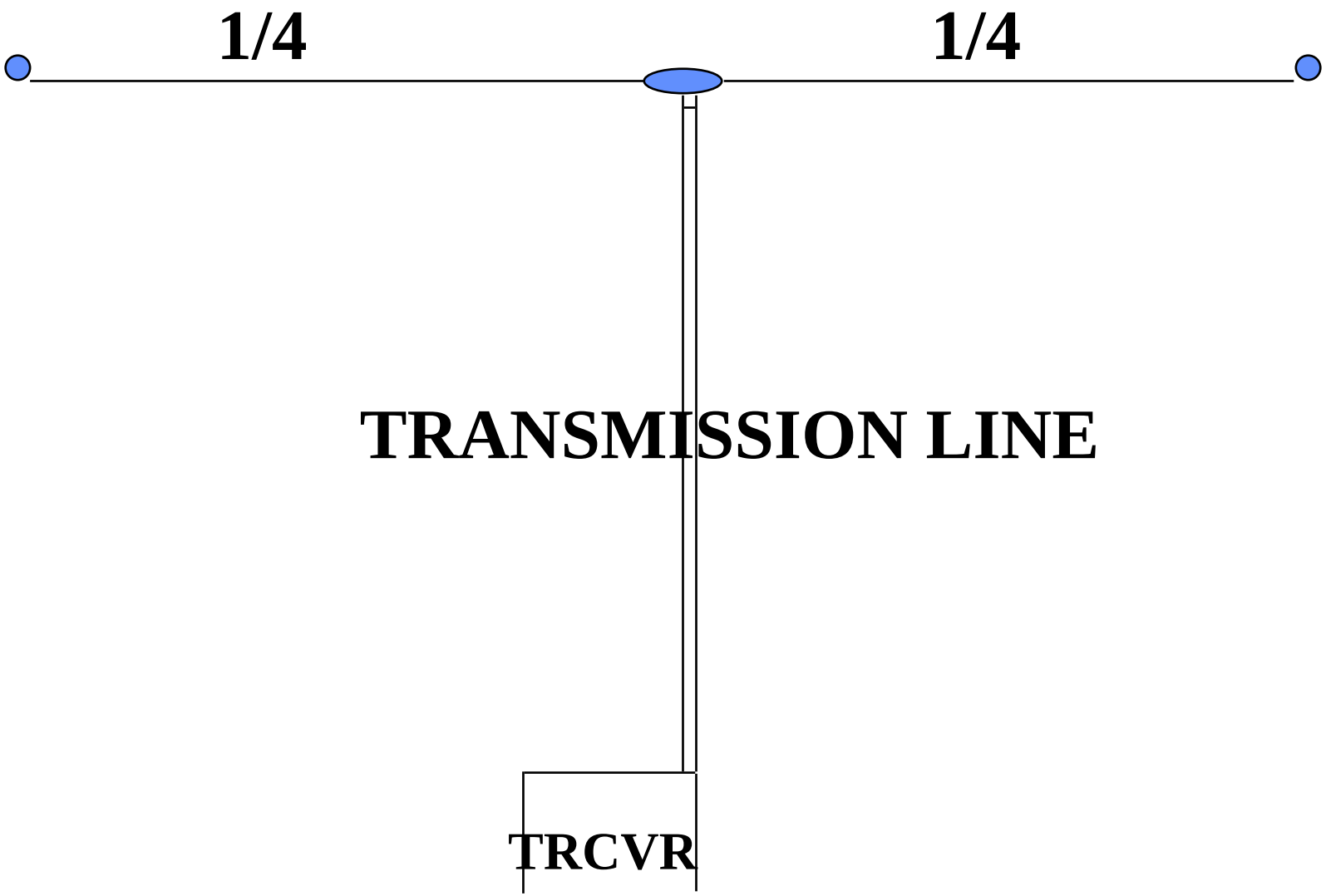
1.1-1 = 100% / 1.5-1 = 94%

2-1 = 89% / 3-1 = 75% / 4-1 = 67%

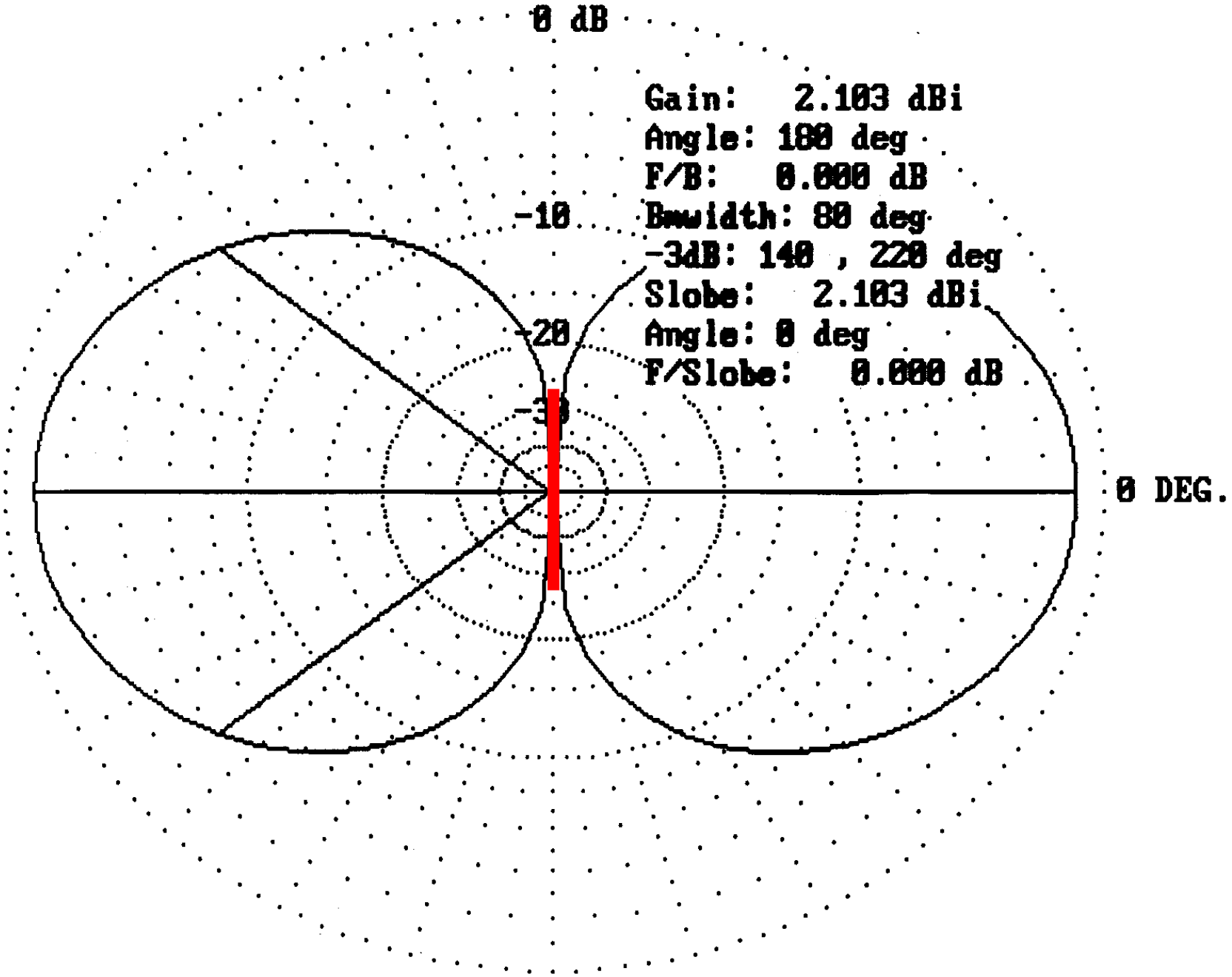
DIPOLE / DOUBLET ANTENNA

The Dipole antenna is a bi-directional antenna that is most commonly used in HF communications because of it's effectiveness and easy construction. This antenna has a "T" configuration with a 1/4 wavelength on each leg and a feedpoint in the center. The formula for any 1/4 wavelength antenna is by dividing 234 by the operating frequency in MHz for each leg, or 468 for total, to give a physical length in feet. The Dipole has an approximate gain of 2 decibals over an isotropic antenna.

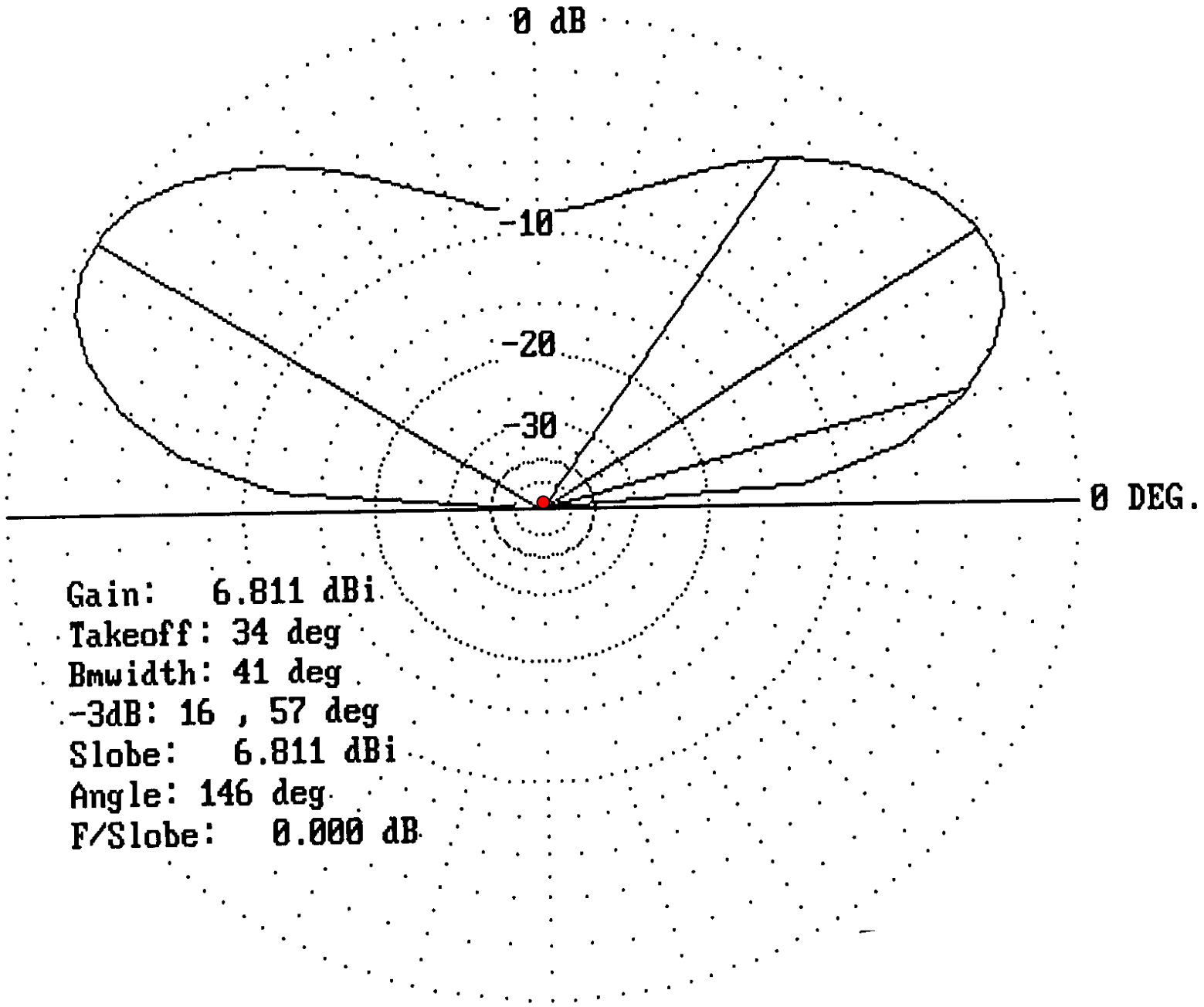
1/2 WAVE DIPOLE



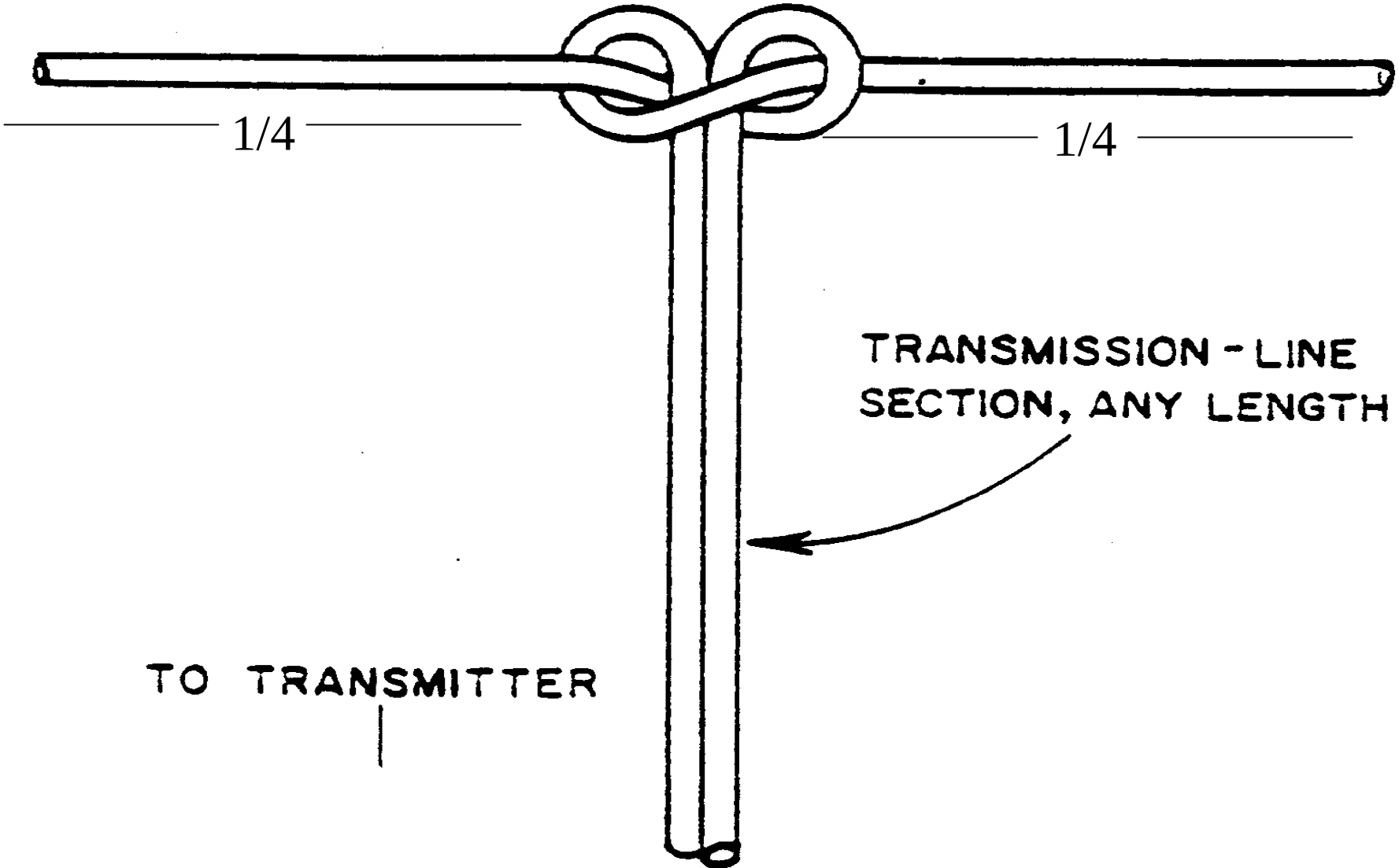
RADIATION PATTERN-DIPOLE (TOP VIEW)



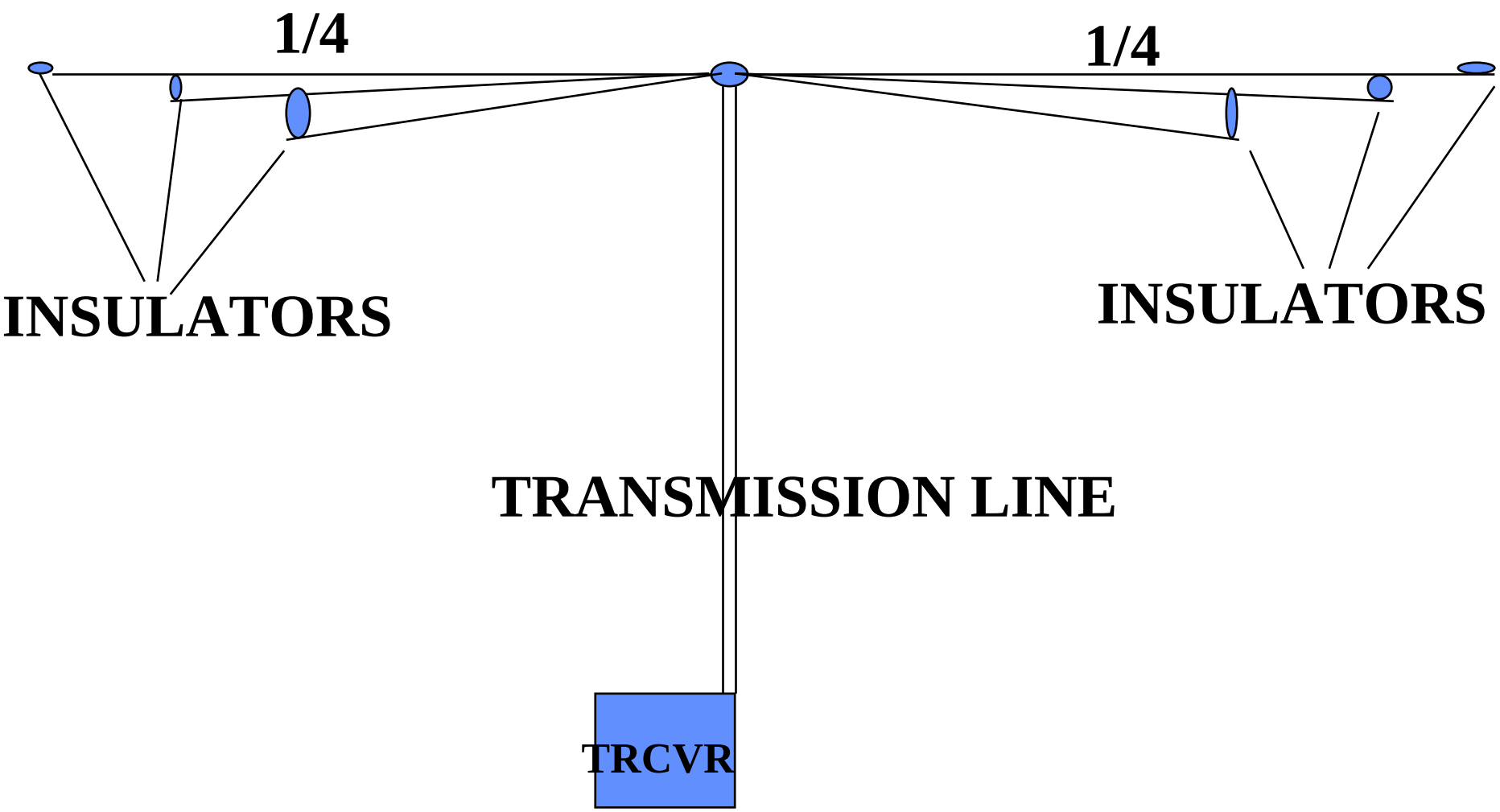
RADIATION PATTERN-DIPOLE (SIDE VIEW)



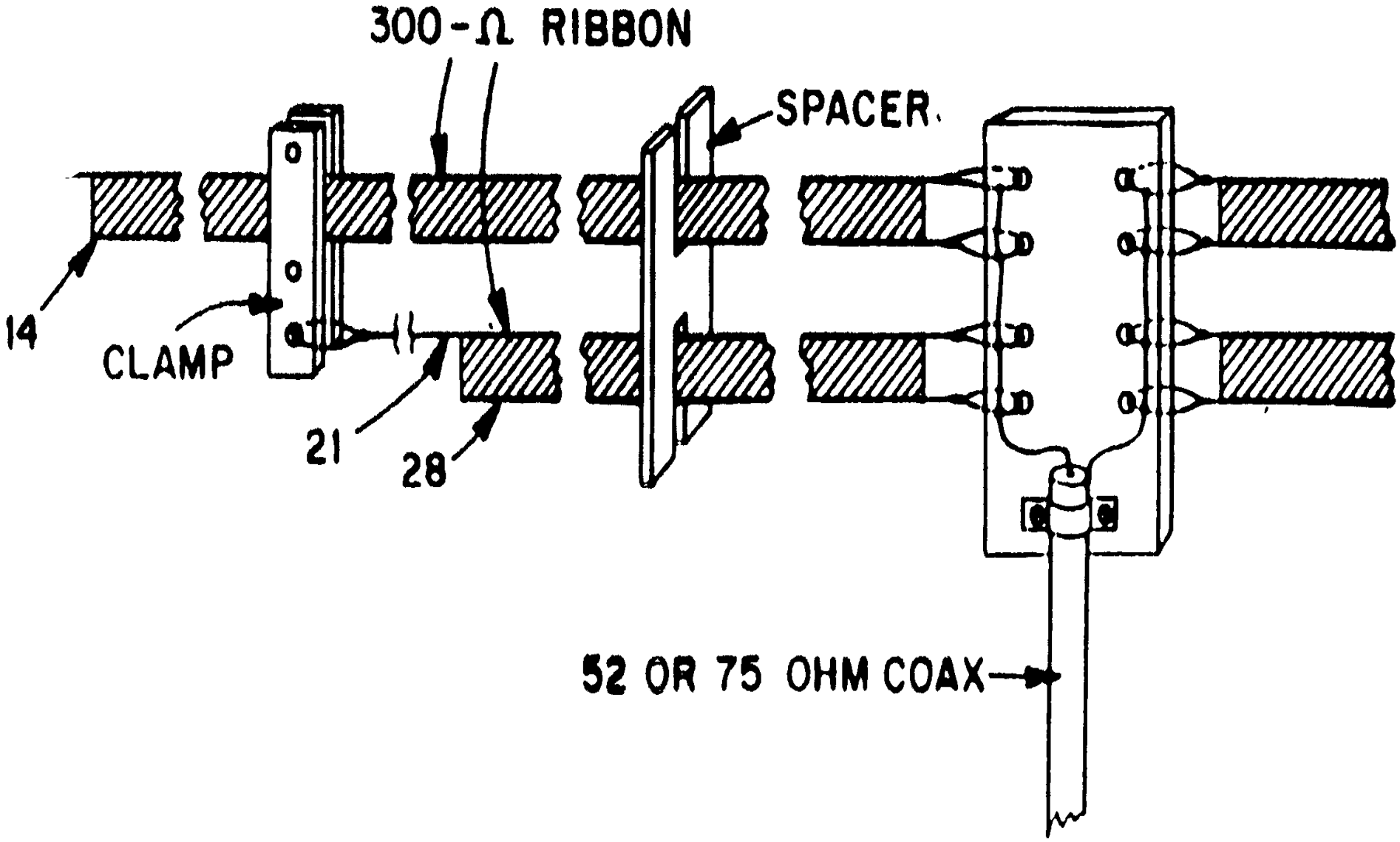
ELECTRICIANS KNOT DIPOLE



MULTIBAND DIPOLE



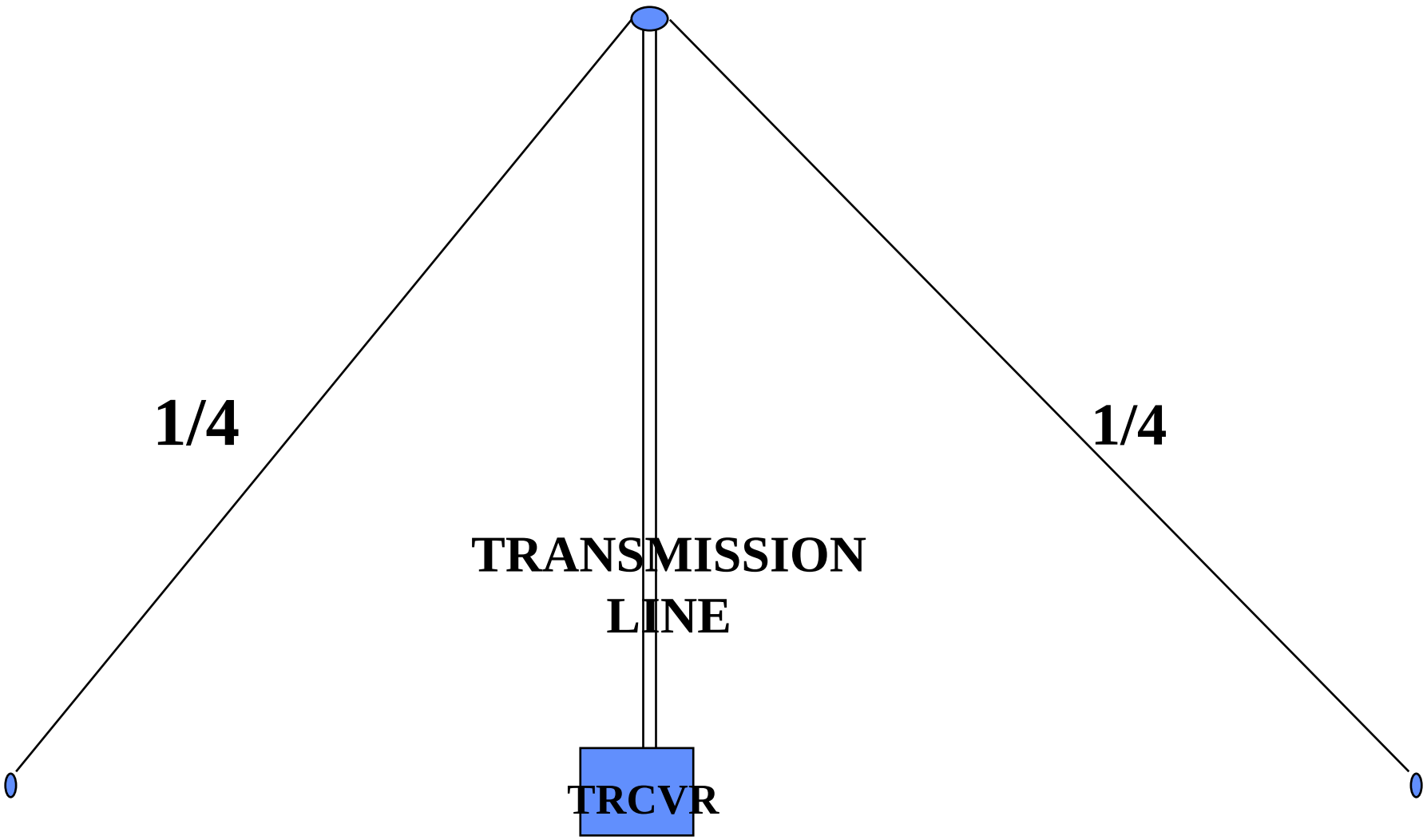
MULTI-BAND FEEDPOINT



INVERTED V ANTENNA

The inverted V antenna is also a 1/4 wavelength antenna but like the Dipole, the legs are brought down to form a "V" configuration. It is also bi-directional unless both legs are close together and a 400-600 Ohm resister is placed on the ends of the legs. This is also a preferred antenna because of it's easy construction, and unlike the dipole it only needs one form of support.

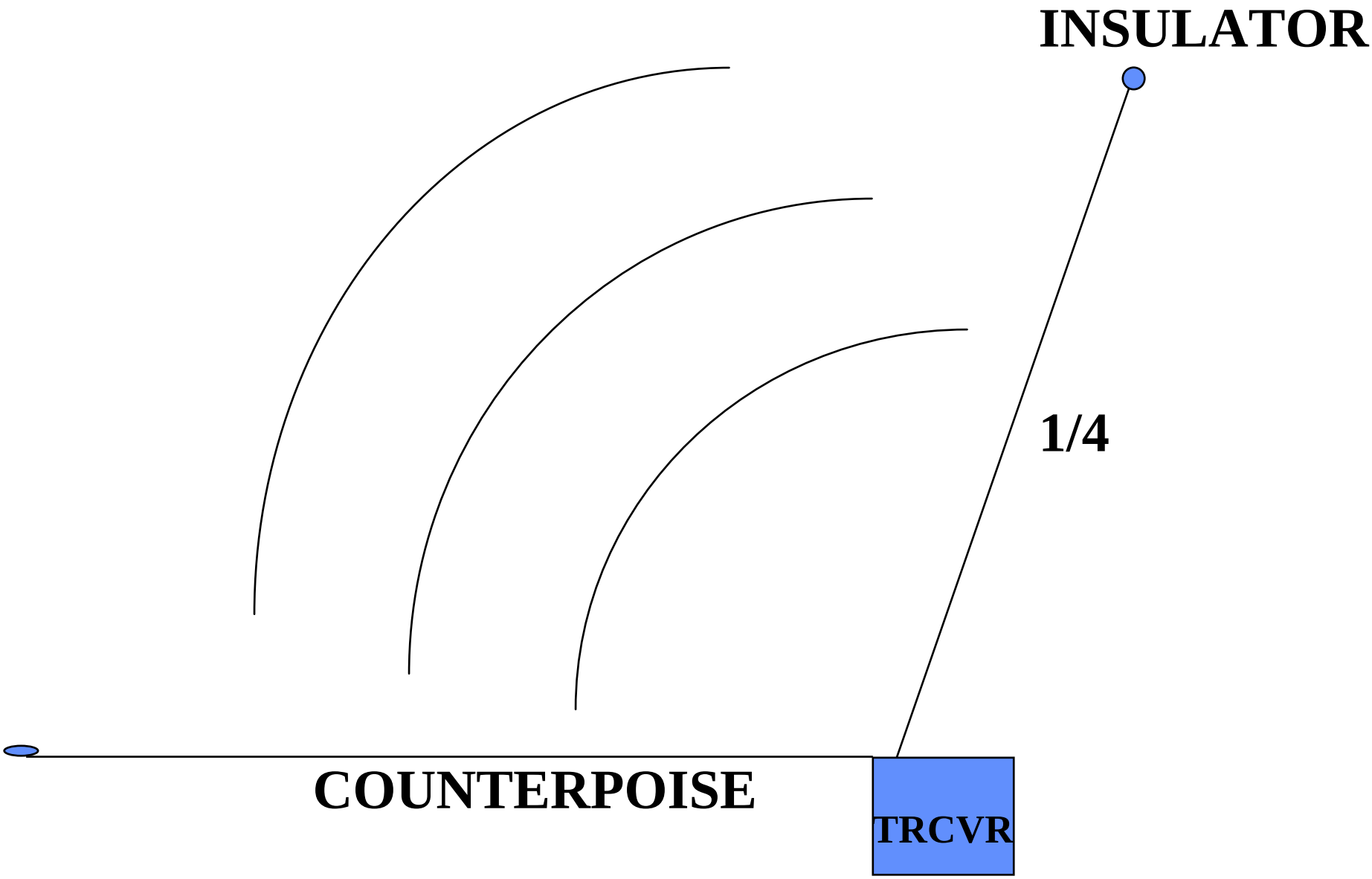
INVERTED V



SLANT ANTENNA

The Slant antenna is also a 1/4 wavelength antenna but, the lower leg acts as a counterpoise or reflector. It is a unidirectional antenna because the counterpoise reflects the radiation in one direction. For construction the same formula is used as the Dipole and Inverted V. It is basically a whip antenna with a reflector for more directivity.

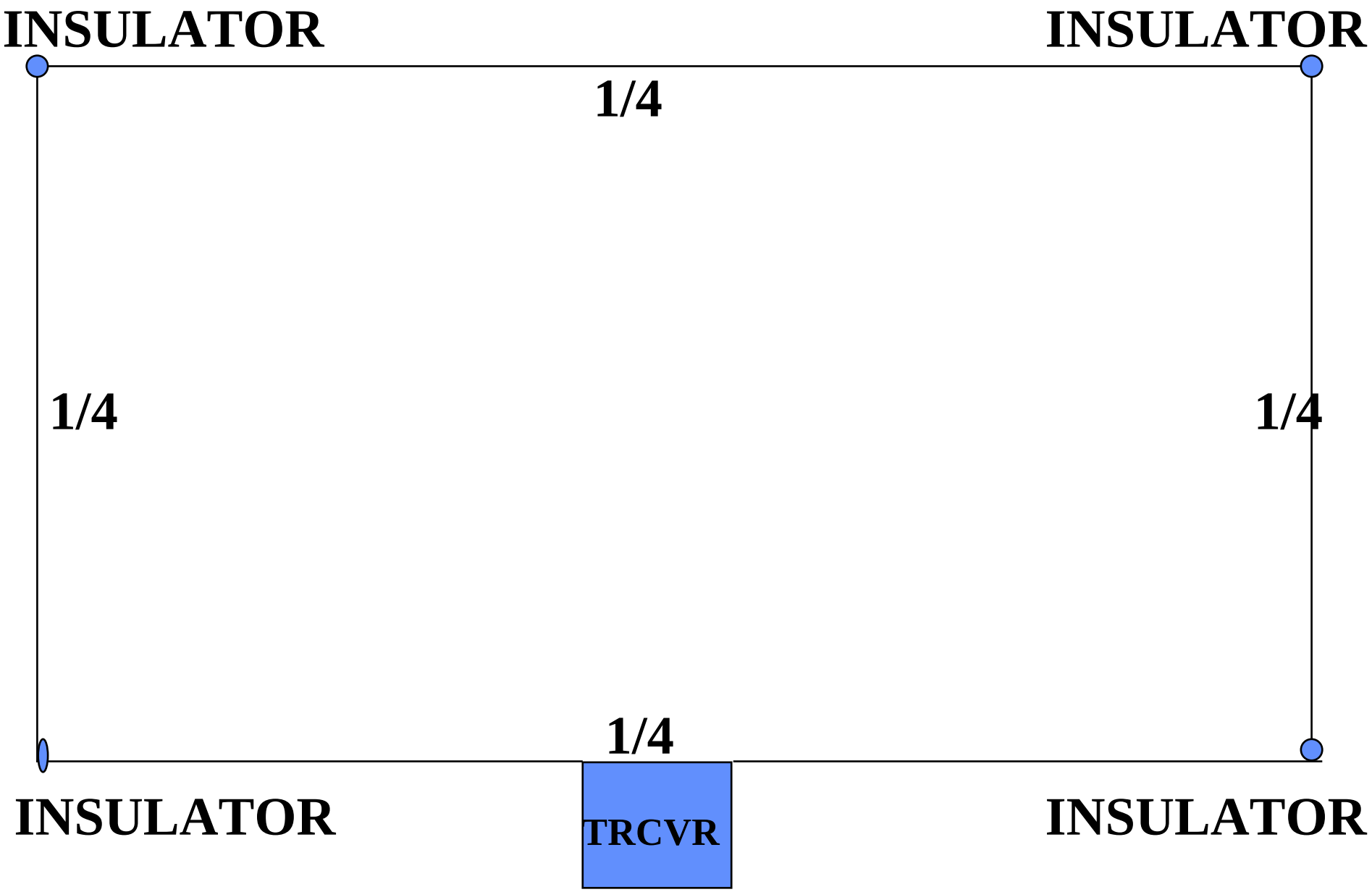
SLANT



LOOP ANTENNA

The Loop antenna unlike the Dipole, is a one wavelength antenna. It is often used indoors because of the supports needed. To find the length in feet, divide 1,005 by the operating frequency. There are several configurations for this antenna such as, Quad loop, Diamond loop, and Delta loop. The Quad and Diamond have 4 sides just divide the length by 4 to get each side, and the Delta has 3 sides. This antenna can either be horizontal or vertical each having a different radiation pattern.

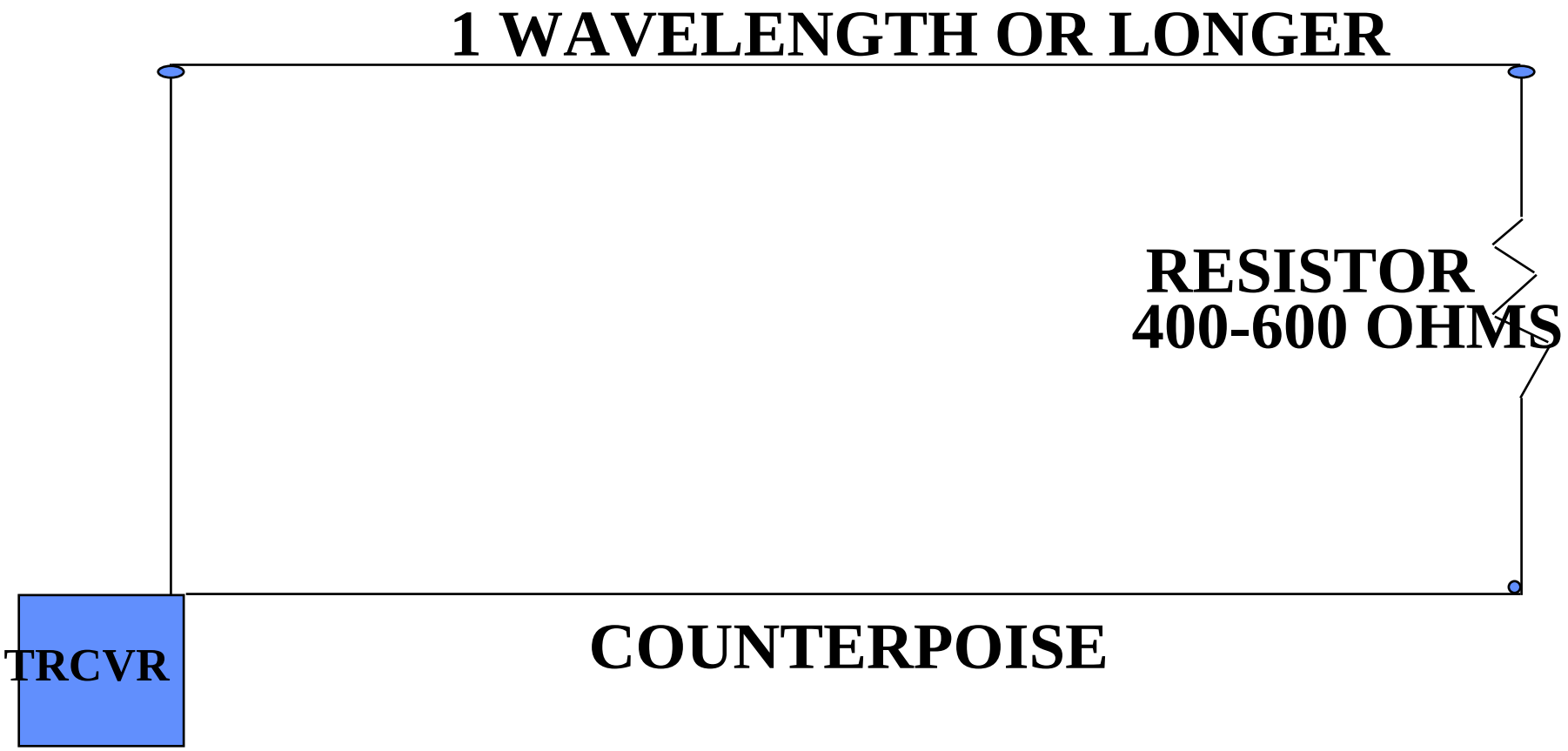
LOOP



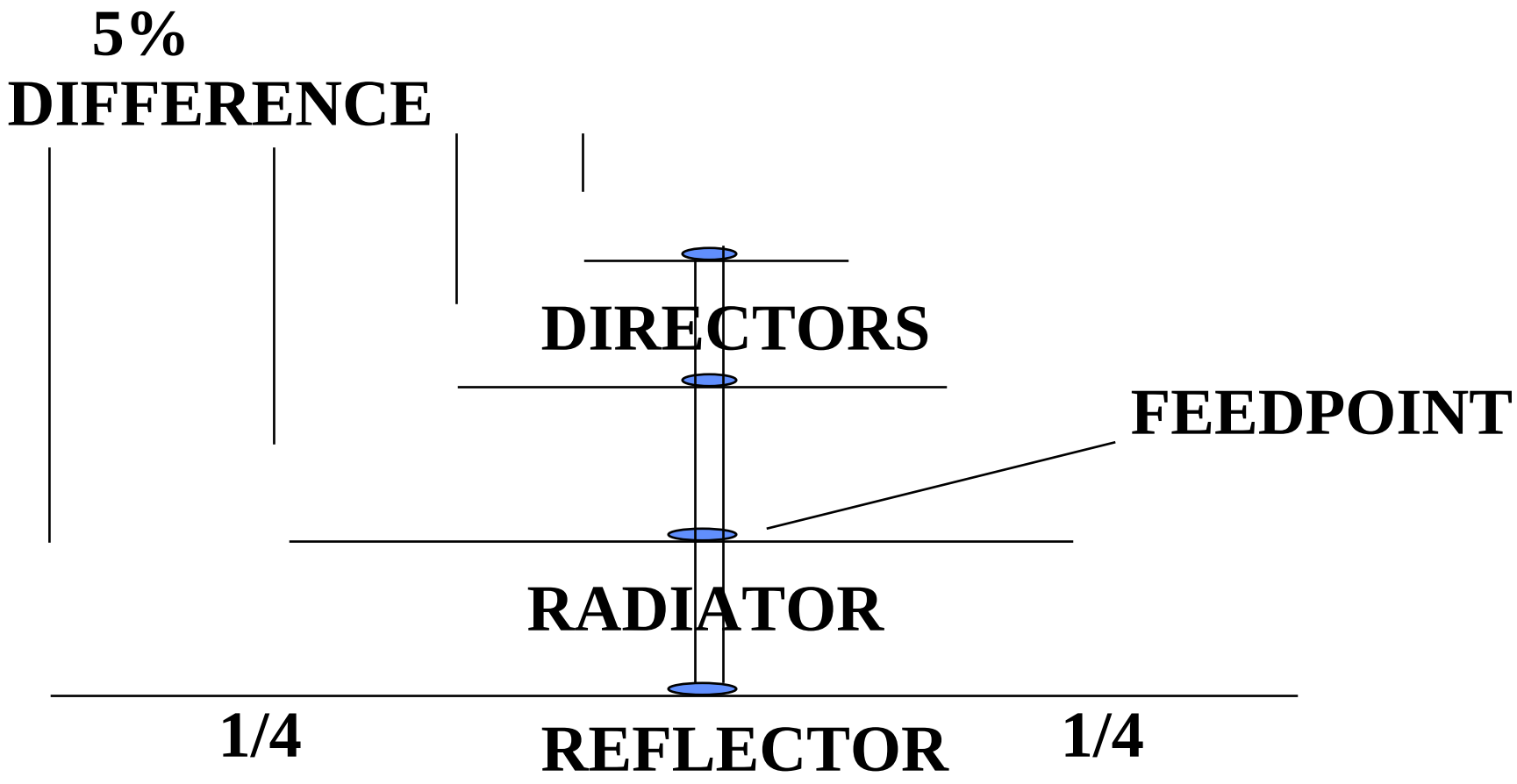
LONGWIRE ANTENNA

The Longwire is an antenna that's total length is over 1 wavelength long. Unlike the dipole, it's energy is radiated approximately 15 degrees off the end not broadside like the others. Because it is more than 1 wavelength long, the wave travels along the length of the wire. The formula for constructing a longwire is multiply 492 times the number of desired wavelengths, minus 5% and divide by the operating frequency. This type of antenna can also be used with a counterpoise and made more directional with a 400-600 Ohm resistor on the end.

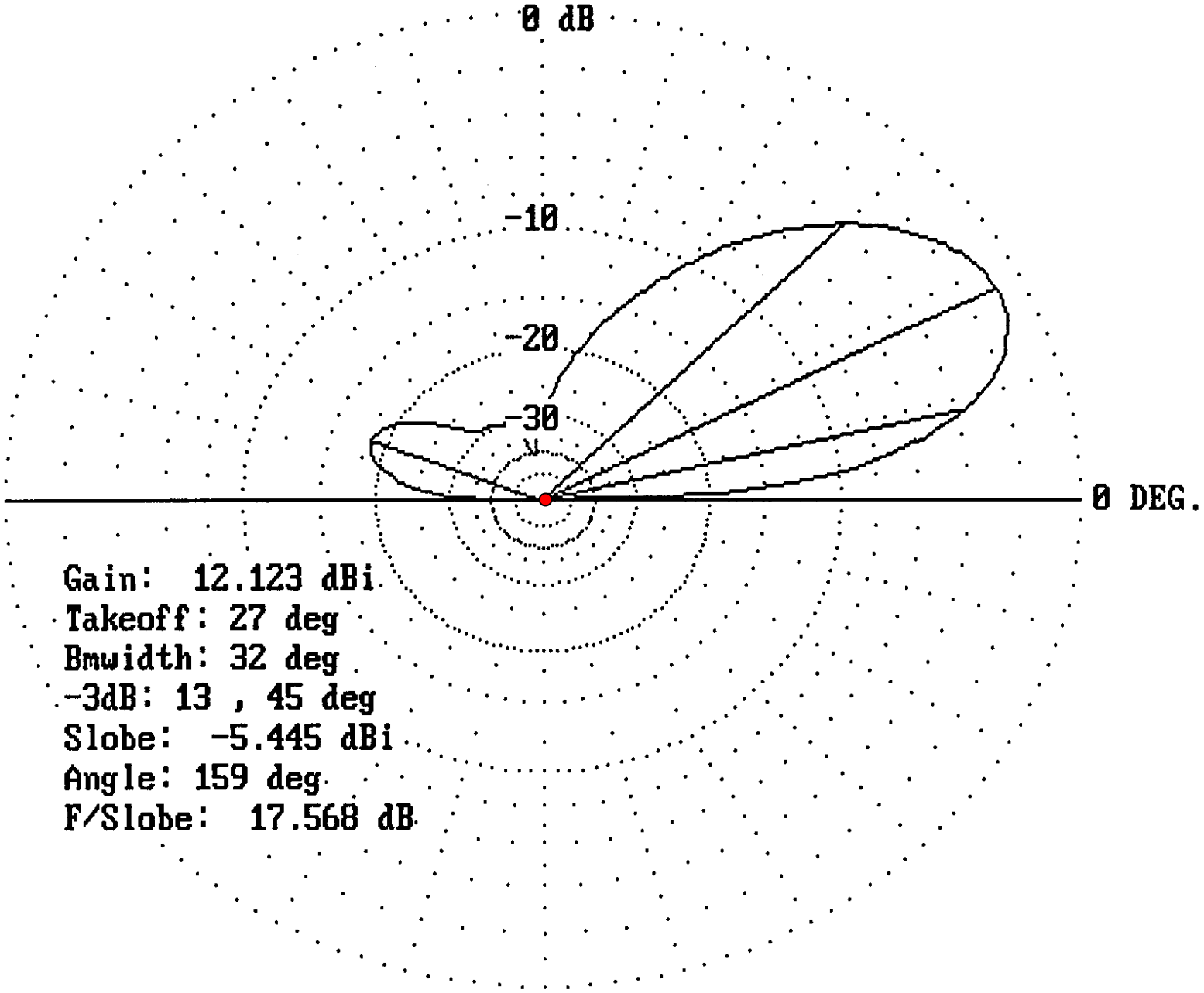
LONGWIRE


1 WAVELENGTH OR LONGER
RESISTOR
400-600 OHMS
COUNTERPOISE
TRCVR

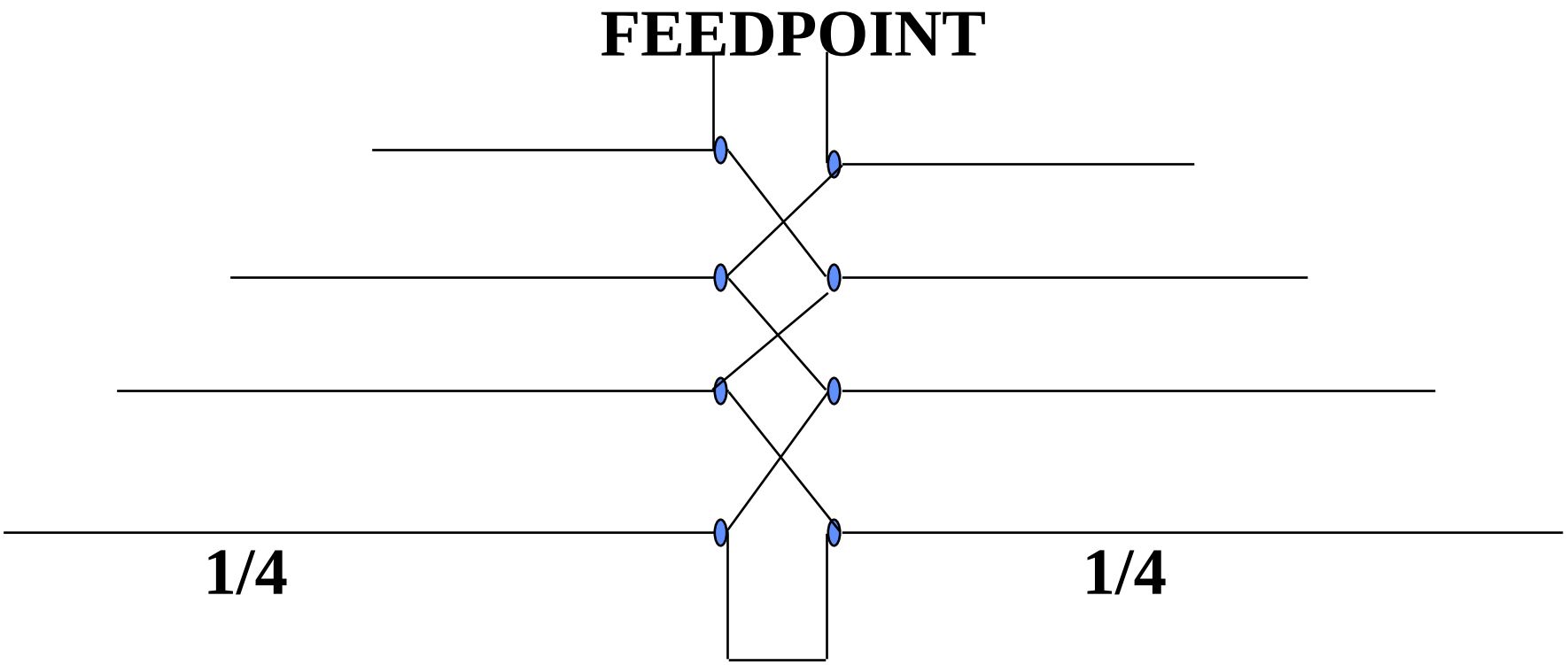
YAGI


5%
DIFFERENCE
DIRECTORS
FEEDPOINT
RADIATOR
1/4
REFLECTOR
1/4

RADIATION PATTERN-YAGI (SIDE VIEW)



LOG PERIODIC



RST
READABILITY / SIGNAL STRENGTH / TONE

READABILITY

1 - unreadable
2 - barely readable, occational words distinguishable
3 - readable with considerable difficulty
4 - readable with practically no difficulty
5 - perfectly readable

SIGNAL STRENGTH

1 - faint signals barely perceptable
2 - very weak signal
3 - weak signal
4 - fair signal
5 - fairly good signal
6 - good signal
7 - moderately strong signal
8 - strong signal
9 - extremely strong signal

RST
READABILITY / SIGNAL STRENGTH / TONE

TONE (CW)

1 - sixty-cycle ac or less, very rough and broad
2 - very rough ac, very harsh and broad
3 - rough ac tone, rectified but not filtered
4 - rough note, some trace of filtering
5 - filtered rectified ac but strongly ripple modulation
6 - filtered tone, definate trace of ripple modulation
7 - near pure tone, trace of ripple modulation
8 - near perfect tone, slight trace of modulation
9 - perfect tone, no trace of ripple modulation

RST = 599

GENERAL INFORMATION

CB CHANNELS AND FREQUENCIES

1- 26.965	**11- 27.085**	**21- 27.215**	**31- 27.315**
2- 26.975	**12- 27.105**	**22- 27.225**	**32- 27.325**
3- 26.985	**13- 27.115**	**23- 27.225**	**33- 27.335**
4- 27.005	**14- 27.125**	**24- 27.235**	**34- 27.345**
5- 27.015	**15- 27.135**	**25- 27.245**	**35- 27.355**
6- 27.025	**16- 27.155**	**26- 27.265**	**36- 27.355**
7- 27.035	**17- 27.165**	**27- 27.275**	**37- 27.375**
8- 27.055	**18- 27.175**	**28- 27.285**	**38- 27.385**
9- 27.065	**19- 27.185**	**29- 27.295**	**39- 27.395**
10- 27.075	**20- 27.205**	**30- 27.305**	**40- 27.405**

WWV- Ft. Collins, Co. 2.5 / 5 / 10 / 15 / 20 Mhz

Universal Time / 18 past the hour Geo alert and Solar Flux Number.

U.S.A. FM Television Stations

59.74 – CBS / 65.75 - PBS

71.70 – UNC / 81.75 - ABC

87.75 - NBC