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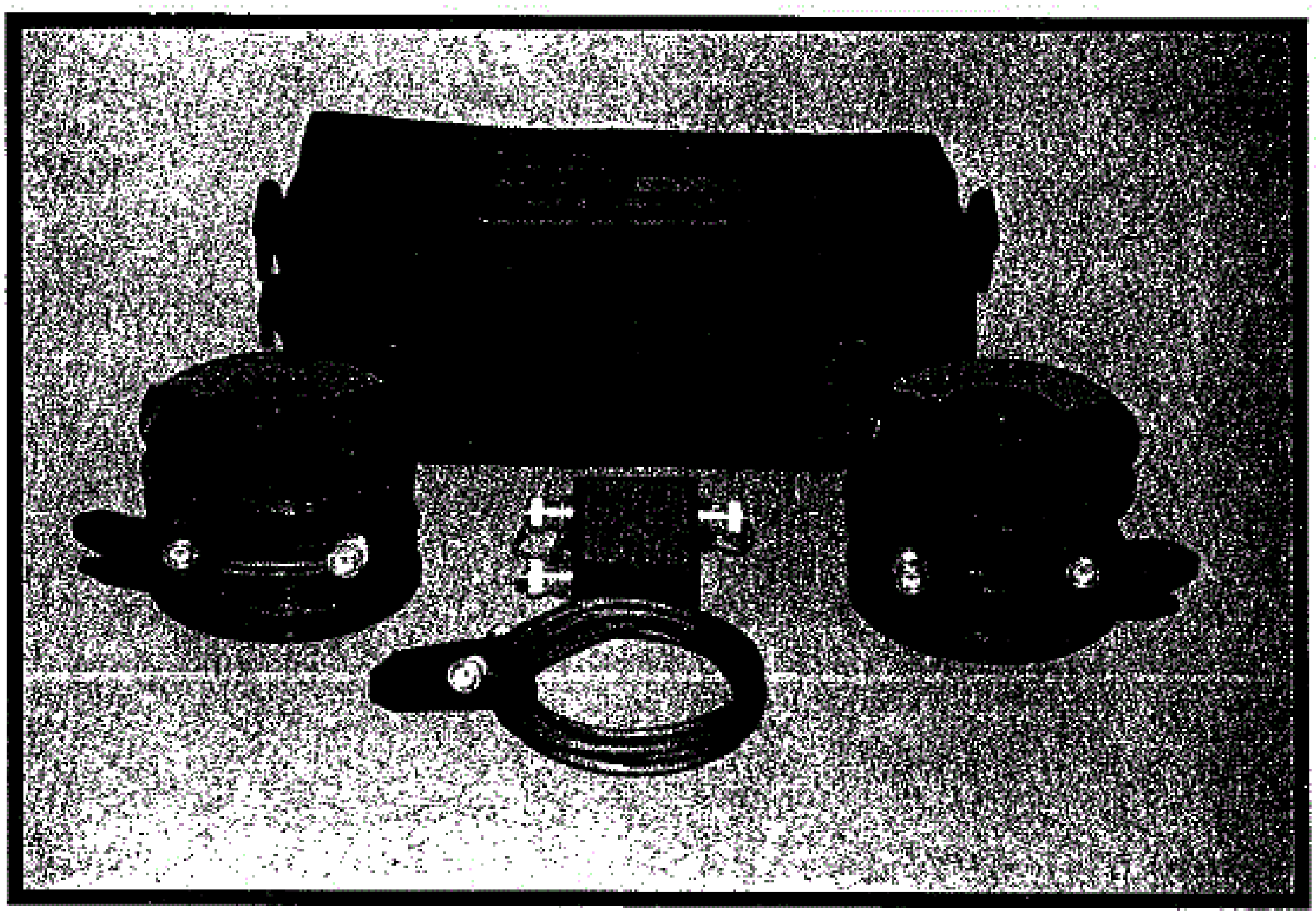
English

Eyring Doc. No. 300-0086
September 1990

Operations Manual for the 302A Eyring Low Profile Antenna



September 1990

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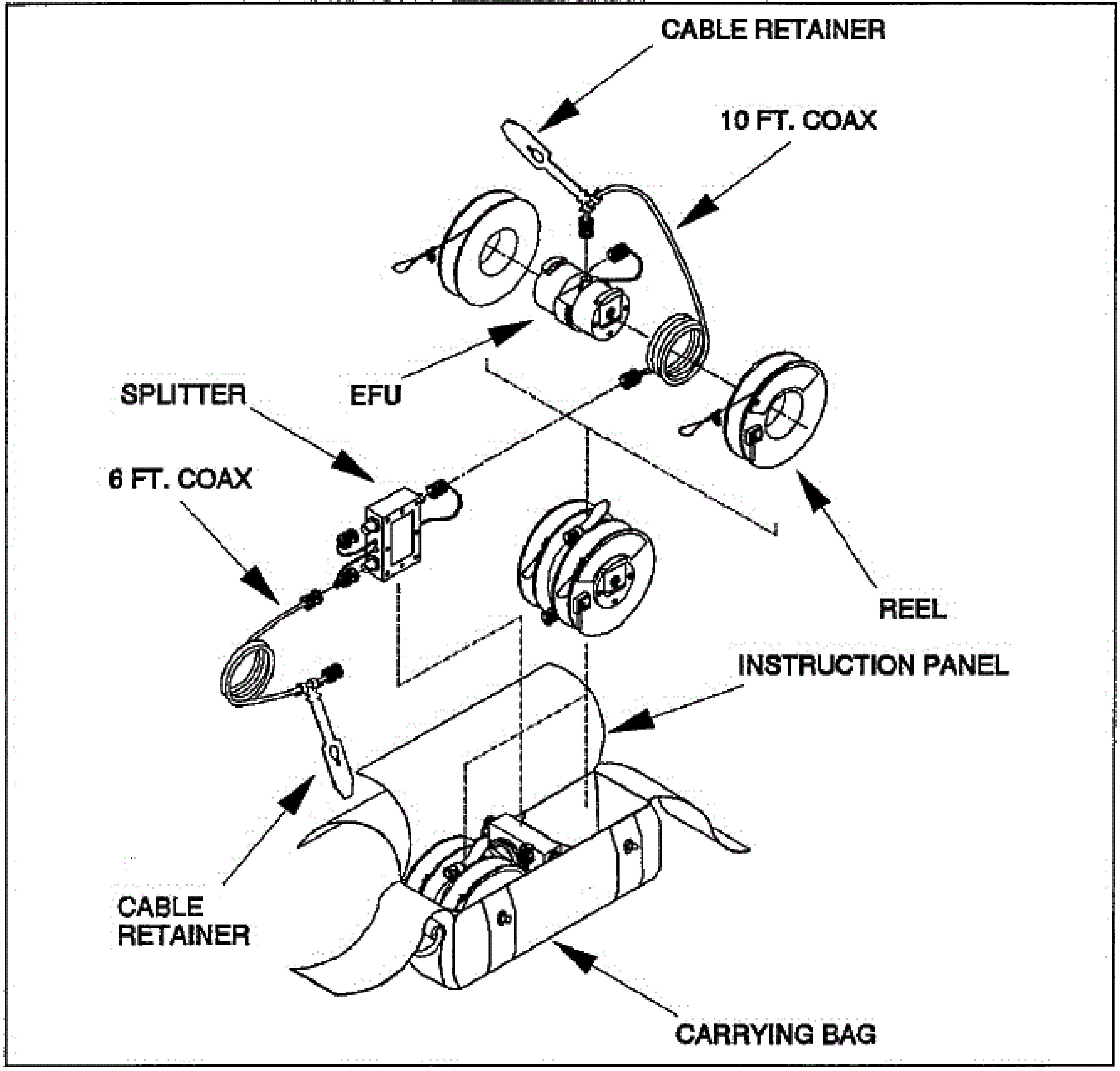
Pictorial Guide to ELPA 302A Packaging



STANDARD PARTS LIST

Number	Description	Part No.
1	**ELPA 302A**	**200-4025-02**
1	Carrying bag	200-4026-01
2	Element feed unit (EFU)	200-4032-01
4	Reel assembly w/150 ft. of phosphor bronze wire	200-4033-01
1	Splitter, power	200-4028
1	6-ft. coaxial cable with BNC male ends	200-4027-02
2	10-ft. coaxial cable with BNC male ends	200-4027-01
3	Cable retainers, on cables	200-4425
1	Operations manual	300-0086

July 6, 1995

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Cover	Eyring, Inc. Communication Systems Division 1455 West 820 North Provo, UT 84601 Phone: (801) 375-2434 Fax: (801) 374-8339 Telex: 88 2000 EYRING	Eyring Corporation Systems Engineering Group 6918 South 185 West Midvale, UT 84047 Phone: (801) 561-1111 Fax: (801) 561-0910
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61	Eyring Communication Systems Division ELPA Warranty Support 1455 West 820 North Provo, UT 84601	Eyring Systems Engineering Group ELPA Warranty Support 6918 South 185 West Midvale, UT 84047
(C-3) data sheet	EYRING/1455 WEST 820 NORTH/ PROVO, UTAH 84601/801-375-2434/ TELEX 882-000/FAX 801-374-8339	EYRING CORPORATION 6918 South 185 West Midvale, UT 84047 Phone: 801-561-1111 Fax: 801-561-0910
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ABOUT THIS MANUAL

This manual is divided into sections that will allow you to apply your HF/VHF communications and antenna knowledge to the operation of the Eyring Low Profile Antenna or "ELPA." The material has been selected to enable you to feel confident in using the ELPA 302A as one of your tactical communications tools.

The ELPA is not a panacea, there will be HF/VHF ionospheric propagation or channel interference conditions under which "nothing will work." However, we are confident through 8 years of ELPA testing and development work that you will find that the ELPA works well over a wide range of operational conditions. We believe that it will allow you to function with many tactical advantages that were not easily accessible before the introduction of the ELPA. We expect you will find its performance to be a valuable asset to your communications capability.

This manual has been assembled to assist you in successfully using this product. Please contact us if we can assist you in working with our products. We will respond to your suggestions for improving our products and this manual.

Thank you
Eyring Communications Systems Division
Provo, Utah, USA
September 1990

This operations manual is designed for training and reference purposes only.

It is not required to set up and operate the ELPA 302A in the field.

The instruction panel flap in the carrying bag is supplied as a field reference guide.

QUICK LOOK GUIDE

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1.0 INTRODUCTION

1.1 Scope

This manual describes the Eyring Low Profile Antenna (ELPA) Model 302A and provides instructions for its deployment, operation and retrieval. It includes instruction for operation under both common and unusual field conditions. The manual also contains alternate deployment options of the basic 302A antenna kit.

1.2 Purpose and Function

The Eyring Low Profile Antenna (ELPA) is a "ground cooperative" antenna that functions on or near the ground. The standard rapid deployment form of the ELPA 302A is shown in Figure 1-1.

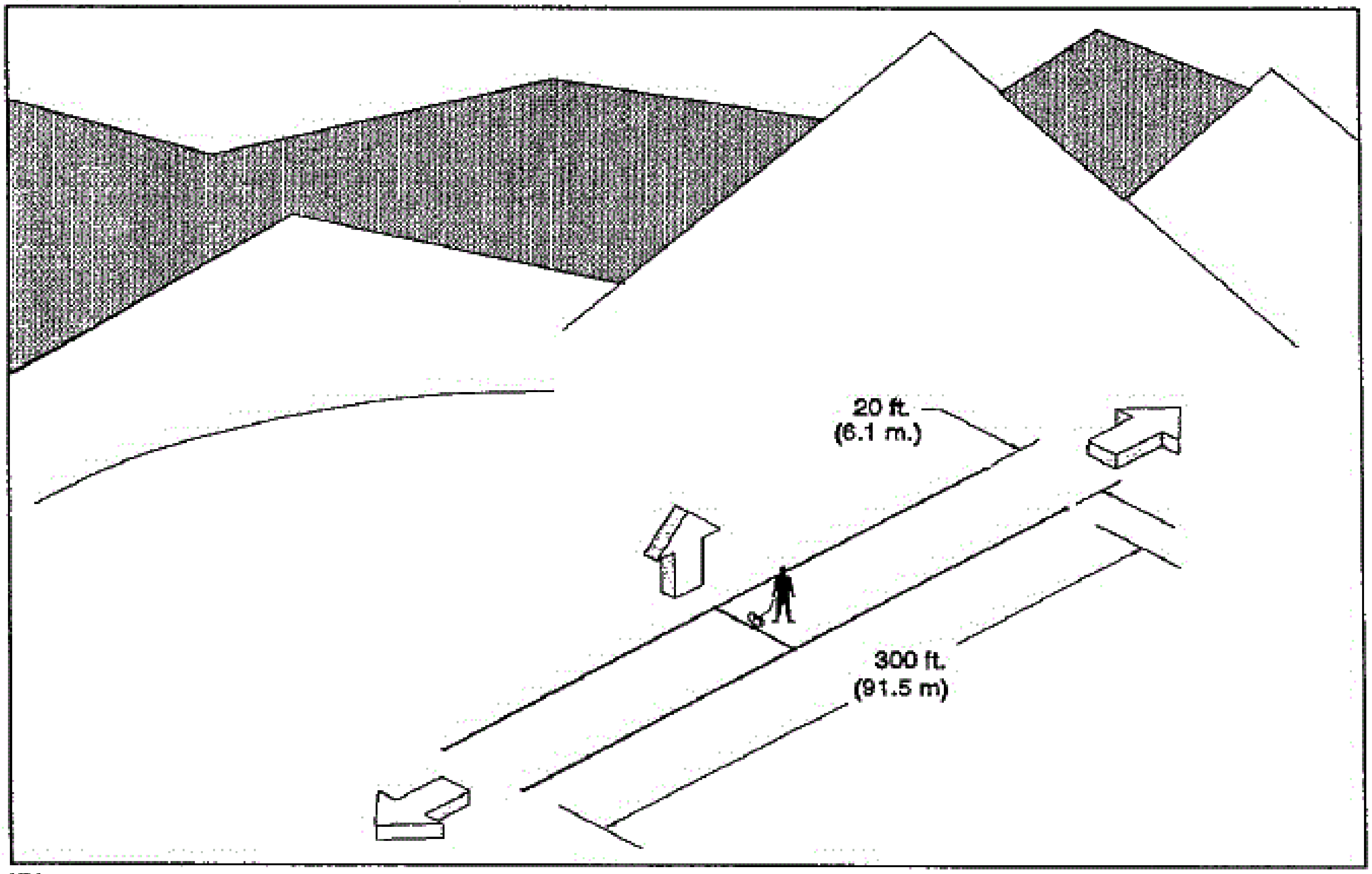

Figure 1-1 ELPA model 302A with standard deployment.

The ELPA 302A provides the user with a lightweight, rugged, rapidly deployed, towerless HF/VHF antenna. The ELPA 302A is a broadband directional antenna that requires no tuning, either electronically (manual or automatic) or by precise length adjustment. The antenna is well suited for use with manpack and transportable CW/SSB (voice)/FSK (data) transceivers* rated at up to 400 Watts peak (200 Watt average).

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* The ELPA has been tested and found compatible with AN/PRC-70, AN/PRC-77, AN/PRC-104A, AN/PRC-132, PRC-1099, RT-1616, AN/GRC-213, AN/PRC-319 and AN/PRC-515 transceivers.

1.3 The ELPA concept

The Eyring Low Profile Antenna (ELPA) embodies a unique combination of antenna concepts. It provides a useful set of antenna tradeoffs between size, weight, deployment time, visibility and environmental flexibility. Thus, *it may be the only antenna* that can be deployed at night, in a wind storm or in a helicopter landing zone.

It is often the only antenna small enough for many tactical applications because of limits on communication system weight, volume and setup time. The ELPA 302A by itself can solve many real world tactical and emergency communication problems over a wide range of hostile site conditions. With option kits*, the 302A provides additional versatility that can transform the ELPA into a no-compromise, optimum performance broadband antenna.

1.4 Communication applications

The ELPA 302A can be used as a direct broadband replacement for familiar antenna types such as dipoles and tuner-matched whips. *The published ELPA gain figures are based on measured, not ideally predicted performance.* Therefore, the margin of performance between ELPAs and conventional tactical antenna/radio systems may be quite small and often to the ELPA's advantage. The ELPA 302A, in its low profile ground contact, rapid deployment mode, is designed to provide instant access to a wide range of communications frequencies and take-off angles. The 302A's standard configuration can be optimized in stages to enhance power gain and take-off angles for a particular frequency band. Similarly the 302's directive gain pattern can be enhanced and oriented to provide interference rejection and jamming resistance for HF and VHF applications. The following figures show ELPAs and common communications antennas in four tactical communications scenarios**. These are:

1.4.1 HF omni-directional near vertical incidence skywave (NVIS) communications (0 to 300 miles) - Figure 1-2;

The NVIS (2 to 8 MHz) communications mode is the primary tactical application of the ELPA 302A. The ELPA is recommended as a good broadband replacement for the standard military AS-2259, tuner matched, sloping dual dipole antenna. It is also a strong competitor*** to tuner matched, fixed length dipole antennas. The ELPA can be used

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* Through the use of either field expedient or manufactured connection, wire and tower kits the ELPA 302A components can be transformed into inverted-vee, Beverage, vertical half-rhombic and sloping-vee antennas.

** A fifth scenario, VHF meteor scatter, is covered by an ELPA 300 series application note.

*** In most cases the ELPA 302A performance will exceed the performance of a short fixed length dipole antenna that has been matched to a non-resonant frequency by an automatic antenna tuner through a length of coaxial cable. A single frequency resonant dipole will exceed the power gain of an ELPA 302A for deployment heights above about 2 ft. At and below 2 ft. the ELPA 302A will typically have a power gain advantage.

as an effective broadband complement to single frequency dipole installations. In NVIS applications the ELPAs can be oriented to minimize low take-off-angle noise pickup while communicating omni-directionally with other stations.

1.4.2 HF directional point-to-point medium and long range skywave communications (300 to 2500 miles) - Figure 1-2;

The basic ELPA 302A can also be used for medium and long range HF communications. The ELPA 302A is classed as a low power gain transmit antenna and a medium directive gain receive antenna. The ELPAs can be used to communicate with conventional long range antennas such as log periodic antennas (LPAs), monopoles and vehicle mounted whip antennas. ELPAs can function in both primary* and backup communications roles and can be co-sited with other antenna types.

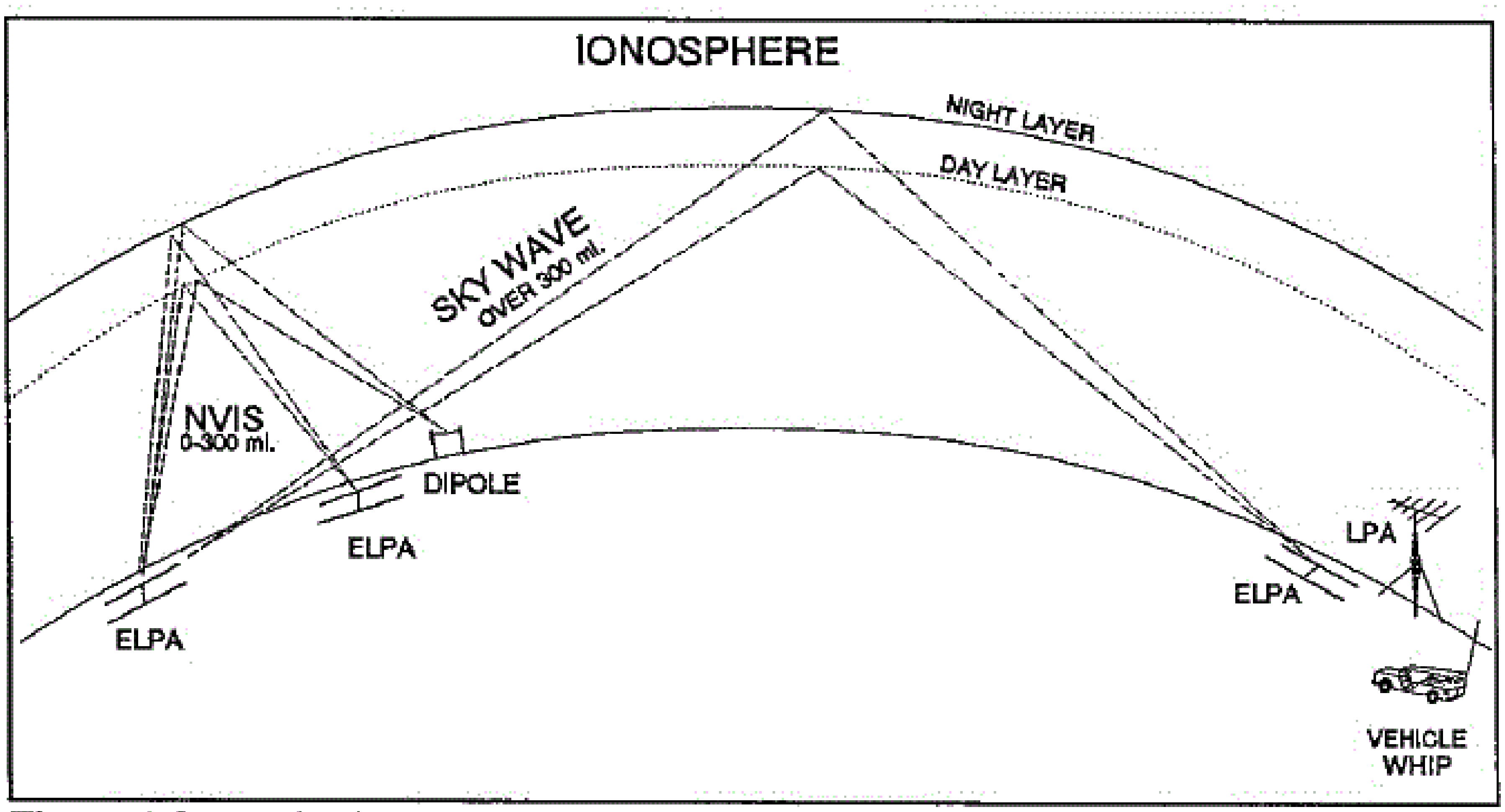

Figure 1-2 Application of ELPAs to NVIS, medium range skywave and long range skywave paths.

1.4.3 HF directional groundwave communications (0 to 30 miles) - Figure 1-3;

For groundwave communications the ELPA 302A is a directional antenna with maximum radiation off the ends of the antenna elements. In the direction of maximum radiation the

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* 4-Element 304A or 8-element 308A uni-directional configurations of ELPA 302As are recommended for use on long range paths. The enhanced power gain and directivity of these larger systems will provide communications under a wider range of propagation conditions than the standard 302A configuration. The vertical half-rhombic, alternate deployment of the ELPA 302A is also recommended.

ELPA 302A has higher power gain than the standard 10 ft. manpack, tuner-matched whip antennas at groundwave frequencies. Off the sides of the ELPA, unlike the omni-directional whip, the radiation and the reception of the antenna will be strongly reduced or "nulled." This null zone of the antenna can be used to a tactical advantage to minimize the possibility of enemy intercept or to minimize the effects of interference or jamming.

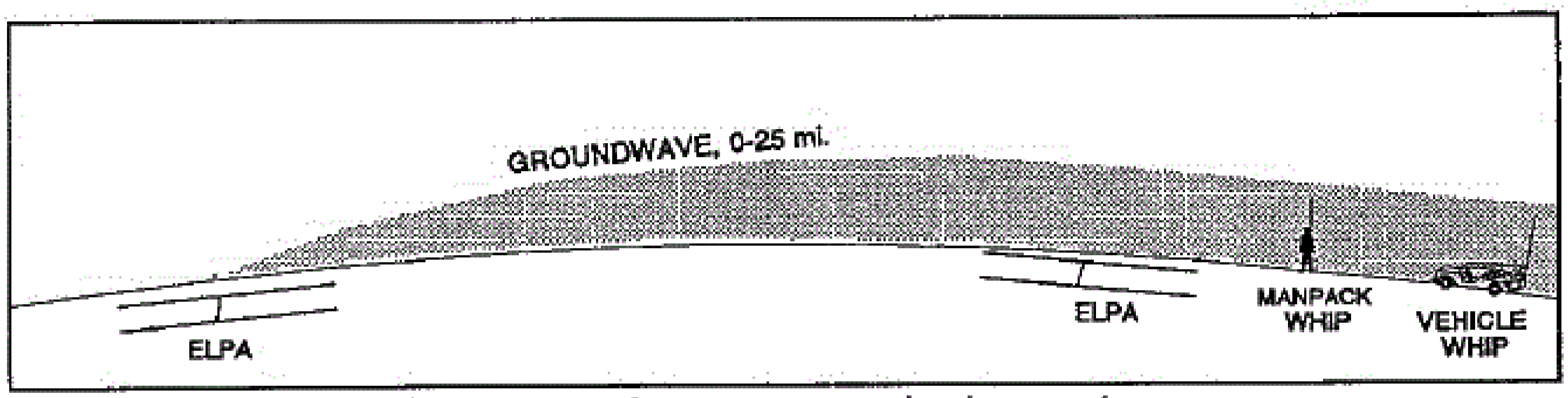

Figure 1-3 ELPA applied to ground wave communications paths.

1.4.4 HF/VHF directional line-of-sight (LOS) communications (0 to 100 miles) - Figure 1-4.

For HF/VHF LOS communications the ELPA offers a unique advantage over conventional antennas. The zero profile, ground contact deployment of the ELPA 302A allows highly effective hilltop-to-valley and surface-to-air communications without exposing the communicator to obvious visual detection (e.g. towers). The main beam of the ELPA pattern from a hill top will provide similar performance to that of a full size VHF monopole (i.e. the hill top provides a height-gain advantage similar to that of a tower). The ground contact deployment performance of the ELPA will match or exceed that of a compact loaded whip antennas in this case. In addition, the nulls of the ELPA antenna will strongly attenuate interfering communications or jamming off the sides of the antenna.

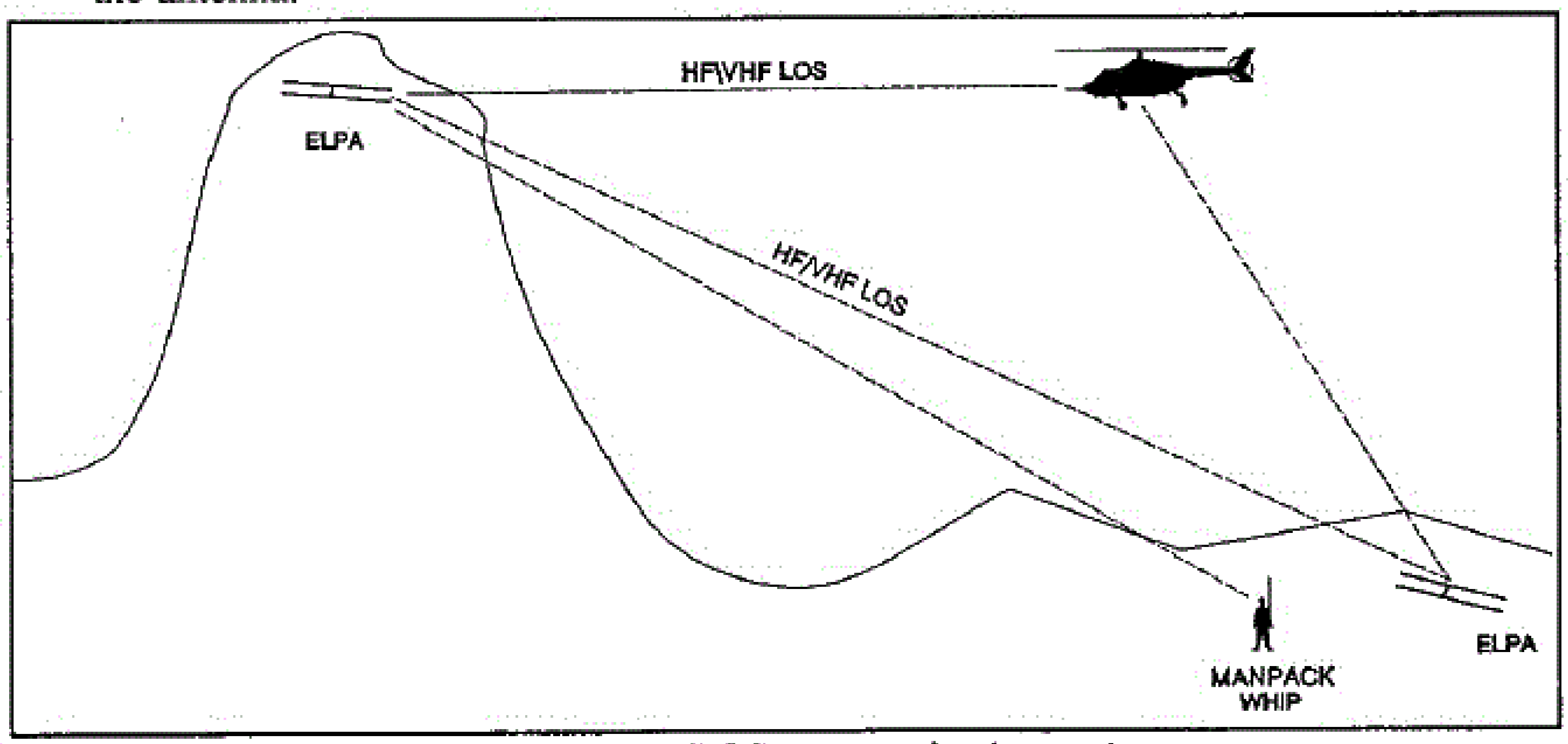

Figure 1-4 ELPA applied to HF/VHF LOS communication paths.

1.5 Basic specifications

The full detail technical specifications of the 2-element ELPA 302A are provided in Appendix A. Key specifications of interest to the ELPA 302A operator are listed below:

Identification	
Model:	ELPA 302A
Eyring part number:	200-4025-02
National stock number:	5985-01-322-0272
Electrical	
Frequency range:	2 to 65 MHz, usable to 90 MHz
Input RF Power:	400 Watts peak, 200 Watts average
Input impedance:	50 Ohms
VSWR:	2:1 or better is typical, layout dependent.
Pattern:	Bi-directional, elevation angle <60 deg. Omni-directional, elevation angle >60 deg.
Polarization:	Vertical, <60 deg. elevation Horizontal, >60 deg. elevation
Azimuth beamwidth:	100 deg. at 3 MHz 25 deg. at 65 MHz, standard deployment
Elevation beamwidth:	160 deg. typical coverage
Mechanical	
RF Connectors	BNC
Deployment	
Maximum area:	1-element standard, 300 ft. x 0.5 ft. 2-element standard, 300 ft. x 20 ft. 1-element vee, 300 ft. x 6 ft. 1-element center-tapped vee, 150 ft. x 6 ft. 2-element center-tapped vee, 150 ft. x 26 ft.
Overall height:	0.0 ft. to 0.1 ft. for ground contact 1 ft. to 3 ft. for staked deployment
Time (one person):	2 to 3 minutes for 1-element standard 4 to 5 minutes for 2-element standard 3 to 4 minutes for 1-element vee 4 to 5 minutes for 1-element center-tapped vee 5 to 10 minutes for 2-element center-tapped vee
Environmental	
Operational/Storage:	-40 °F to 131 °F (-40 °C to 55 °C)
Deployment:	-4 °F to 131 °F (-20 °C to 55 °C)

1.6 Technical characteristics

The ELPA antenna series has undergone a wide range of testing, both technical and operational. Based on these tests, this section presents a brief description of the ELPA's radiation pattern and feedpoint VSWR characteristics.

1.6.1 Radiation patterns - To best understand how to work with the ELPA it is useful to visualize its radiation pattern. Figure 1-5 is a three-dimensional (3-D) graphic representation of an ELPA 302A's radiation pattern for a frequency of about 3 MHz. The relationship of the pattern to the layout of Figure 1-1 can be seen. The shaded volume of the pattern displays the

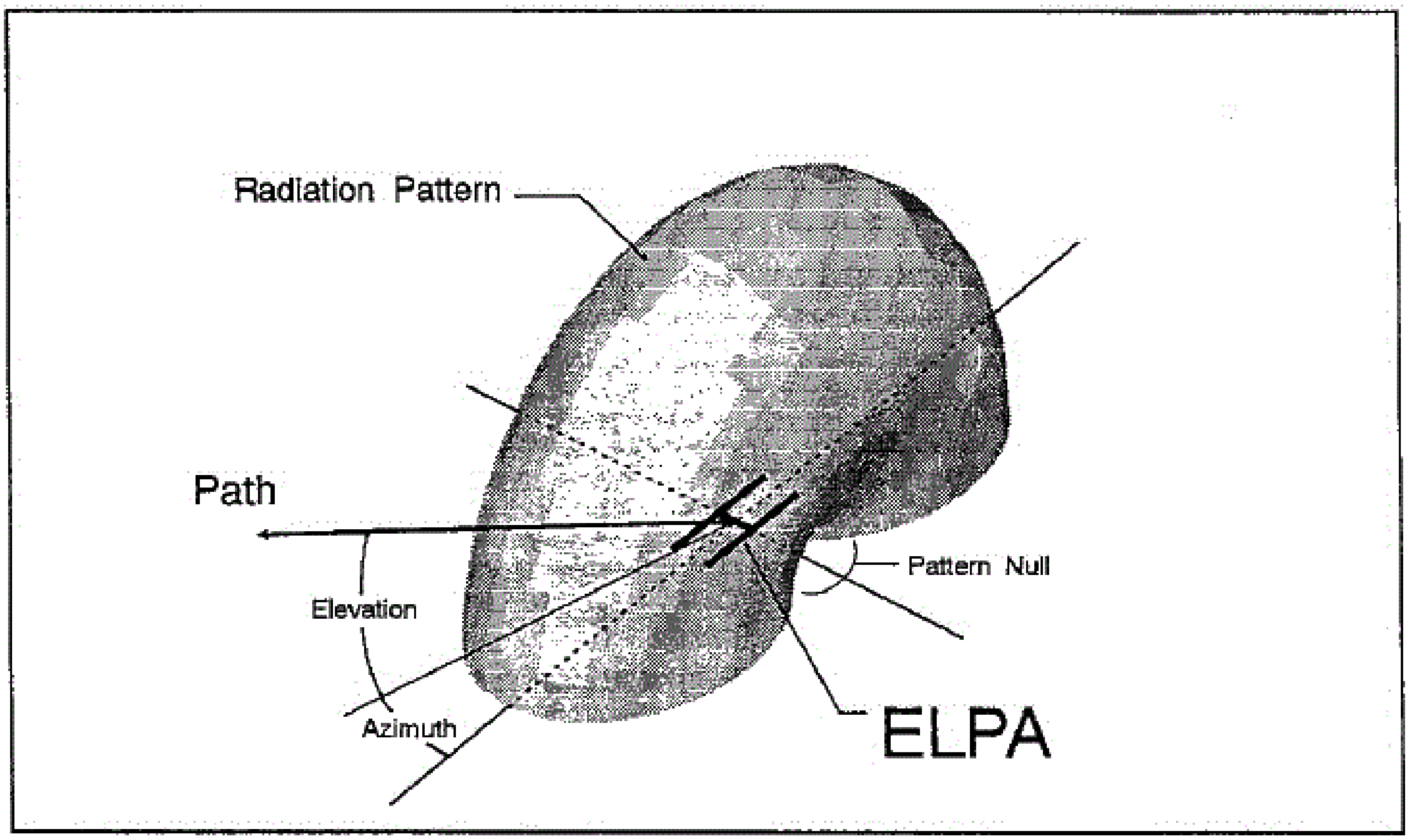

Figure 1-5 3-D representation of an ELPA skywave radiation pattern.

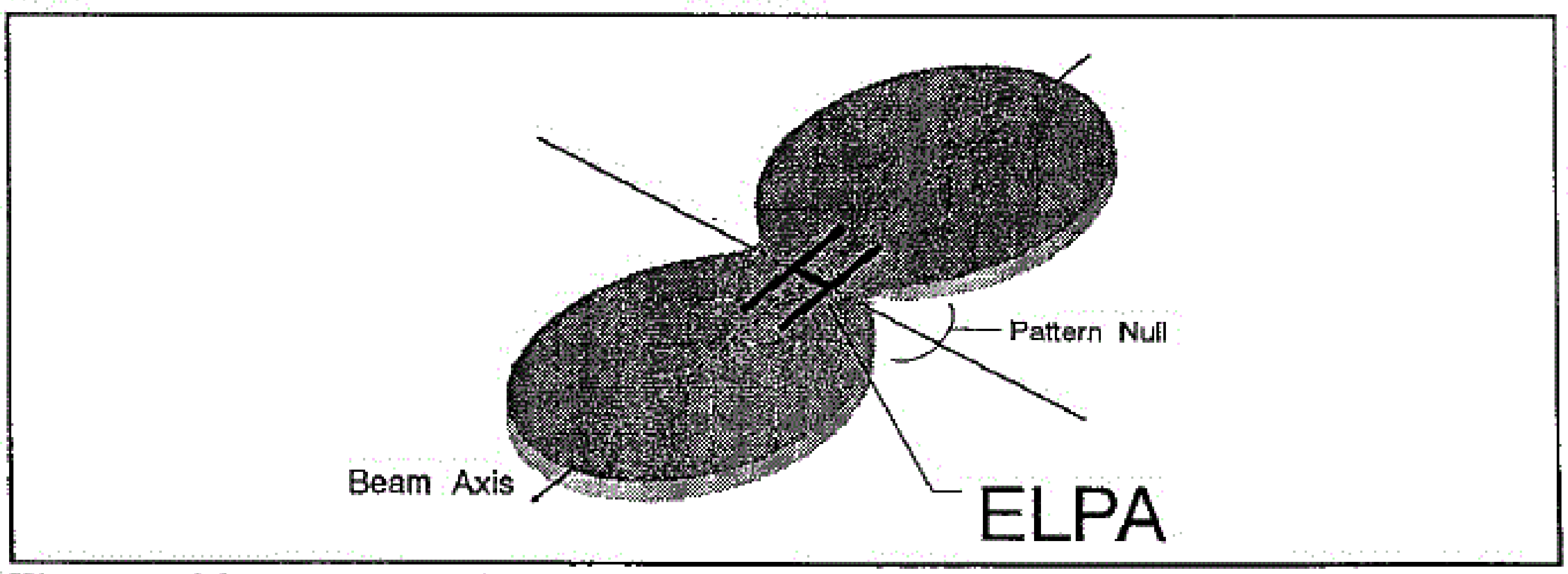

Figure 1-6 3-D representation of the groundwave radiation pattern of an ELPA.

shape of the power emitted in each direction. Figure 1-6 represents only the groundwave portion of the ELPA radiation pattern.

Figure 1-7 is a 2-dimensional representation of the elevation radiation pattern with the skywave, LOS, NVIS, and groundwave propagation paths shown in relation to their path take-off angles. Figure 1-8 is the azimuth view of the same antenna pattern. For low take-off angles the antenna is vertically polarized. Figure 1-9 shows the high angle patterns for the same antenna. Here the horizontal component of the pattern is stronger and combines with the vertical polarization pattern to produce a "near omni-directional" total power pattern.

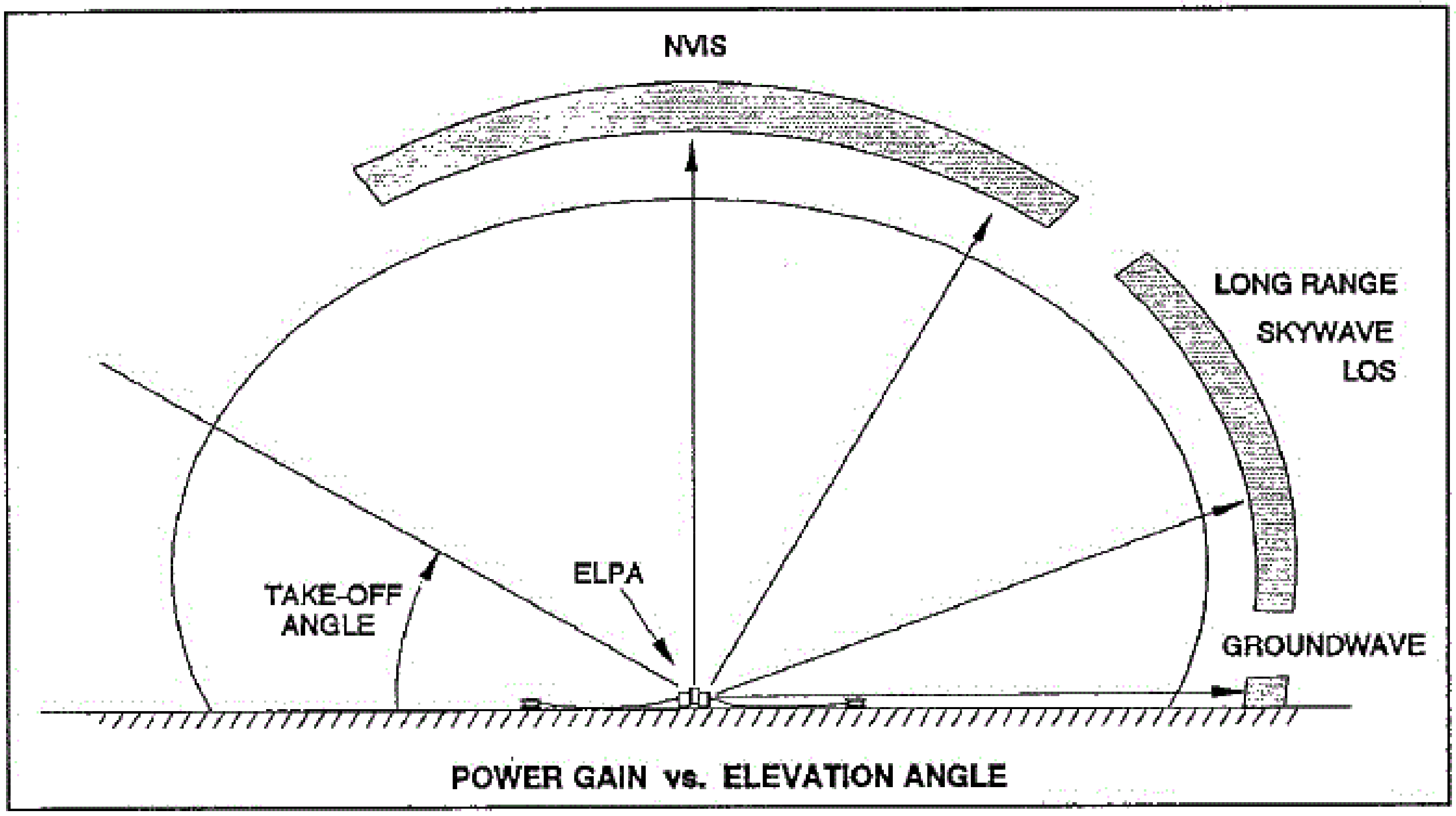

Figure 1-7 ELPA power gain vs elevation angle for propagation paths.

The geometry of the radiation patterns are expressed in several terms of comparison. The directivity of the antenna pattern is solely a function of the antenna's geometry. An antenna with a perfectly spherical pattern in free space has 0 dB directivity. An antenna with a perfectly hemispherical pattern over the ground has a directivity of 3 dB. The 3-D ELPA pattern of Figure 1-5 represents a directivity of about 5 dB. When an antenna pattern is described at a specific azimuth and elevation angle, its gain is stated in terms of power gain, directive gain and efficiency for that point. This relationship, expressed in logarithmic units of decibels (dB) with respect to a 100% efficient, isotropic (i) radiator is:

Power gain (dBi) = Directive gain (dB) + Efficiency (dB)

Several pattern points of the ELPA 302A are expressed in these terms in the specifications of Appendix A and the measured power gain examples of Appendix E. Note that the power gain specification is significant to transmitting applications and directive gain is significant to receive applications.

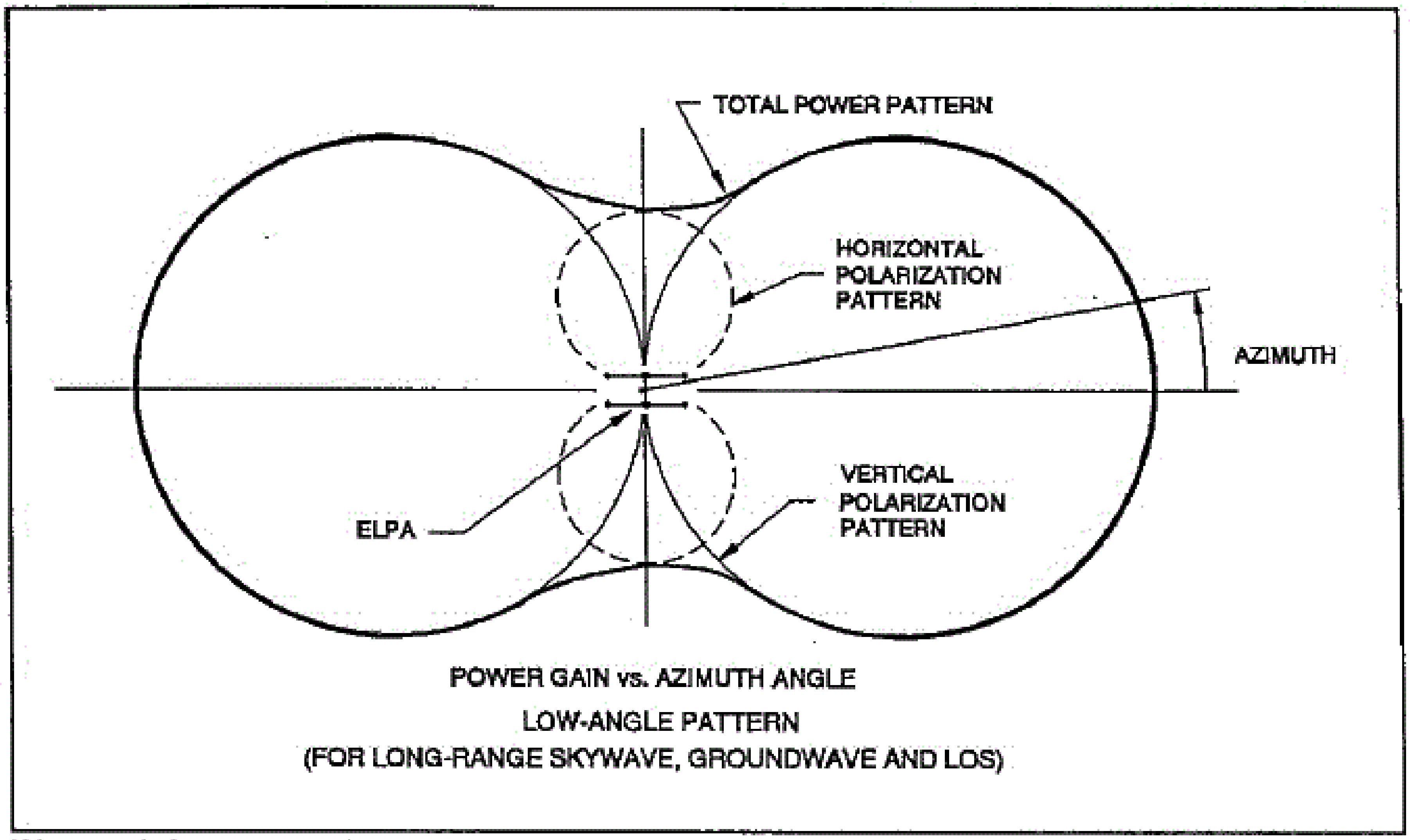

Figure 1-8 Power gain vs azimuth angle for low angle patterns.

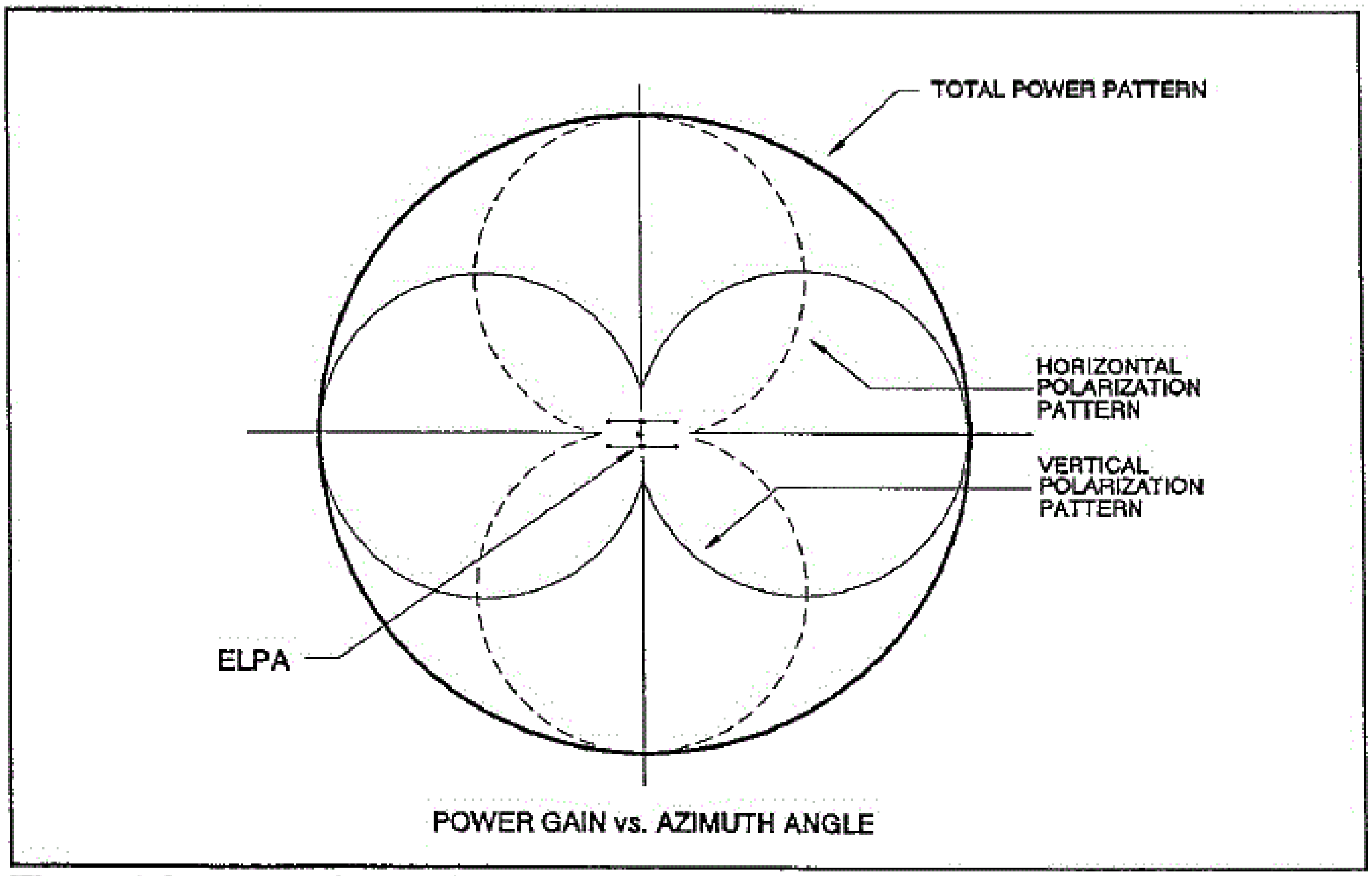

Figure 1-9 Power gain vs azimuth angle for high angle paths.

1.6.2 VSWR - The Voltage Standing Wave Ratio (VSWR) is a measure of the antennas ability to accept power from the transmitter. Low VSWR values of 2.0 or less indicate a transfer of virtually all power from the output terminals of the transmitter to those of the antenna. VSWR values of up to 3:1 can be handled by most modern solid state transmitters*. VSWR values between 2 and 3 represent radiated power losses of between 0.5 dB and 1.25 dB or 11% to 25% power reflected back to the transmitter.

The ELPA antenna configurations present feedpoint VSWR values of from 1.2 to 3.0 within their operating range. The ground (soil) characteristics of the antenna site determine the lowest frequency that an ELPA can operate for a given element length (e.g 150/150 or 300 ft. span). The ground characteristic (e.g. wet or dry) determines the electrical length of the fixed ELPA element which is always less than it is in air. A wet soil increases the electrical length of the ELPA elements and therefore lowers the minimum operating frequency to 2 MHz or lower.

Figure 1-10 displays the measured VSWR characteristic as a function of frequency for an ELPA 302 in its standard, 150/150 ft., ground contact deployment. The soil at this site was very dry farm soil** (nearly a worst case, condition for achieving low frequency coverage with the standard 2-element ELPA configuration). In this example the standard configuration ELPA displays a VSWR of 2:1 or less from 2.74 MHz to beyond 51 MHz (below 1.7 at 90 MHz). The lowest usable frequency of this antenna for these soil conditions is 2.6 MHz with a 3:1 VSWR. A change to the single element 150/150 vee configuration would extend the range to 2.15 MHz with a VSWR of 3:1 (see Sections 4.5.1, 5.5 and Appendix E). An environment with more moisture in the soil will give frequency coverage to 2 MHz or lower with the same configuration and element length.

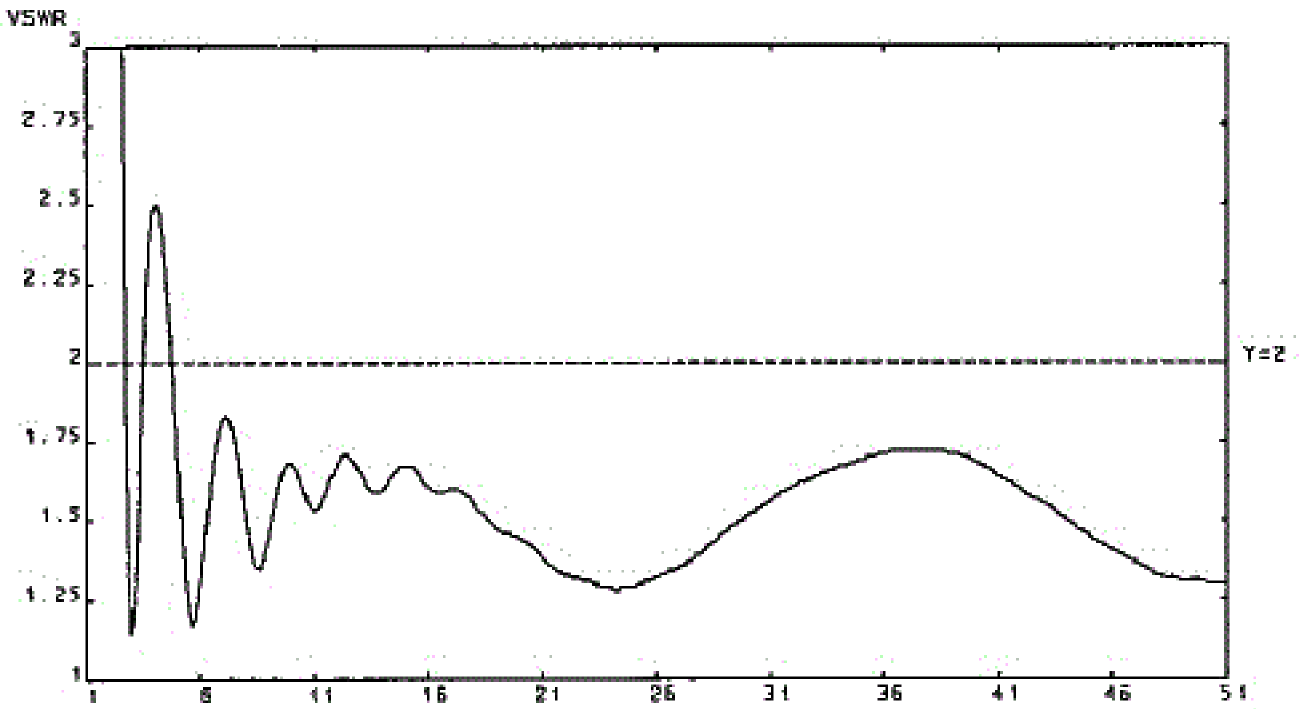

Figure 1-10 VSWR plot of standard ELPA 302A deployment.

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* For VSWR's above 2.5, many solid state transmitters automatically lower their output power in proportion to the reflected power to avoid damage to their output stage.

** The measured soil parameters at this site were a conductivity $\sigma = 6.6$ mS/m and a relative dielectric constant $\epsilon_r = 15.2$ for 6 MHz. The 27 MHz parameters were $\sigma = 11.8$ mS/m and $\epsilon_r =$ 9.9.

2.0 DESCRIPTION

2.1 Layout

The ELPA 302A components are shown in Figure 2-1. The antenna components have a very low visual signature. It is nearly impossible to see a deployed antenna from a distance of 75 feet (22.9 m) or greater in most environments.

2.2 Components

The ELPA 302A components are shown in their assembly relationships in Figure 2-1. A 1-element assembly of element wire reels and EFU is shown connected with its 10-ft. feed cable attached to the power splitter. A packaged EFU/reel unit is shown in the foreground with its 10-ft. coaxial cable removed. A packed carrying bag is shown open in the photo of Figure 2-2. In Figure 2-3 the contents of the bag are identified.

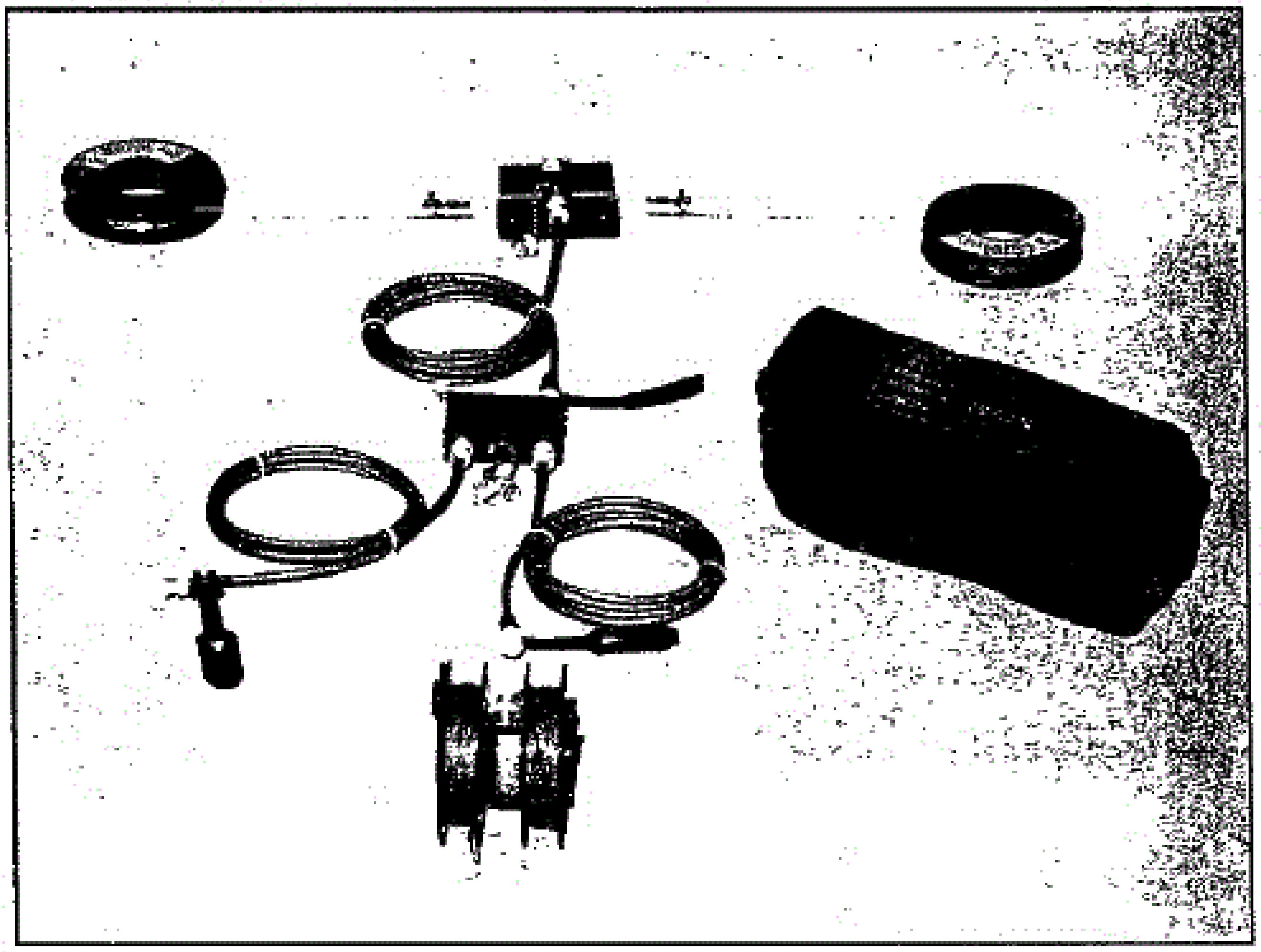


Figure 2-1 ELPA model 302A standard single wire deployment.

2.2.1 Bag - The canvas carrying bag is designed to hold all of the basic 302A components. The bag is olive drab with tan lettering. The snap hardware is non-reflective black. The two attachment "D" rings are made of high strength black Delrin®. Inside the bag, under the main flap, is a tan cloth instruction panel that provides the basic setup information for the ELPA 302A (see Figure 2-4). Export models have both English and foreign language panels.

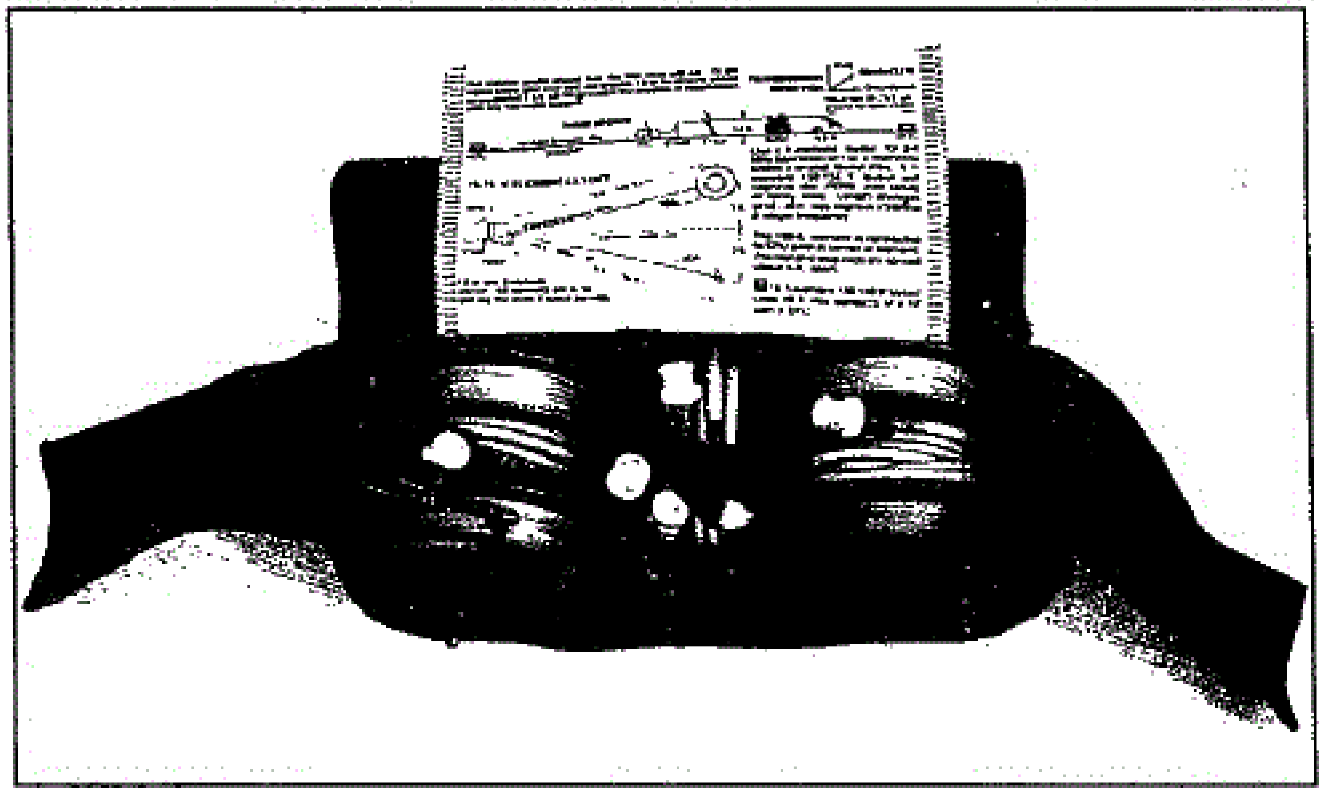
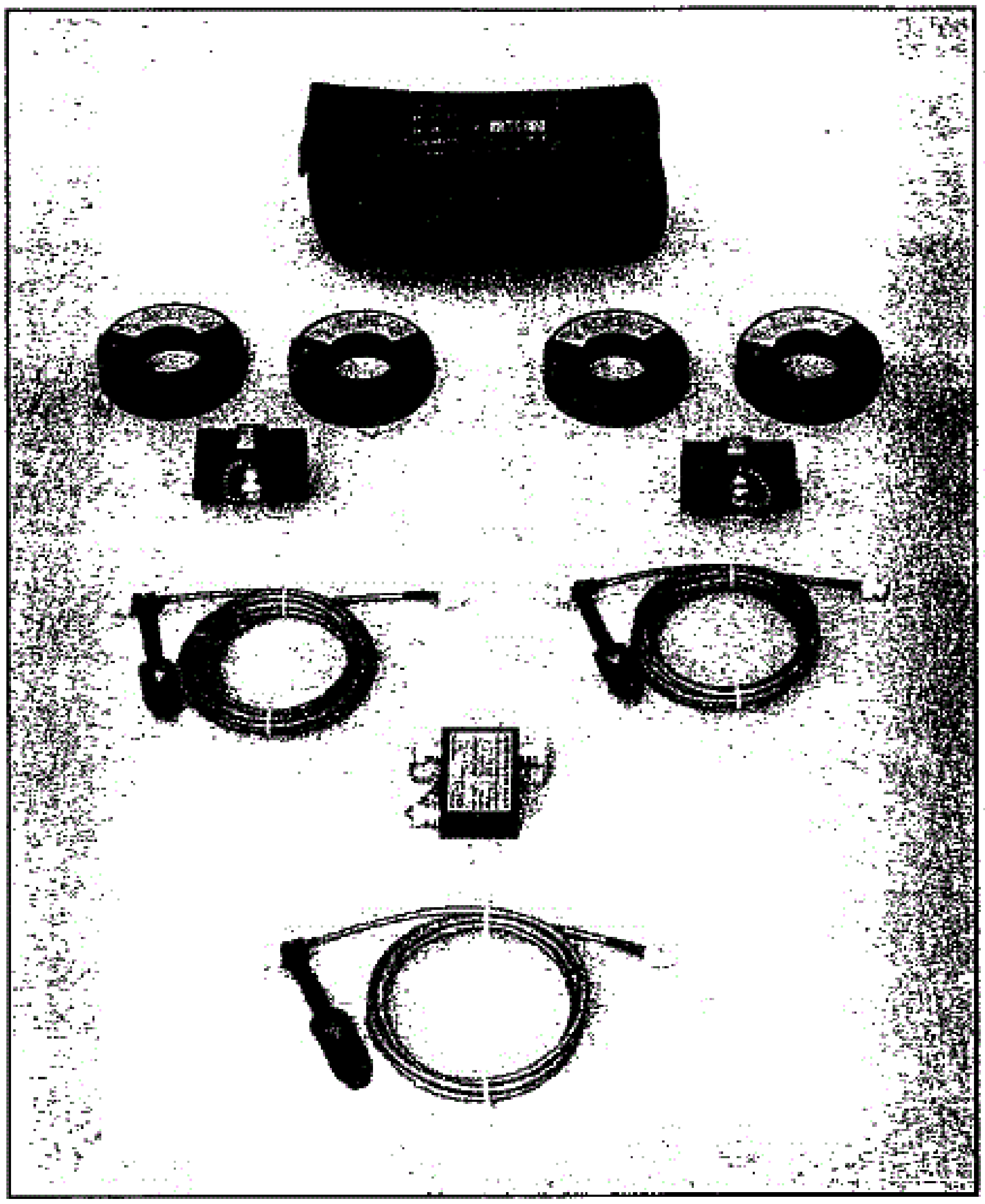


Figure 2-2 ELPA 302A carrying bag, open to show contents.



Bag

Reels with element wire

Element feed units (EFUs)

10-ft. coaxial cables

Power splitter

6-ft. coaxial feed cable

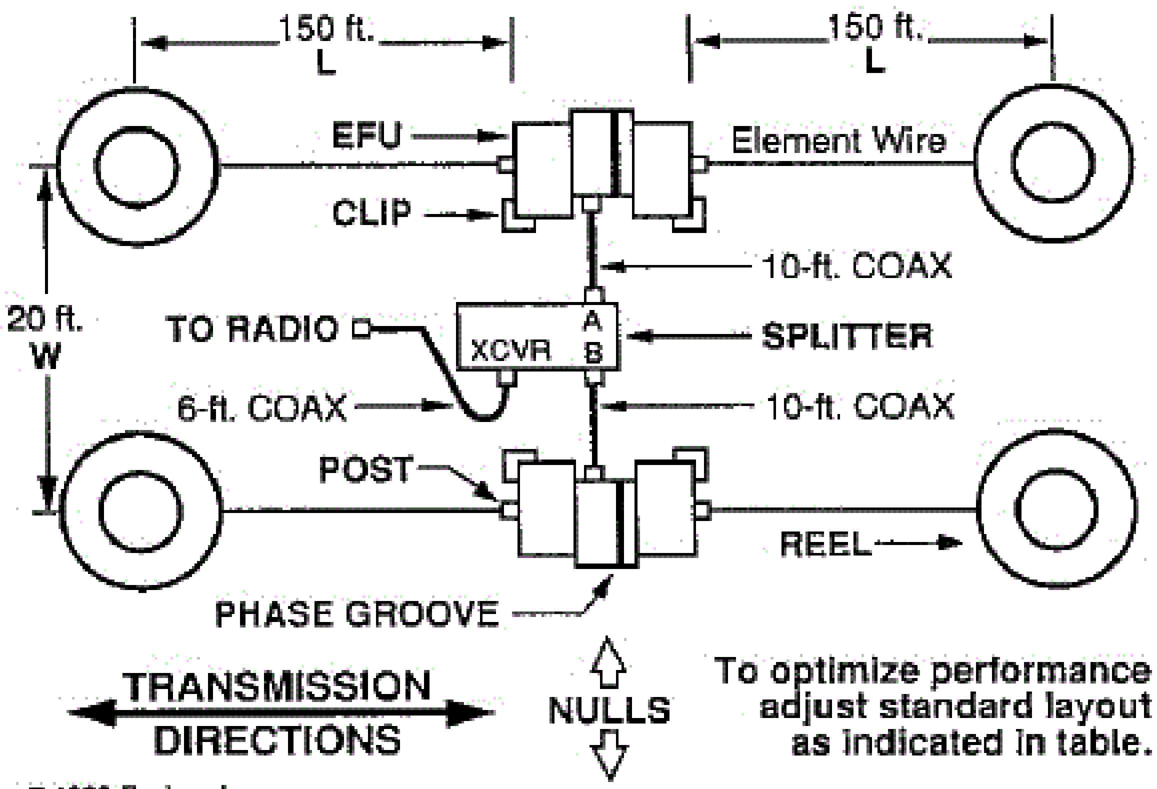
Figure 2-3 302A bag contents.

ELPA 302A POCKET PACK ANTENNA LAYOUT INSTRUCTIONS

200W AVERAGE 400W PEAK 2-65 MHz WIDEBAND 2:1 VSWR TYPICAL–TUNER NOT REQUIRED

STANDARD 2-ELEMENT 150/150 SINGLE WIRE CONFIGURATION SHOWN–USABLE 2-65 MHz

The antenna will look like this when laid out on the ground.



To optimize performance adjust standard layout as indicated in table.

The antenna pattern is directional along the element wires for groundwave, skywave, (over 300 mi.) and 30-65 MHz VHF LOS. The pattern is omnidirectional for 2-8 MHz NVIS (under 300 mi.).

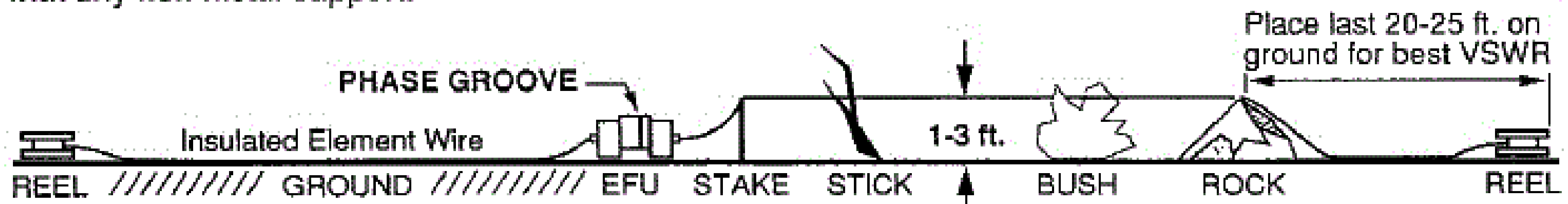
! Both phase grooves must be located on the same side of the antenna layout as shown.

1-Element layout with direct feed to the EFU can be used in place of the standard layout to save time.

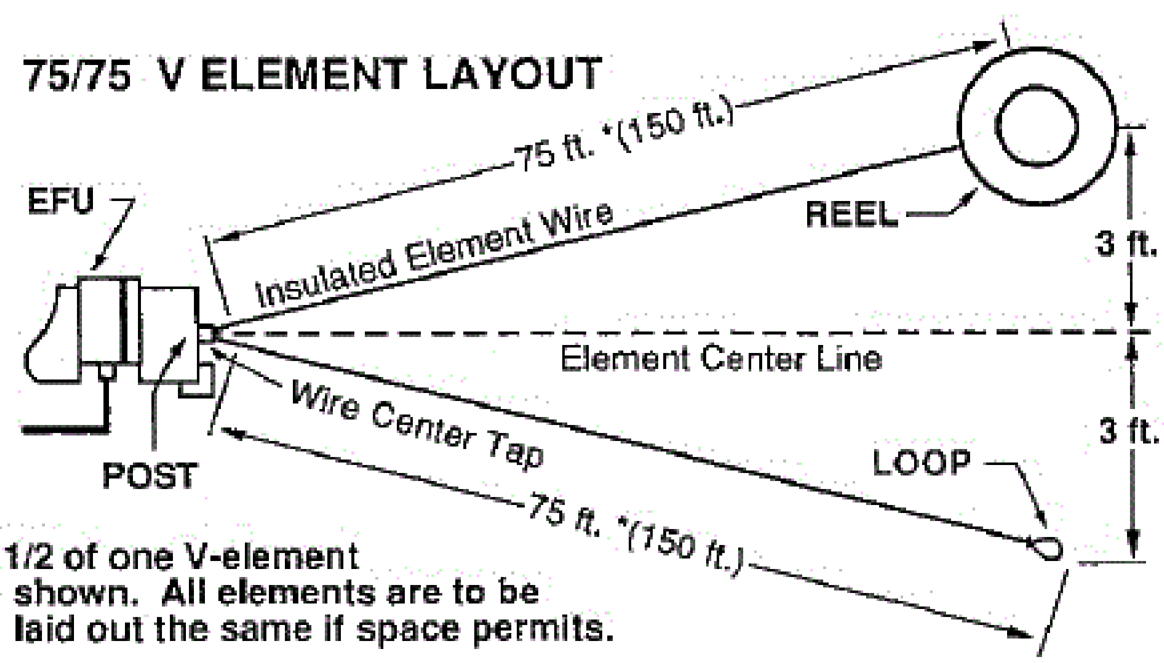
FREQUENCY	L	W
2-30 MHz	150 ft.	20 ft.
4-50 MHz	75 ft.	20 ft.
10-65 MHz	50 ft.	10 ft.
15-65 MHz	25 ft.	10 ft.

(See manual for other options)

The antenna profile should look like this when laid out. To get higher power gain over very wet ground, 1/2 of the antenna should be supported 1-3 ft. off the ground in the direction of transmission with any non-metal support.



75/75 V ELEMENT LAYOUT



1/2 of one V-element shown. All elements are to be laid out the same if space permits.

Use a V-element layout for 2-6 MHz operation of 1 or 2 elements within a limited layout area. A 1-element 150/150 V layout will improve the VSWR over sandy or rocky soils. Length changes of 10-20 ft. may improve VSWR at a single frequency.

The 150-ft. element is connected to EFU post at center of element. The reel and loop ends are spread about 6-ft. apart.

! *A 1-element 150/150 V layout uses all 4 wire elements of a kit with 1 EFU.

Figure 2-4 Bag instruction panel

2.2.2 Reels - The reels contain 150 ft. (45.7 m) of nylon jacketed element wire. The wire is 7x7 strand phosphor bronze. The attachment points to the reel, the center tap, and the reel end loop are made of wear resistant stainless steel wire. The reel ends of the wire are terminated with loops to allow the joining of two wires to create longer radiating elements for antenna option kits. A wire retaining hook is located behind the wire loop as shown in Figure 2-5. It is used to lock the rolled up wire onto the reel. To do this the hook is slipped under several adjacent wraps of element wires (3 minimum) and pulled to cinch the wires in place.

NOTE: The breaking strength of the standard element wire is 40 lbs. The loop and center tap pull test is for 25 lbs. This is sufficient for low profile and ground contact ELPA modes. *The standard wire is not recommended for tensioned suspension of the element feed units to create dipoles. Inverted-vee and Beverage antennas constructed with this wire should not be highly tensioned.* See Section 4.7 and Appendix F for details on alternate deployments.

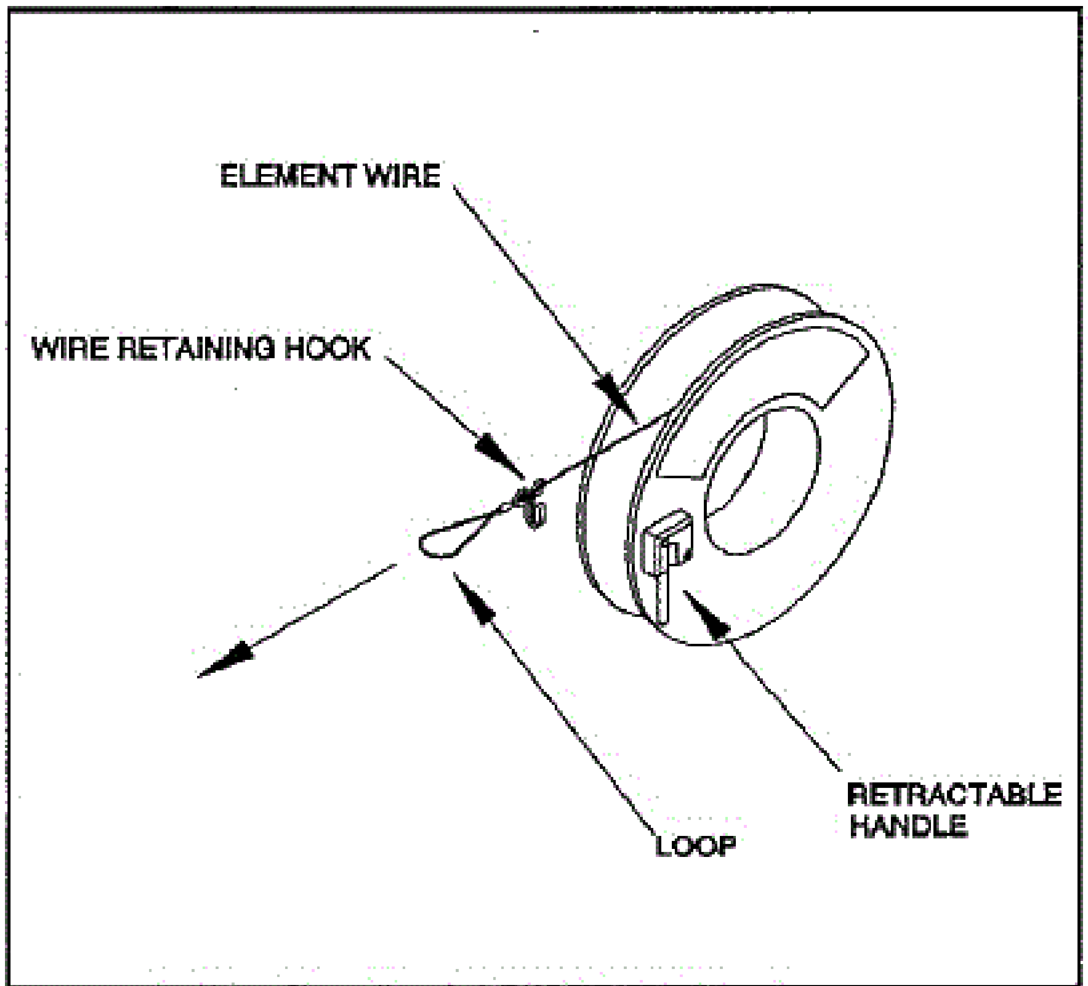


Figure 2-5 Reel with element wire.

The reel has a small retractable handle mounted on its outside edge. This handle is used to rapidly retrieve the element wire.

2.2.3 Element Feed Units (EFUs) - The EFU, shown in Figure 2-6, has a mechanical latching clip on each end which has a dual purpose. The clip serves to retain the wire reel on the EFU to allow easy wire spooling during retrieval or deployment. Depressing the clips allows the attachment of element wires to the posts of each EFU. Within the EFU is a ferrite autotransformer that is used to transform the 50 Ohm input impedance up to the high impedance (about 450 Ohms) of the ELPA radiating elements. The "high," phase groove terminal post, end is tied to the center of the coaxial feed and the

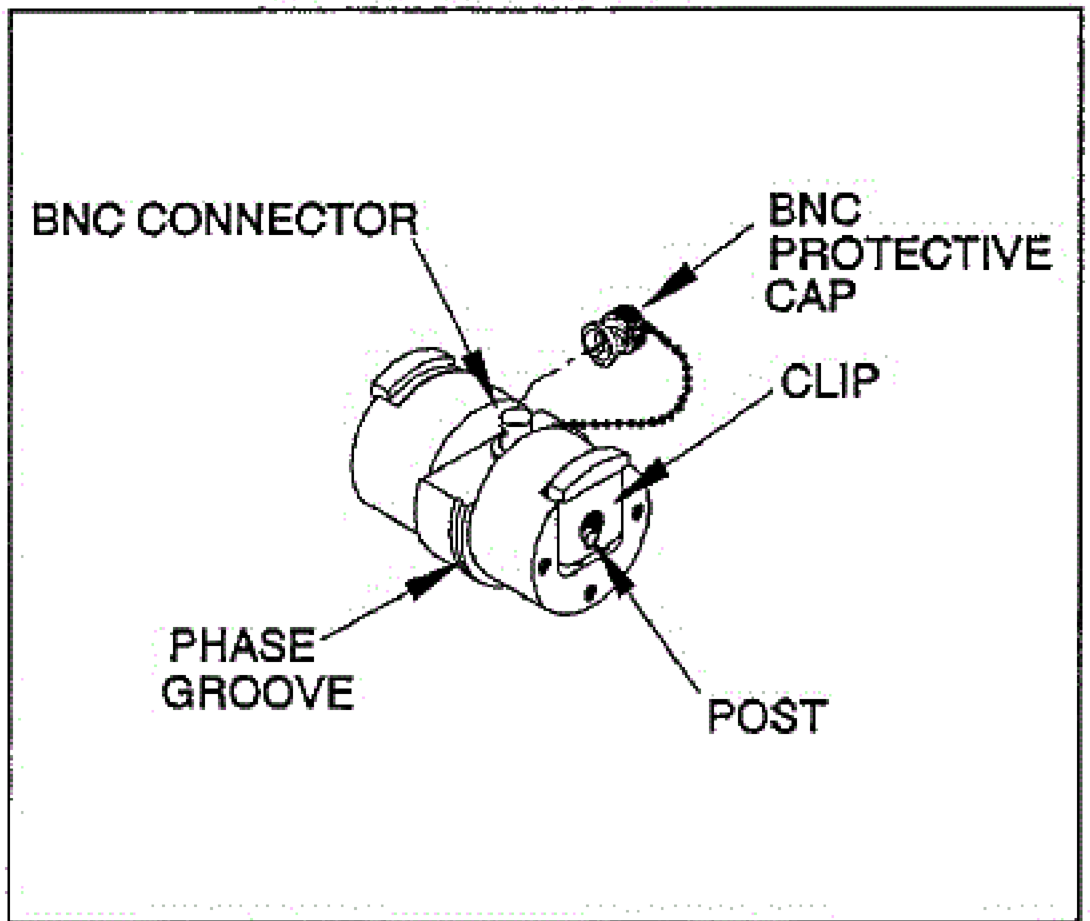


Figure 2-6 Pictorial view of EFU

"low" (unmarked) terminal post end is tied to the coax shield and is nearer to ground potential. A single EFU is rated at 1/2 the power handling capacity of the entire 302A antenna. The aluminum center section of the EFU is the housing for the ferrite transformer. When an EFU is operating at rated average power (100 Watts) with a VSWR of 2:1, *the center hub of the EFU may become warm or even hot to the touch.* This condition is normal. See Appendix D for an electrical schematic.

The EFU end caps (reel hubs) and clips are machined from black Delrin® with a temperature range of -40 °F to 180 °F (-40 °C to 82 °C).

2.2.4 10-ft. Coaxial cable - The RG-400 /U cables are used to connect the EFUs to the power splitter or single elements directly to a transceiver. The cables are double shielded and constructed internally and externally from extruded FEP Teflon®. Both the outer braids and the center conductors are silver plated copper. These cables provide high crush resistance, flexible strength and low signal loss over a -94 °F to 392 °F (-70 °C to 260 °C) temperature range. A cable retainer is provided to secure the 10-ft. cable for storage about the center of the EFU.

> **NOTE:** The cables to each EFU are matched in length (+/- 6 inches or less). Do not substitute alternate cable types or lengths to feed a pair of EFUs from the splitter of a multi-element ELPA antenna. Single elements can be operated with any length or type of coaxial cable.

2.2.5 Splitter - The power splitter feeds the power from the transmitter to match the combination of two ELPA radiating elements. The splitter is a 50 Ohm input, 50 Ohm output ferrite transformer device designed to handle 400 Watts peak and 200 Watts average power. The EFUs are connected to the identical "A" and "B" ports of the splitter. The transceiver is connected to the port labeled "XCVR." A splitter is shown in Figure 2-7. See Appendix D for an electrical schematic.

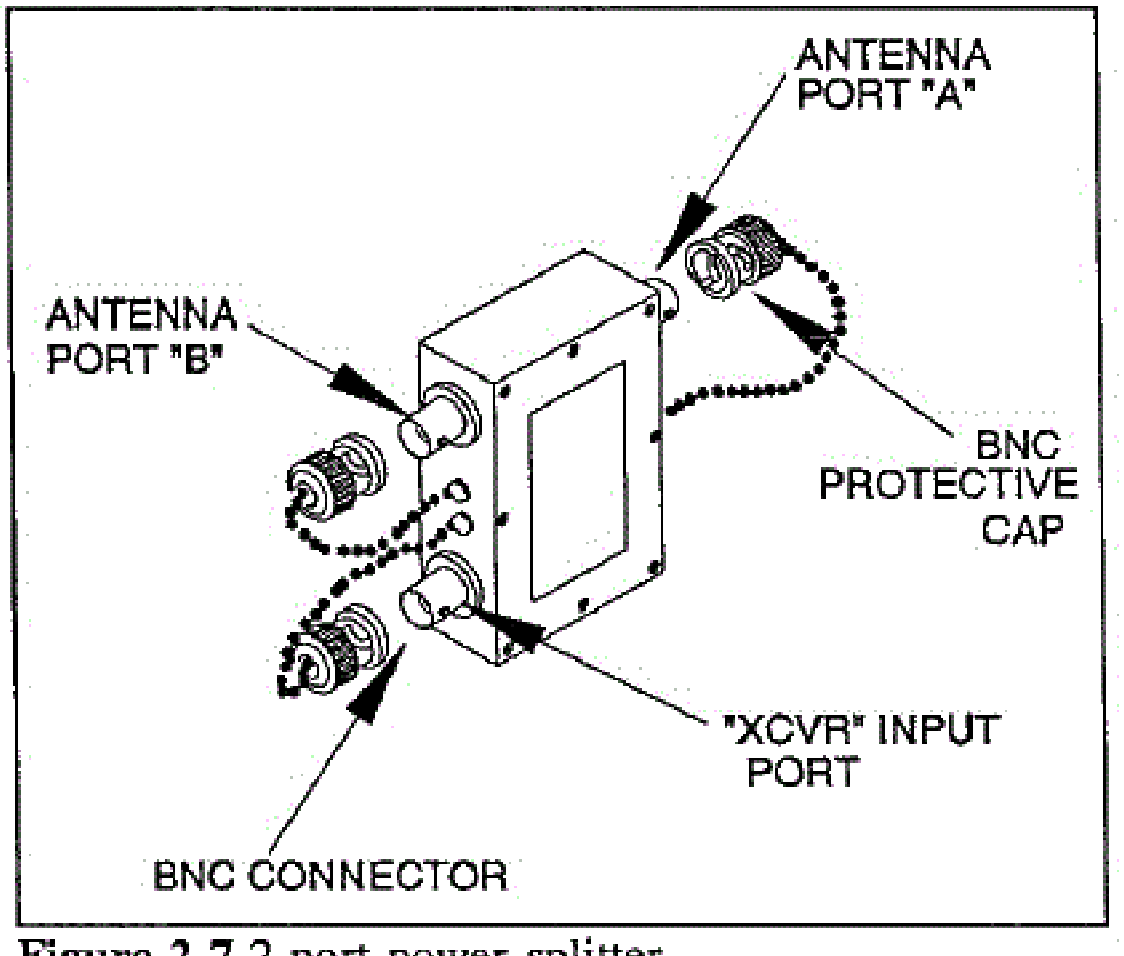


Figure 2-7 2-port power splitter.

2.2.6 6-ft. Coaxial cable - This RG-400 /U cable is identical in construction to that of the 10-ft. cables. It is used only to connect the input "XCVR" port of the power splitter to the output antenna jack of the transceiver. The cable retainer is provided to secure the cable for storage in the carrying bag pouch.

3.0 ANTENNA SITING

The ELPA 302A is very adaptable and tolerant of site conditions. The ELPAs have been used successfully on rocky soil, desert sand, beaches, rich farm land (loam), wet soil (marshy areas), Arctic tundra, on snow, under snow, laid on asphalt pavement, draped over brush and woven through forests. With few exceptions the communicator should always be able to deploy an ELPA, even in the most rugged of terrain.

When a choice of site is possible, the most desirable location for transmission and reception is in a clearing, similar to conventional antennas. The ELPA excels in low conductivity soil conditions that present problems for the deployment and operation of many conventional high profile antenna systems. Thus the ELPA is ideally suited for use on mountain tops, hillsides, forests, grassy planes and sand dunes. It does not require long unobstructed areas for the location of tensioned wires or the positioning of towers, guy lines and guy stakes.

In the immediate environment of the antenna, the non-resonant, traveling wave operating principle of the ELPA is uniquely forgiving of the effects of the environment and nearby structures. It can be threaded around obstacles such as trees and brush.

The layout areas required to set up the standard single wire, vee and center-tapped vee configurations of the ELPA 302A are summarized is Table 3-1. The layout area of the ELPA can be adapted to the terrain's surface features and ground cover through element length, width and direction (transmission path) adjustments.

Table 3-1 ELPA 302A layout areas.

DESCRIPTION	ELEMENTS	AREA
2-65 MHz full coverage, full size layout		
1-element standard single wire	150/150	300 ft. x 0.5 ft.
1-element standard vee wire	150/150	300 ft. x 6 ft.
2-element standard single wire	150/150	300 ft. x 20 ft.
4-50 MHz coverage, compact wideband layout		
1-element center tapped vee wire	75/75	150 ft. x 6 ft.
2-element center tapped vee wire	75/75	150 ft. x 26 ft.
10-65 MHz coverage, mid and high band layout, standard 20-ft. width		
1-element standard single wire	50/50	100 ft. x 0.5 ft.
2-element standard single wire	50/50	100 ft. x 20 ft.
15-65 MHz coverage, high band and receive only layout, narrow 10-ft. width		
1-element standard single wire	25/25	50 ft. x 0.5 ft.
2-element standard single wire	25/25	50 ft. x 10 ft.

3.1 Soils and deployment surfaces

3.1.1 Native soil and rock - When a choice of soils is possible for deploying an ELPA, select the soil type based on the preference list in Table 3-2.

Table 3-2 Native soil preference.

Most desirable...	Dry rocky
	Sandy
	Dry farm land
	Loam or rich organic farm soil
	Clay
Least desirable...	Wet, marshy

NOTE: for wet loam, clay, or marshy areas the elevated element deployment should be used (see section 4.5.2).

3.1.2 Asphalt and concrete surfaces - The ELPA can be laid out on asphalt roads and parking lots. The ELPA will not work well if it is laid out on a steel reinforced concrete or an asphalt covered concrete and steel area such as an airport tarmac (see 3.2.4).

3.1.3 Snow and ice - When the ELPA is deployed over snow or ice the thickness determines the deployment options. For snow depths of 1 to 3 feet, treat the ELPA like it was being deployed as an elevated element antenna (section 4.5.2). Walk on the ends of the element to increase the coupling to the ground.

> **NOTE:** On thick ice and snow (3 ft. or more) the ELPA may act like a long resonant dipole antenna and may have a high VSWR. If this is suspected, remove the power splitter and use only a 1-element ELPA configuration (150/150 vee deployment using four element-wire reels is recommended for low frequencies). A closely coupled (short coaxial cable) antenna tuner may be used with this electrically small antenna or it can be adjusted to match to the transmitter by making incremental length adjustments to obtain a low VSWR for a favorable transmit condition as shown by the transceivers tuning indicators.

3.1.4 Subsurface and surface electrical cables and conductive pipes - It is not desirable to setup the ELPA in this type of environment but it will work. The ELPA has little interaction with buried or surface conductors that cross its element wires at right angles (90 degrees from the direction of transmission) and are separated by 6 to 12 inches. When possible, cables that have to pass under an ELPA should be routed along side of the 10-ft. coaxial EFU feed cables and under the EFU.

Subsurface conductors traveling parallel to more than 50% of an element wire's length should be avoided when possible. The effect these conductors will have on the ELPA is dependent on the depth of penetration of the antenna's energy at each particular frequency of operation. Conductors buried 10 ft. in dry soil under the ELPA should not cause a noticeable problem for an operator using frequencies in the ELPA's operating range. For very wet soils, subsurface conductors have a smaller effect. Therefore, buried conductors can be closer to the surface in wet soils with less chance of an interaction with the antenna.

> **NOTE:** In the special case of a site that contains the buried radial ground plane of a monopole or similar antenna *the ELPA can be used if no more than 1/2 of the element wires on the layout side opposite the phase grooves, are over the ground plane. None of the element wires on the phase groove side can be over the ground plane. The EFU section of the ELPA radiating elements may not be "shorted" by the ground plane.*
>
> Similarly, *but not in the same configuration as above*, the last 20 to 30 feet of either end of an ELPA element can rest on a ground plane since the effect will be to increase the termination loading of the element.

3.2 Nearby objects

The general guideline for ELPA deployment is to maintain a boundary distance of 10 to 20 ft. from large conductive objects such as vehicles. When possible, it is best to keep the object near the center and off to the side of the ELPA element span (pattern null area). If low-angle skywave or groundwave communications paths are to be used, the end of the antenna pointed in the direction of transmission should not be obstructed by large conductive objects. In this respect the ELPA is similar to conventional monopole antennas.

> **NOTE:** If extra space is needed to extend the element wires to operate at a low frequency, the wires should be extended despite the 10 to 20 ft. boundary. The better matching and radiation efficiency should outweigh the potential losses due to approaching the obstruction.

In general, the non-resonant, multi-element operating design of the ELPA makes it less susceptible to the pattern distortion and energy absorption effects of both conductive and non-conductive objects.

3.3 Forests and jungles

In forested areas with light canopies (e.g. pine forest) the easy deployment and distributed radiating area of the ELPA can be an asset for NVIS communication. In jungle environments with heavy canopies the signal penetration of the ELPA will be limited in a manner similar to conventional HF antennas. The ELPA may be used to more access NVIS at lower frequencies (2 to 6 MHz) which receive less jungle canopy attenuation than at higher frequencies.

> **NOTE:** The use of the ELPA has been reported in jungle areas. The use of disposable vee-element wires with spans of 300 ft. are suggested for 2 to 6 MHz operation with end-loading ground contact. The wires are expected to be threaded through the foliage and around trees in approximately straight lines.

3.4 The interference, noise and the electronic warfare environment

One of the advantages of the ELPA is its ability to position a low angle null pattern toward noise sources and interfering signals. It is also able to receive and transmit through a directional beam pattern that is narrow in azimuth*. Figure 3-1 provides an example of communications between two ELPA antennas in the presence of an interference source (noise or station) or an electronic warfare jamming transmitter. In this case the ELPAs are oriented to use the lower gain, off-axis sides of their main beam patterns to effect a groundwave, skywave, or LOS communications path. If the communications path is NVIS the high angle omni-directional pattern of the ELPAs would be used for the link. In the NVIS case the operator has virtually complete freedom to orient the ELPA to reject interference.

> NOTE: An ELPA will often appear to have a "quieter" background noise level than other tactical antennas. This is due to the pattern directivity of the antenna**. The ELPA can be positioned to strongly reject low angle distant noise sources as well as local noise sources. The local noise rejection phenomena of the ELPA has been observed at several test and demonstration locations that had high levels of local noise. The rejection mechanism is related to the ELPA's low or zero profile elements which give it a virtually zero vertical aperture in its off-axis near field environment.

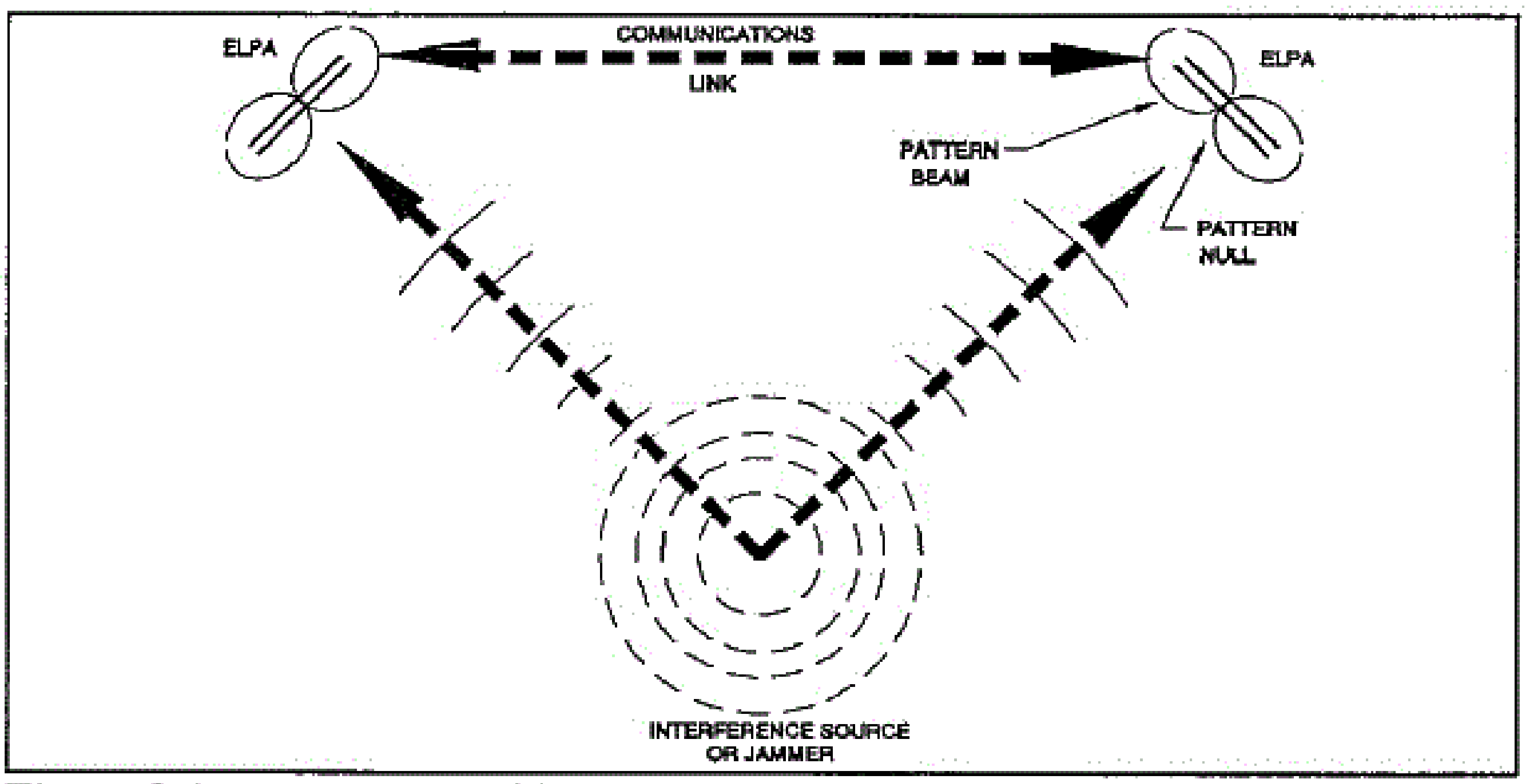


Figure 3-1 Two ELPAs positioned to reduce noise and increase jamming resistance.

* This beam can be narrowed by combining ELPA 302As to form 4-element and 8-element antennas. The beam can also be narrowed by increasing the spacing between elements to increase directivity.

** In the 2 to 30 MHz HF band the ELPA's power gain is typically not a factor in limiting reception since the received noise level is set by atmospheric noise and the crowded conditions of the HF spectrum. Often the directivity of the ELPA will allow separation of signals within the crowded HF spectrum which can usually only be accomplished by more sophisticated directional antennas.

4.0 ANTENNA DEPLOYMENT AND RETRIEVAL

4.1 Deployment Strategies

Key ideas for the ELPA 302A operator are:

- **Get on the air quickly.**
- **Communicate with the least complicated antenna configuration.**
- **Use the shortest element length that will meet your frequency range.**
- **Use ELPA frequency access and pattern directivity to work with propagation conditions;**
- **Optimize the antenna configuration as mission conditions require.**

The fundamental guideline of ELPA 302A deployment is to set up the standard 2-element 150/150 single wire configuration whenever in doubt about what a mission will require. This configuration is likely to satisfy most quick reaction tactical requirements. If 2 to 4 MHz coverage is not required and additional minutes of set up and retrieval time are available the 2-element 75/75 center-tapped vee is the preferred configuration.

The ELPA 302A element spans that can be selected to support a mission's frequency assignments are summarized in Table 4-1. The deployment sequence chart in Figure 4-1 provides the operator with an efficient sequence of deployments for the standard configuration and the compact tapped-vee configuration. Listed in Figure 4-1 are the subsections of this manual which describe these configurations.

Table 4-1 Standard ELPA element spans vs frequency band.

Element span Ft.	(length/length) (ft./ft.)	Frequency MHz	Typical communication paths
300	(150/150)	2 to 30	Groundwave, NVIS, skywave,LOS
150	(75/75)	4 to 50	NVIS, skywave, LOS
100	(50/50)	10 to 65	Skywave, LOS
50	(25/25)	15 to 65	Skywave, LOS

The basic deployments described in Sections 4.2 through 4.3 are supplemented by the knowledge of the ELPA optimization techniques described in section 4.5. Element configurations are summarized in a chart in Section 4.6. Alternate deployments are summarized and charted in section 4.7. These deployments further enhance the utility of the basic ELPA 302A kit by assisting the operator in utilizing the components to assemble larger multi-element ELPAs, or higher profile HF antennas with optimized power gain characteristics.

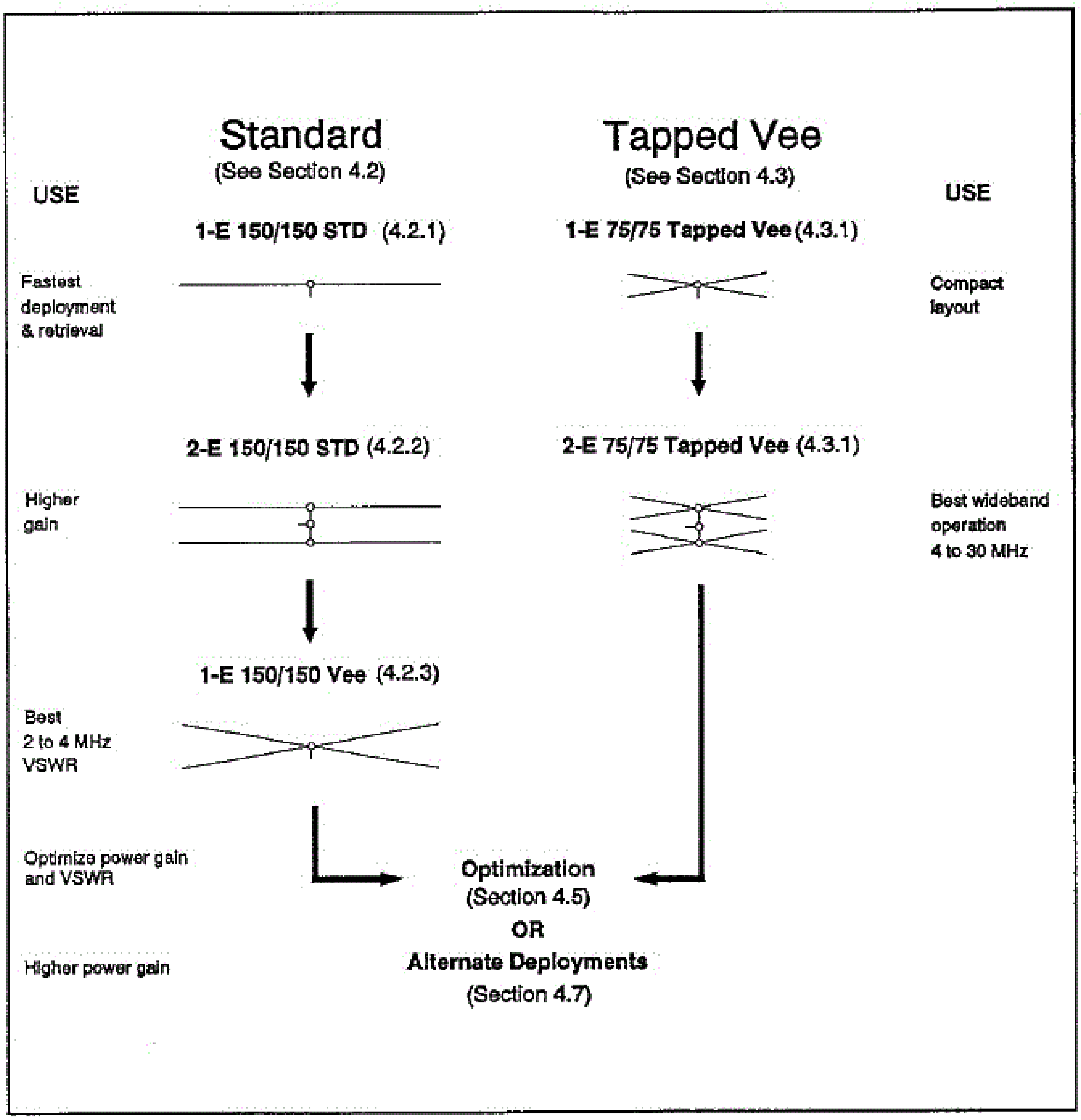


Figure 4-1 Basic deployment sequence chart.

4.2 The standard ELPA 302A deployments

4.2.1 The 1-element 150/150 standard deployment - The 1-element standard deployment is the most basic configuration for the ELPA 302A. All other ELPA deployments use this configuration as a building block. The 1-element layout, which is also designated an ELPA 301A, looks like Figure 4-2 when completed.

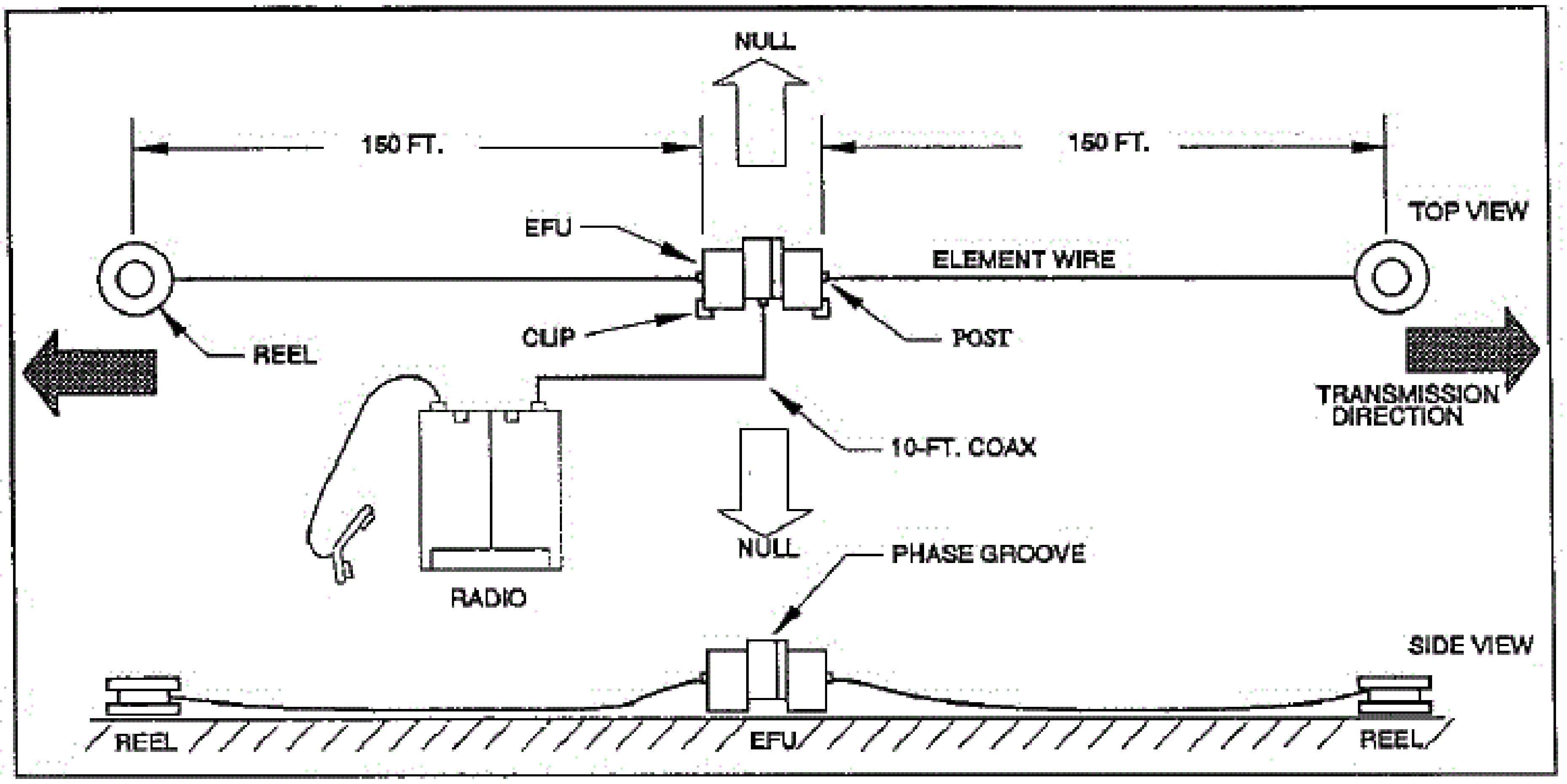


Figure 4-2 Standard 1-element 150/150 single wire configuration.

- Locate the ELPA 302A Carrying bag.

  NOTE: Use the bag's instruction panel as a guide for field setups. Use this reference manual for more insight into the options presented in the panel figures and chart.

- Determine the transmission direction and element lengths for the antenna.

  NOTE: Set the element span (length/length) to cover the lowest required transmitting frequency. Excessive length to support low frequencies will cause a loss of gain at high elevation angles for higher frequencies due to soft pattern nulls.

  NOTE: If you plan to set up a 2-element antenna, plan for the space at this time.

- Remove one EFU/reel/coaxial cable unit (also known as a 301A antenna).

- Detach the coaxial cable retainer that secures the 10-ft. cable about the center of the EFU and remove the cable.

- Remove the two element wire reels from the EFU.

● Attach an element-wire loop to the EFU post on the phase groove side as shown in Figure 4-3).

● Place the EFU on the ground.

> **NOTE:** The phase groove of the EFU should be on the side of the antenna element wires pointing in the direction of transmission (NVIS applications only require that the grooves are matched).

● Unroll the first element wire in a straight line, walking in the direction of transmission/reception.

> **NOTE:** The wire must be spooled off smoothly by letting the reel spin freely on the fingers of one hand as in Figure 4-4.

> **WARNING: Do not unwrap the element wire from a stationary reel. Unwrapping the wire in this manner twists the wire. These twists will become permanent kinks that will make rapid wire retrieval difficult.**

● Return to the EFU and attach the second element-wire loop to the opposite EFU post.

● Unroll the second element wire in a straight line, walking in the opposite direction.

● Connect the 10-ft coaxial cable to the EFU and then to the radio.

● **The 1-element standard deployment antenna is now ready for communication.**

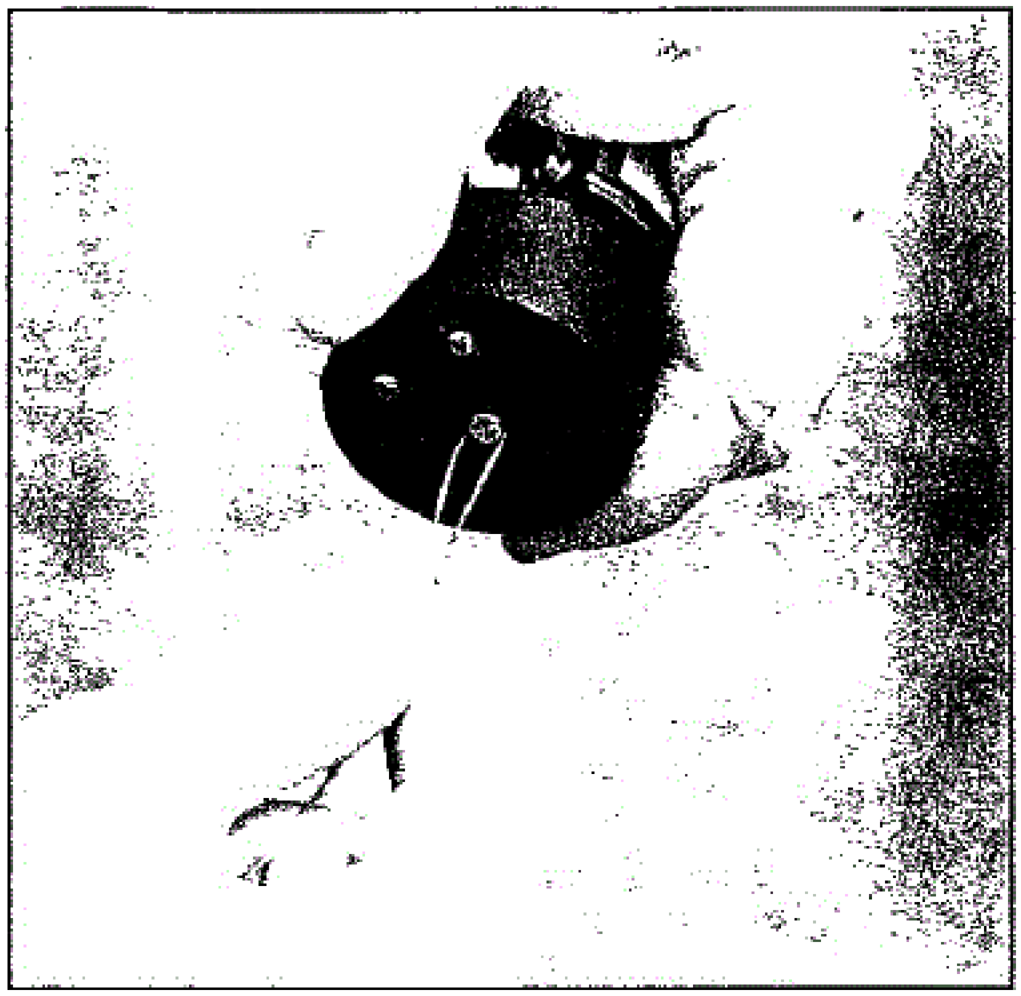


Figure 4-3 Connecting element wire loop to EFU.

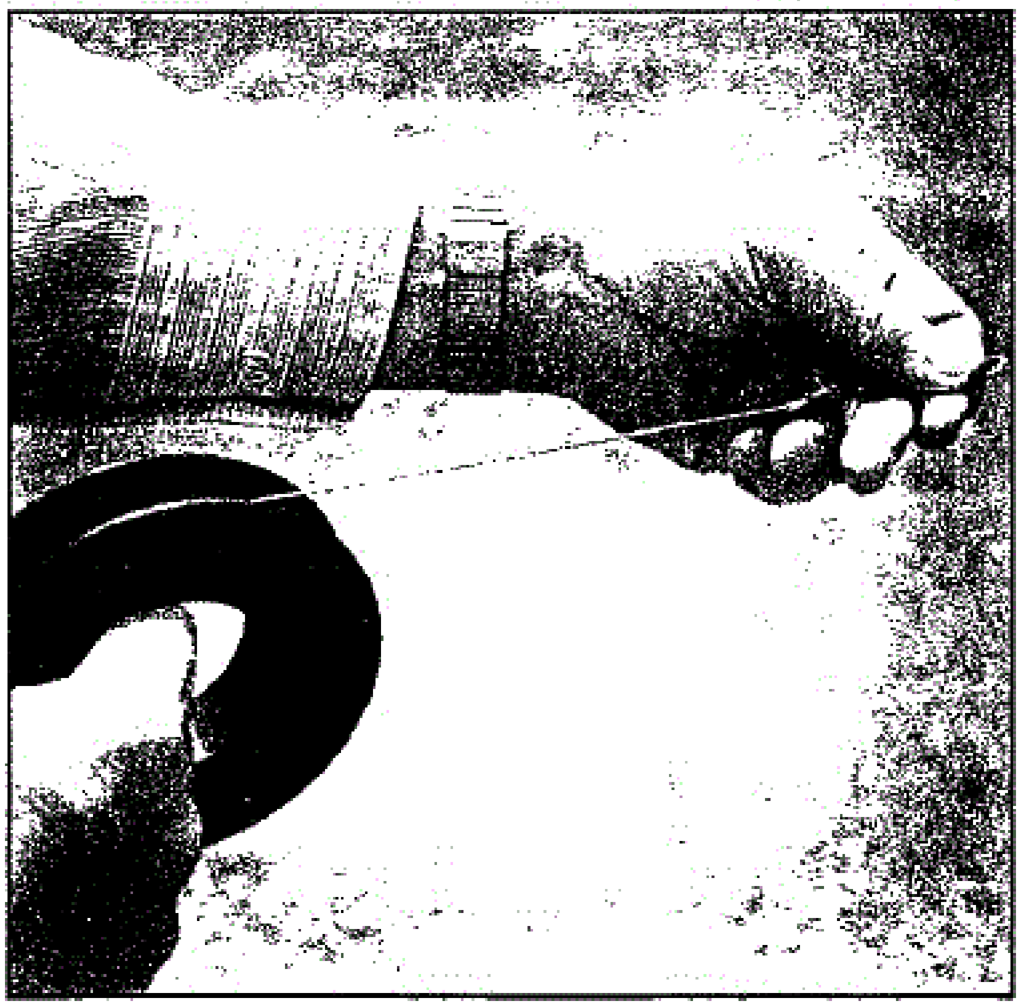


Figure 4-4 Spooling wire of the element reel.

Continue to section 4.2.2 to deploy the second element for a 2-element standard ELPA.

4.2.2 The 2-element 150/150 standard deployment - This deployment is a continuation of the 1-element deployment described in section 4.2.1.

The 2-element layout will look like Figure 4-5 when it is completed.

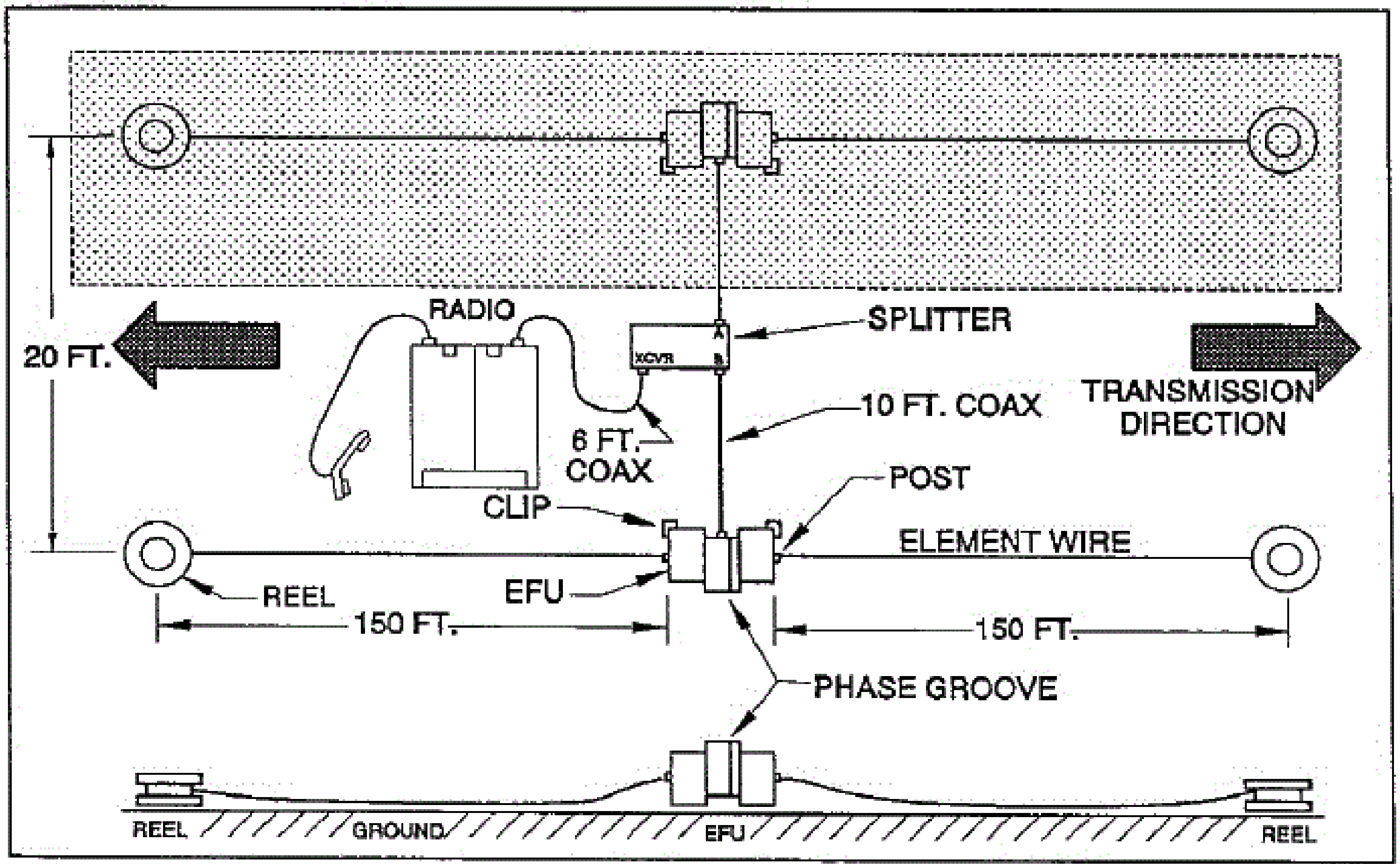


Figure 4-5 Standard 2-element 150/150 single wire configuration.

- Deploy the first element (shaded box) as described in Section 4.2.1. This can be used for transmission/reception while the second element is being deployed.

> **WARNING: Do not connect, disconnect or move element wires while they are being used for transmission. Contact with the element wires is hazardous at high power levels. See Section 5.8 for details on operation safety.**

- Locate the second EFU/reel/coaxial cable module. Remove the 10-ft. coaxial cable and the reels from the EFU. Locate the splitter.

- Connect the 10-ft. coaxial cable between port "B" of the splitter and the second EFU.

- Lay out the splitter/cable/EFU assembly in a straight line at a right angle (90 deg.) from the first deployed element with the splitter 10-ft from the first EFU.

- Orient the second EFU's phase groove side to match that of the first deployed element.

  WARNING: Both EFUs must be oriented with the phase grooves on the same side to connect to element wires in the same half of the layout. Opposing phase groove layouts will severely degrade antenna gain but will not necessarily degrade the antenna's input VSWR.

- Connect the element wires to the second EFU and unroll them in opposite directions.

  NOTE: The ELPA element wires should be straight and parallel. However, wires can be laid around trees or rocks with little or no effect on antenna performance. It is critical the elements form a true "H" pattern on the ground. Deviations of more than 3 ft. will degrade the array performance of 2-element antennas. Figure 4-6 shows right and wrong layouts of an ELPA 302A.

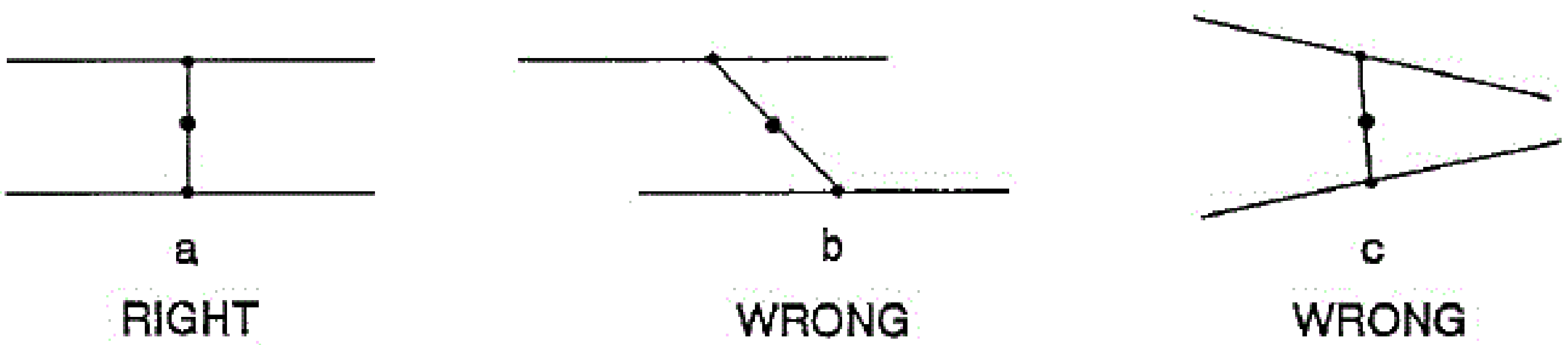


Figure 4-6 Right and wrong 2-element layouts.

- Connect the 6-ft coaxial cable from the splitter port marked "XCVR" to the radio.

  NOTE: If the first element was in use the 10-ft feed cable from the first element must be disconnected from the radio and connected to splitter port "A".

  NOTE: The transmitter may be located away from the center of the antenna by supplying an additional coaxial transmission line of at least 20 ft. or greater in place of the 6-ft. line (the operator can be 10-ft. away from a radiating element if high power operation requires this distance - see Section 5.8.2, radiation hazard). The line should lie on the same line as the 10-ft. coaxial cables and pass under the EFU as it exits the layout area.

- **The 2-element standard deployment antenna is now ready for transmit and receive operation.**

4.2.3 The 1-element 150/150 vee deployment - Deployment of the 1-element Vee is identical to the 1-element standard deployment described in section 4.2.1, except that two element wires are attached to each EFU post. The 1-element 150/150 vee uses all four reels from the 302A kit. The 1-element 150/150 vee can be constructed directly or by moving the element feed wires from an existing 2-element standard 150/150 deployment. The completed 1-element 150/150 vee wire deployment is shown in Figure 4-7 below.

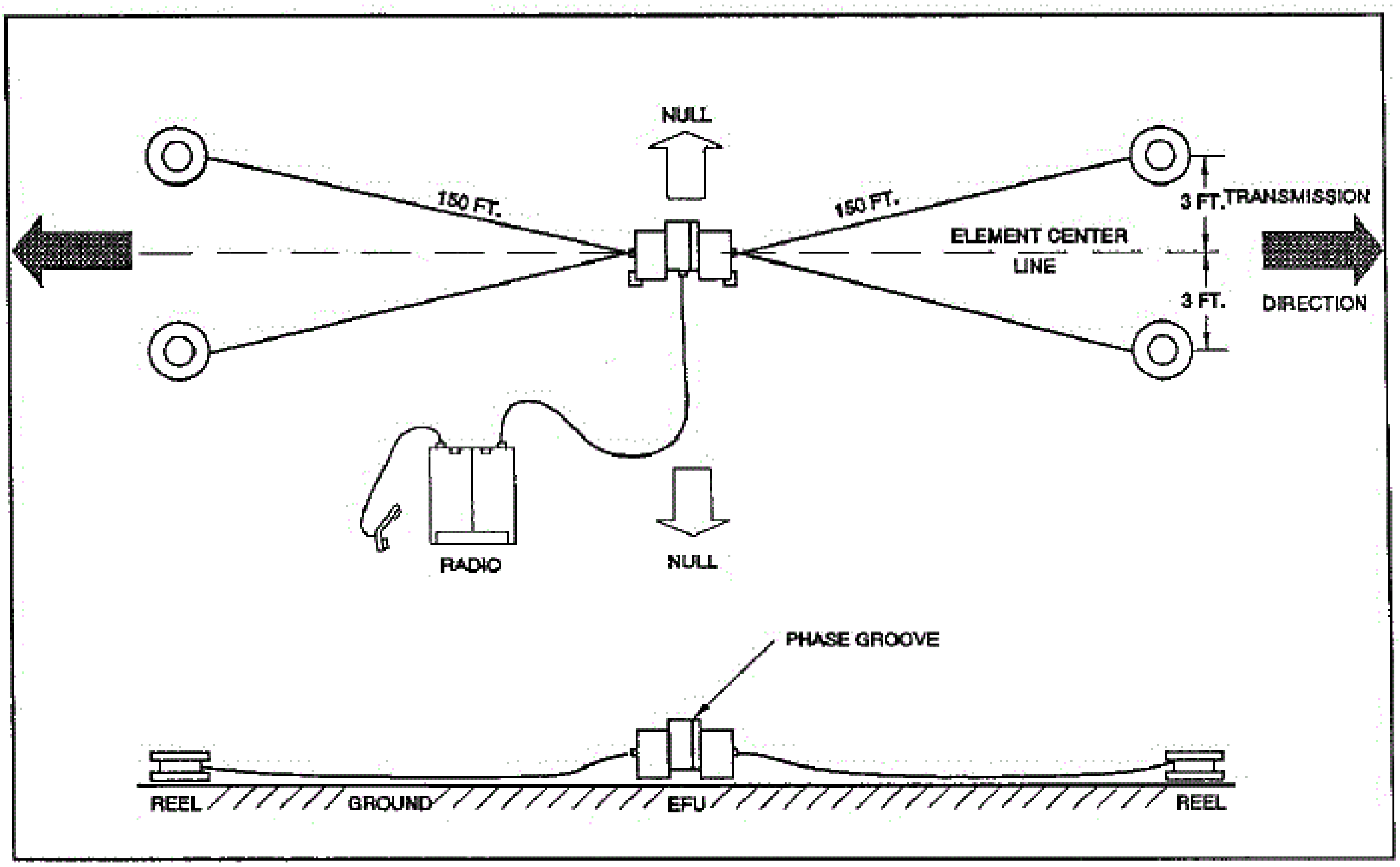


Figure 4-7 Vee-wire 1-element 150/150 configuration.

- Deploy the ELPA in the 1-element standard configuration (Section 4.2.1).

- Locate the two remaining element reels and connect them to posts on opposite sides of the EFU.

- Unroll both element wires in a straight lines offset slightly from the previously deployed single element wires to avoid entanglement. When the end of the element is reached, separate the wires approximately 6 ft. or at arms length.

- **The 1-element 150/150 vee is now ready for communication.**

4.3 Tapped vee-wire deployments

4.3.1 The 1-element and 2-element tapped-vee wire - The tapped-vee wire deployment provides smooth wideband performance in a compact area. The tapped-vee wire deployments use the 75-ft center tap position of the standard 150-ft element wire. This deployment is the same as the standard 1-element and 2-element single wire deployments of sections 4.2.1 and 4.2.2 except that the element wire center taps are used to connect to the EFU. The element wires are connected to the EFU posts at their bare wire center-tap sections and laid out in a vee configuration.

A 2-element center-tapped 75/75 vee-wire deployment is shown in Figure 4-8.

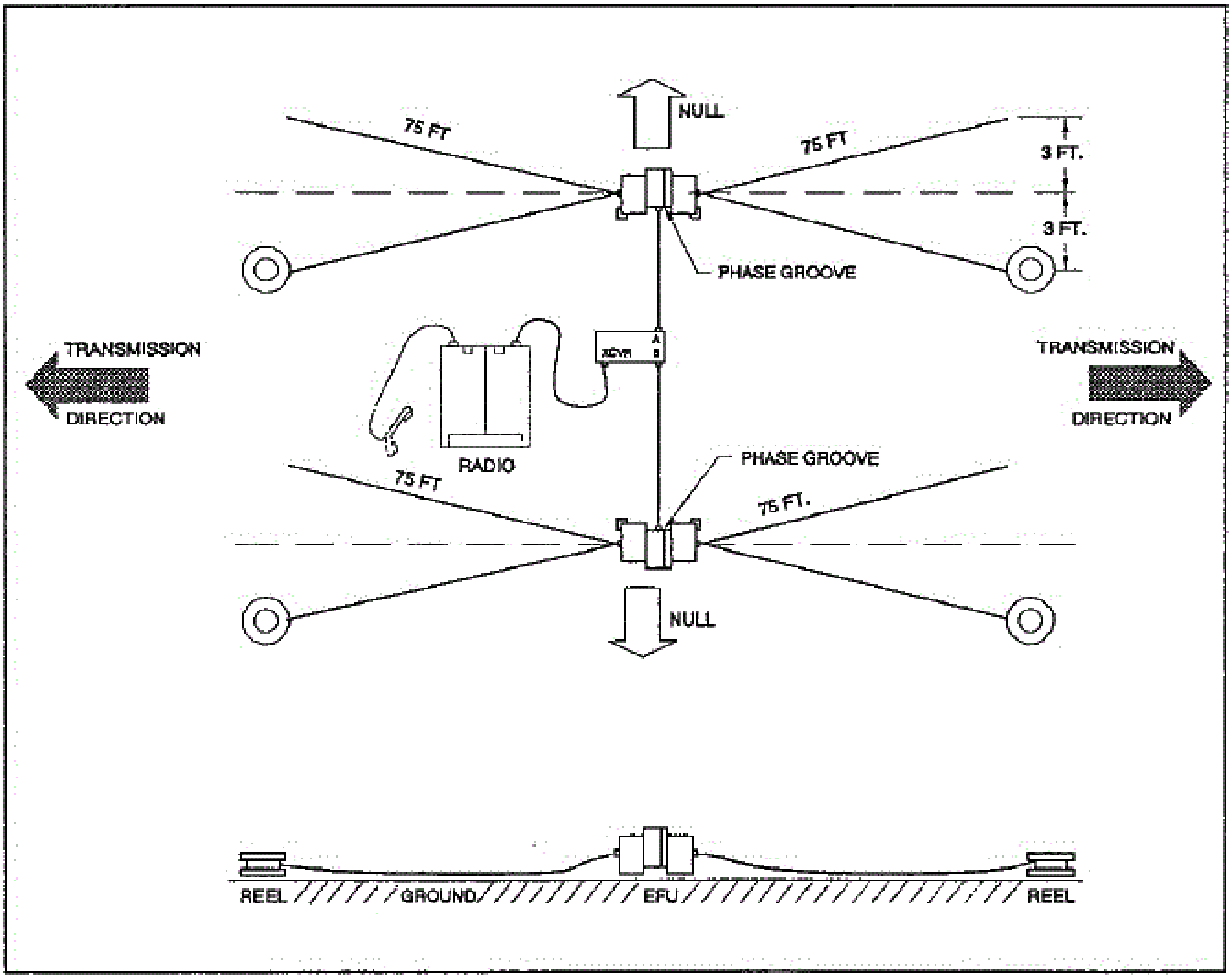


Figure 4-8 Center-tapped vee-wire 2-element 75/75 configuration.

For tapped-vee wire deployments the element wire must be unspooled from a point estimated to be 75-ft away from the EFU. The center tap of the element is located while unspooling the wire and walking toward the EFU. The center tap is a stainless steel wire section in the middle of the standard 150-ft. element wire. The center-tap point is attached to the EFU as shown in

Figure 4-9. The remaining wire on the reel is then unspooled back to the 75-ft. point and the wires arranged in a vee, 6-ft. apart at its ends (about an arm's span wide).

NOTE: A smooth stake, tent peg or screw driver can be driven into the ground as an anchor point next to the EFU location. The use of this anchor point greatly accelerates the deployment of a center-tapped vee element from the normally stated deployment time*.

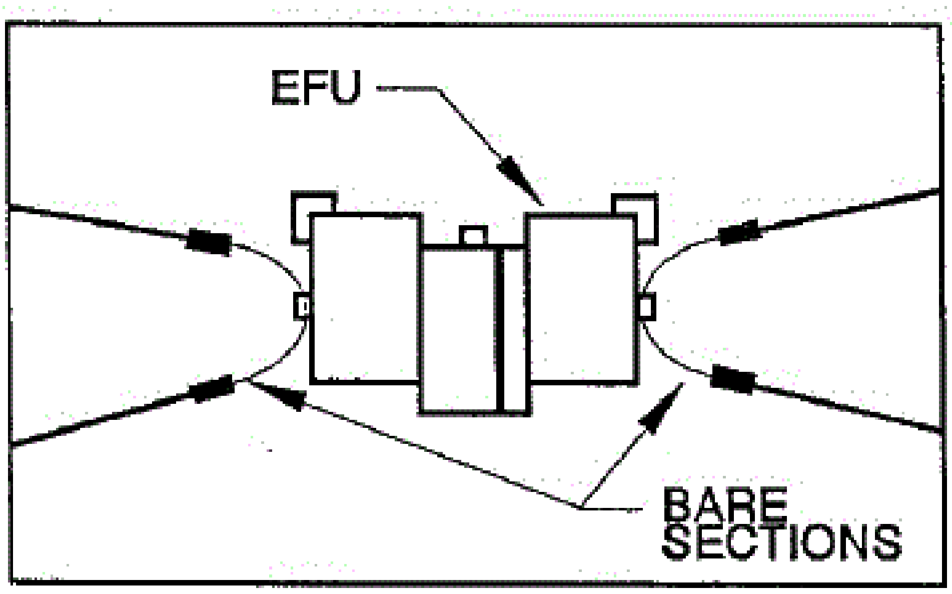


Figure 4-9 Center-tapped wires connected to an EFU.

The rapid center-tapped element deployment sequence using a stake is as follows:

- Place the stake in the ground (it must be smooth since the wire will be pulled around it).

- Spool off several feet of wire from the element wire reel to form a single broad loop, several feet in diameter between your hands. Locate the small stainless steel EFU connection end loop in one hand and the wire reel in the other.

- Position the broad loop to pass around the stake.

- Back away from the stake. Hold the stainless EFU connection steel loop in one hand and the element wire reel loosely in the other. Continue backing away from the stake as the wire unspools from the reel.

- When the reel is empty the stainless steel center tap will be positioned at the stake next to the EFU. Pull gently on the element wires to straighten the wires. Spread the wire ends about 6 ft. apart and lay them on the ground.

- Connect the center tap to the EFU.

- Repeat the process for the other elements.

- **The 2-element 75/75 tapped-vee deployment is now ready for service.**

---

* The non-assisted 2-element setup time for one person without tools is estimated at 5 to 10 minutes. The use of a stake as a wire layout tool can cut deployment to under 5 minutes. This technique makes the center-tapped vee deployment nearly equivalent in deployment time to the standard straight wire rapid deployment mode.

4.4 Deployment check list

The deployment check list, Table 4-2, is provided as a condensed training guide. The sub paragraphs add understanding to the check list requirements.

Table 4-2 Deployment checklist

1. **Correct element phasing** - All elements must be correctly phased. Element feed units (EFUs) have a phase groove (notched ring on EFU's center hub). The phase groove side of the EFU must be pointing in the same direction on all EFUs.

   An antenna assembled with mixed phasing will exhibit low directive gain *but still may* have an acceptably low VSWR presented to the transmitter.

2. **All electrical connections must be completed** - All coaxial cables and element wires must be attached securely.

   The antenna performance is a function of the number of working elements, but elements can be connected only in units of 1, 2, 4, or 8. Odd combinations leaving open cables will degrade performance in a frequency sensitive manner. A transmitter VSWR reading at a single frequency or at harmonically related frequencies may not detect this problem. Several frequencies must be checked.

3. **Accurate element layout** - Element feed units, located on the EFU layout line must be at a right angle to the element wires and laid out in a straight line (+/- 3 ft.).

   This alignment allows the elements to add as an array. Misalignment will degrade pattern gain. The element wires may jog up to 3 ft. around trees, rocks or brush near the EFU and up to 10 ft. near the end of a long element (150 ft.).

4. **Coaxial cable lengths must not be altered** - All coaxial cable lengths from the splitter to each EFU must have the same physical length (+/- 6 in.) and cable type.

   This is required to maintain the phase relationships of the antenna elements. The electrical length and physical length of two cables are only the same for an *exact* match of cable types (i.e. same wave velocity factor).

5. **Element ends must contact the ground** - The radiating elements must be in ground contact for approximately the last 1/3 of their length or 20 to 25 ft. (whichever is longer).

   This is necessary to establish a dissapative termination for each radiating element.

6. **The radio tuner should be bypassed** - For best efficiency the tuner should be out of the circuit - See section 5.5 for exceptions.

4.5 Deployment optimization

The ELPA antennas are designed to make compromises between optimum tactical antenna characteristics (e.g. low profile, simplicity, small area, deployment time) and optimum antenna performance (e.g. VSWR, gain, pattern). Therefore, *to optimize an ELPA is to change the priorities that defined the antenna's configuration.*

The information in this section is designed to enhance and adapt the performance of the standard configuration single wire 1- and 2-element deployments as well as the vee and center-tapped vee deployments.

> **NOTE:** *It is not necessary for optimization techniques to be used in every deployment. The detailed commentary of this section is designed to guide communicators in applying the ELPA in varied situations.*

4.5.1 Operating frequency - The frequency range of an ELPA is related to the length of its elements. The element length determines the lowest frequency the ELPA can be expected to provide an acceptable VSWR and power gain. Table 4-3 summarizes these ranges.

The deployment sequence outlined earlier in Figure 4-1 provides the first example of a change in performance priorities. The center-tapped vee-wire deployment alternative is more complex to setup than the standard deployment and is limited in its low frequency response. For the bands of 4 to 50 MHz this optimized configuration has superior broadband gain and pattern characteristics with a smaller layout area.

Table 4-3 ELPA element span and frequency band vs optimum VSWR and power gain.

Element span Ft.	(length/length) (ft./ft.)	Good VSWR MHz	Best power gain MHz
300	(150/150)	2 to 30	2 to 10
150	(75/75)	4 to 50	4 to 20
100	(50/50)	10 to 65	6 to 30
50	(25/25)	15 to 65	12 to 65

4.5.2 Antenna element gain - The ELPA's directive gain is stable over all soil conditions and is a function of element geometry. The ELPA's power gain and VSWR are a function of soil conditions, particularly moisture content. The operator can increase the power gain of the ELPA between 4 and 65 MHz by elevating the antenna element wire(s) 1 ft. to 3 ft. on the side of the antenna pointing in the direction of transmission. This is illustrated in Figure 4-10. The wire can be suspended on any non-conductor which could include rocks, sticks, bushes or stakes. At low frequencies of 2 to 4 MHz, such as those used for groundwave and NVIS communication, elevating the wires will not improve the radiation pattern of the antenna unless the gro saturated with water as in a marsh or wetland area. At and above 6 MHz, up to 5 dB can be added to the power gain of the ELPA by the elevation of the elements. At 50 MHz up to 8 dB can be added. In addition to providing added power gain, the elevation of the elements tilts the radiation pattern forward in the direction of transmission to provide an increase in directive gain of up to 3 dB. This effect is represented in Figure 4-11.

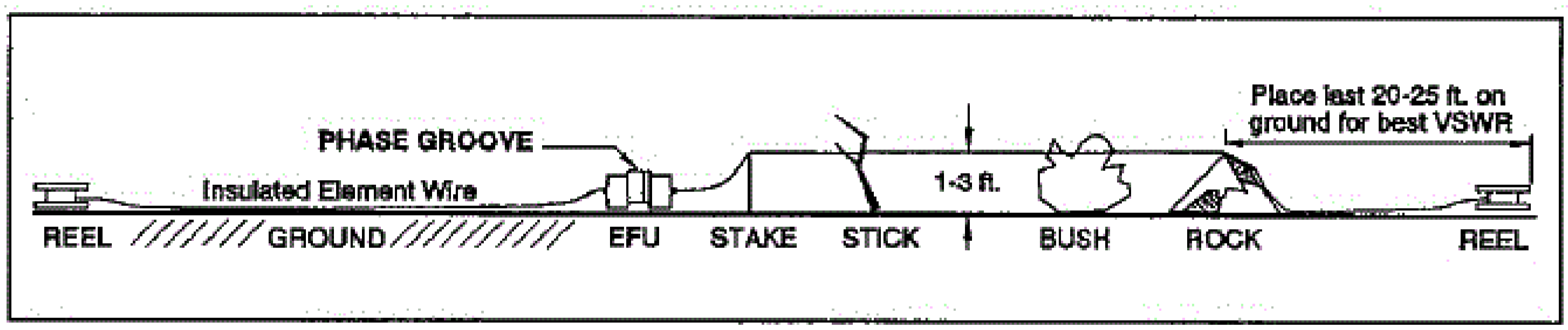


Figure 4-10 Elevating the element wire.

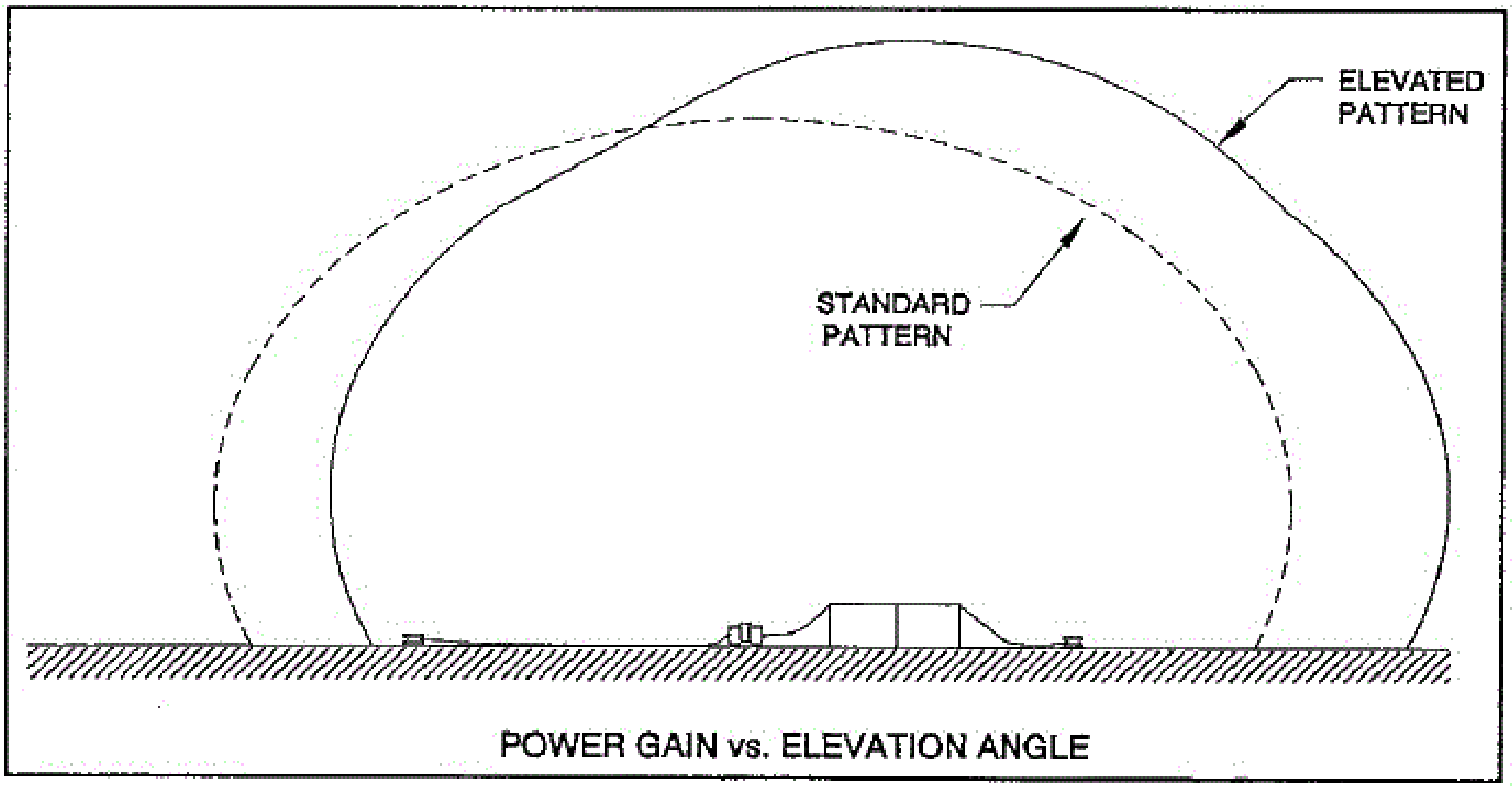


Figure 4-11 Representation of elevation patterns for ground contact and elevated wires.

Both sides of an ELPA element can be elevated to produce a balanced, bi-directional radiation pattern. The balanced configurations produce peak power gains that are similar or identical to those provided by single-sided uni-directional ELPAs. Examples are shown in Appendix E.

An increase in element height can degrade the VSWR. The operator should be aware of this trend and use VSWR optimization techniques to obtain a low VSWR for an operating band.

> **NOTE:** The process of increasing the height of the radiating elements can be an incremental process and can involve one or both elements of a 2-element deployment. Increments of up to 80% of an element's length can be elevated totally or in stages. The element loading effects of soil contact are in practical terms, incremental and additive.

4.5.3 VSWR adjustment - *The VSWR of the ELPA is usually stable over a wide range of conditions.* Therefore adjustment should not be necessary for most deployments. Adjustments are most likely to be needed when operating at or near the lowest frequency listed for an element span in Table 4-3.

> **WARNING: If the VSWR is high at both mid-band and high-band frequencies of the antenna's operating range, the VSWR problem could be due to a missing element wire, disconnected coaxial cable or a damaged component - see the Table 4-2 Deployment Checklist.**

The VSWR adjustment strategy for the ELPA is:

- Increase or decrease element length if possible, in 10-ft. to 20-ft increments. The adjustments can be very coarse since the ELPA is not being matched to a resonance point like a dipole.

> **NOTE:** An additional 50 to 100 ft. of wire may be added to each element for enhanced low frequency operation at or below 2 MHz (typically to 1.6 MHz). Each standard 150-ft. element wire has an attachment loop for this purpose that is exposed when the wire is completely unwrapped from the reel.

- If the elements are elevated (staked), drop sections of the elements to the ground in increments of 10 ft. to 20 ft. to increase the ground termination.

- Change a straight wire deployment to a vee or center-tapped vee layout.

- Bury the last 20 to 25 feet of the element wires under 6 to 12 inches of native soil.

- Change a 2-element standard straight wire layout to a single vee layout if the VSWR is to be improved in the 2 to 4 MHz band.

4.5.4 Direction of transmission beam - The azimuth beam pattern of the 2-element ELPA 302A is relatively wide over most of the HF band. It ranges from 100 degrees at 2 MHz to 40 degrees at 30 MHz and does not represent a critical aiming problem for HF applications. At VHF, 2-element operation with a standard deployment 150/150 vee can produce beamwidths of 25 degrees at 65 MHz. The recommended, narrower, 10-ft. spacings for high HF and VHF operation widens the 30 MHz, 2-element beam by 10 degrees to 50 degrees. The 65 MHz beam also widens 10 degrees to about 35 degrees.

For HF NVIS operations between 2 and 8 MHz the high angle elevation pattern coverage of the 302A is nearly omni-directional. Therefore the antenna can be oriented in any convenient manner to communicate. The low angle pattern null can be positioned for interference rejection.

4.5.5 Direction of side nulls - The side null pattern of the ELPA is a useful interference rejection feature at low elevation angles. The side null can be effectively positioned to direct a rejection notch of about 10 to 20 dB (vertical and horizontal polarization). Figure 4-12 shows a set up strategy for an ELPA 302A that uses two single elements, positioned at right angles to each other. This configuration allows the operator to search for the antenna direction that will provide the best received signal-to-noise ratio. In this example the received signals and noise on the North-South axis are compared to those of the West-East axis by switching the connection of the element feed cable to the receiver. Simple repositioning of each element axis (e.g. NE-SW) will allow the best side null position to be determined. A successful positioning of a null against an interference source located in the SE direction would be an element laid out on the NE-SW axis. The noise source would have the strongest signal on a NW-SE element. For this receive-only set up, the element lengths can be single wires and limited in span to about 100 ft. (50/50 standard 1-element layout).

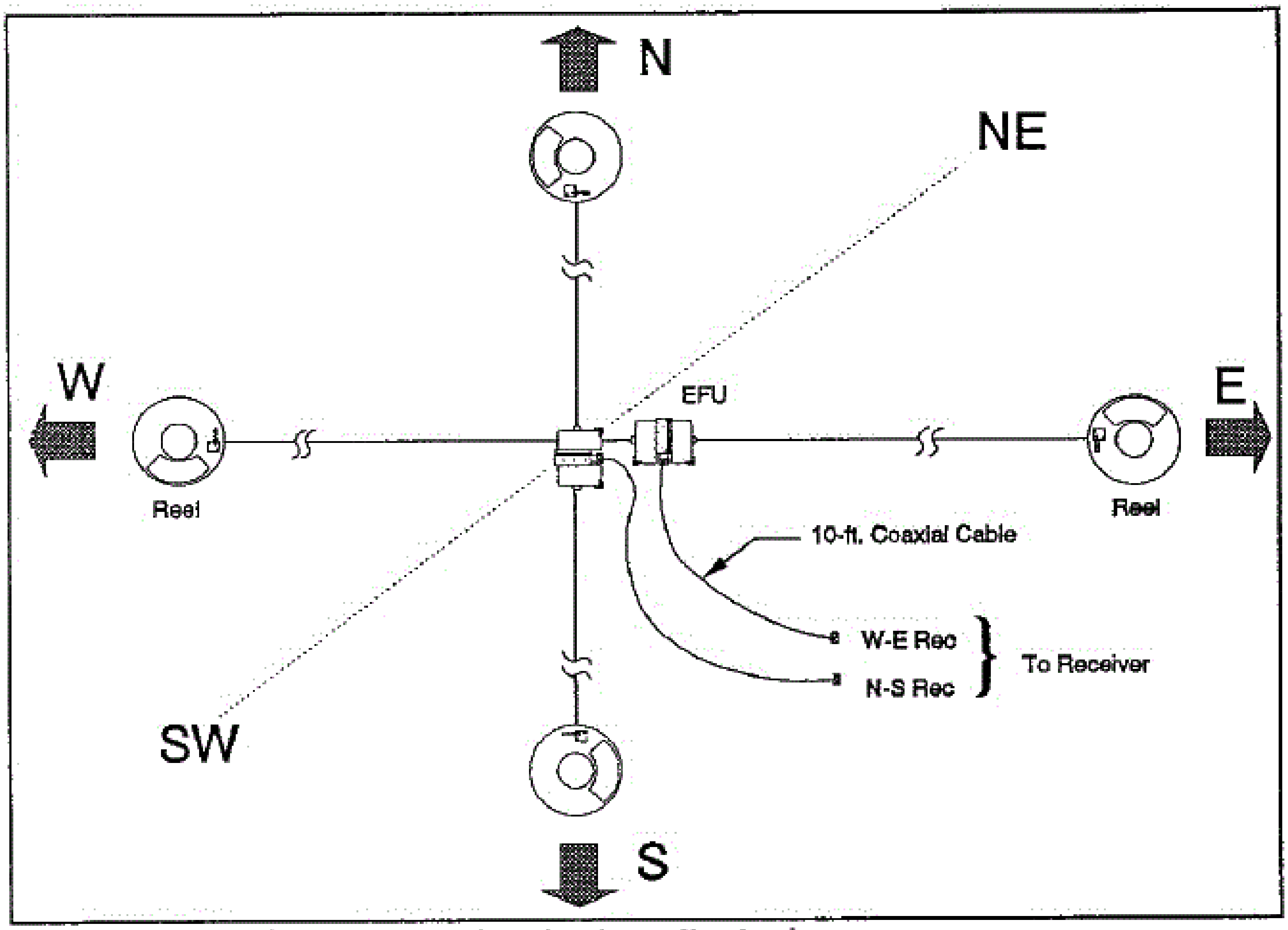


Figure 4-12 Interference source location by null selection.

4.5.6 Pattern effects - The ELPA has pattern properties that are similar to both a vertical-loop antenna and a terminated long-wire antenna. When operated with minimum element length for its lowest operating frequency a 1-element ELPA pattern is similar to a vertical loop antenna. At its highest operating frequency, where the element wire is several wavelengths long, the 1-element ELPA has a similar pattern to that of a long wire antenna *with the exception that the low angle horizontal pattern components are very weak due to ground interaction.*

The ground interaction of the ELPA element can be seen as a mixing process which combines vertical-loop antenna pattern properties with those of a long-wire. These properties are enhanced for the ELPA by the use of multi-element arraying techniques which increase the directivity and efficiency beyond that of a single element.

The close proximity of the element wire to the ground makes the electrical length longer for an ELPA than its physical length (e.g. a 1/2 wavelength element in air could become a 3/4 wavelength element when in contact with the right soil conditions). Therefore the ELPA is electrically longer within a smaller physical space than a higher profile surface antenna with a similar frequency coverage range.

The physical length of a wire element with respect to each operating frequency determines an element's elevation pattern (smooth or lobed) and as well as its basic azimuth pattern. The compact size of the basic ELPA element over a wide range of frequencies gives it a more stable wideband pattern (e.g. 75/75 center-tapped vee) than other wideband antennas of the same physical size. The elevation pattern lobing of an ELPA is not as sharply defined as in high profile long wire antennas since the ELPA elements's interact with the soil in a manner that does not create sharp pattern nulls*.

The formation of a soft zenith (90 degrees, straight up) pattern null in the elevation pattern starts at about 5 MHz for the 150/150 deployments and 9 MHz for the 75/75 deployments. Therefore, the use of the shorter 75/75 deployment could provide an improvement over the 150/150 configuration but the improvement would not be extreme enough to notice under most propagation conditions.

In the case of the ELPA 302A the azimuth beamwidths and directivity for several frequencies are given in Table 4-4. The azimuth narrowing effect can be seen as the operating frequency is increased. For multi-element ELPAs the spacing between the elements further determines the azimuth beamwidth (see Table 4-5 for 4-element details).

Table 4-4 Selected beamwidth characteristics of a 2-element ELPA.

Standard 2-element 150/150 single wire array with 20-ft. spacing

Frequency	Azimuth beamwidth	Directivity
3 MHz	100 degrees	5 dB
15	80	8
30	40	11
65	25	13

* Computer modeling approaches are typically limited in predicting actual antenna power gain in pattern null regions. This occurs because a complete accounting of the ground and element geometry factors presents a significant, computationally intense, problem that is outside of the range of most modeling efforts. Pattern measurements show that the actual nulls are softer than predicted.

4.6 Effects of adjustments to configurations

The effects of changes to the ELPA configurations are understandable as basic additive effects. Figure 4-13 is a pictorial summary of valid ELPA deployments in open and obstructed environments. The adjustments that support these configurations are summarized as:

4.6.1 Length of elements - the electrical length of an element when in contact with the local soil, sets the lowest operating frequency for the ELPA. This lowest frequency electrical length is approximately 3/4 wavelength. The maximum power gain for an element in contact with the soil occurs at an electrical length of about 1 wavelength. As the operating frequency of an element is increased, so that multiple wavelengths are guided on an element wire, the directivity of the ELPA increases significantly over that of a dipole. In this respect an ELPA displays directivity at higher frequencies like that of a long-wire antenna.

4.6.2 Number of elements - increasing the number of elements significantly increases the performance of an ELPA. The second element of an ELPA adds up to 3 dB (50%) in directivity, directive gain and power gain as well as efficiency. Thus the transmitted and received signal levels are increased and the signal-to-noise level can improve due to the narrowed azimuth beamwidth (depending on element spacing). The second element increases the effective capture and radiating area of the antenna. This improves the signal fade margin and decreases the probability of the antenna being shadowed by small obstructions. The VSWR is also improved with the combning of element feeds through a power splitter.

4.6.3 Element-to-element spacing - The spacing between ELPA elements is set at a compromise point of 20 ft. An increase in spacing (balanced between the feeds from the power splitter) will increase the directivity of the antenna and narrow the azimuth beamwidth. The 2-element 50/50 and 25/25 deployments are recommended with 10-ft. spacings between elements to widen their beamwidth for high HF and VHF frequencies (15 to 65 MHz).

4.6.4 Height of elements - The gain of an ELPA increases with the height of its elements above the ground until it no longer has adequate loading from the ground. This point occurs at approximately 3-ft. for most soils. Beyond this point alternate methods of element termination must be used. Increased mutual coupling between elevated elements also sets a limit on the compactness of array designs.

4.6.5 Element terminations - The standard ELPA deployments use the combined effects of element radiation and ground coupling to form a distributed traveling wave termination for each element. When an elevated wire configuration is used, it is important that the last 20 to 25 ft. or about 1/3 of the element length be in ground contact. This contact provides a dissapative termination for the element. In cases where there is an inadequate deployment area to support the frequency range required, it is possible to shorten the ELPA layout by the use of end terminations. This is accomplished by replacing the electrically "Lo" side of each ELPA element with a 3- to 6-ft. ground stake (side opposite of the "Hi" or phase groove side). Note that for this scheme to work the ground stake must have adequate electrical contact with the soil to be the near dissipative equivalent to the replaced ELPA element half. In very dry, poor conductivity soils this may be difficult to achieve.

It is also possible to terminate the end of a shortened antenna element with a resistive path to a ground stake at the end of the element. Therefore a 150/150 antenna could be cut in size to a 125/125 or less with a small power gain penalty if the elements were resistively terminated. Details on element termination can be obtained as an application note (see Appendix G).

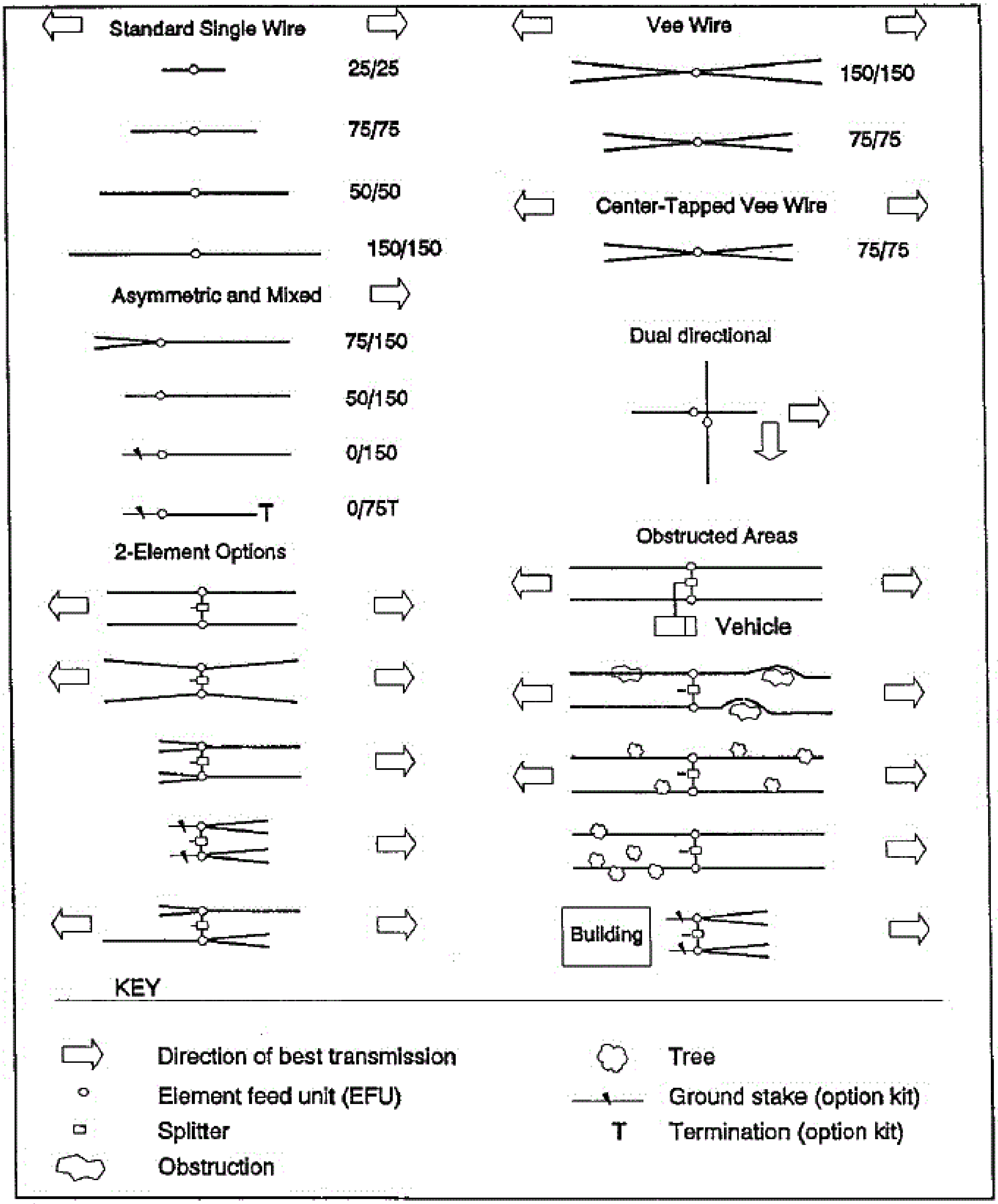


Figure 4-13 Pictorial summary of ELPA deployments.

4.7 Alternate antenna configurations

ELPA 302A kits can be used to configure alternate ELPA antennas as well as more conventional higher profile structures. To form alternate configurations, one or more ELPA 302A kits are used with additions of element wire, clips, coaxial cables, 50 Ohm loads, ground clamps, ground stakes, and element wire supports (e.g. rocks, stakes, trees, towers, buildings). The alternate configurations are summarized in Table 4-5. A pictorial summary of these deployments is provide in Figure 4-14. Some of these configurations are described in detail in Appendix F and in the application notes listed in Appendix G of this manual.

Table 4-5 Summary of alternate ELPA 302A deployments.

Antenna	Frequency	Mode	Comments
Inverted vee	8 to 65 MHz 1.6 to 65 MHz	broadband tuned	Simple extension of the ELPA 302A kit's 150/150 single wire or vee configuration. It is suitable for groundwave, NVIS, LOS and medium range skywave service. This configuration is also known as a fan dipole or multi-band inverted vee.
Beverage	1.6-65 MHz	broadband	Foundation configuration for the vertical half-rhombic. It is used for groundwave and medium range skywave service. It is also known as a terminated long wire.
Vertical half rhombic	1.6-65 MHz	broadband	Improved power gain over the Beverage deployment with increased height. Used for groundwave, medium and long range service. This configuration is also known as a terminated long wire or bent long wire.
Sloping vee	4-65 MHz	broadband	This is the highest power gain configuration supportable by the alternate deployments of the ELPA 302A. The pattern is controlled by the wire length and the apex angle selected. Power gains of 13 dBi and directive gains of 22 dB are achievable. Note that the azimuth beamwidth is effectively broader than the apex angle selected.
4-element ELPA	2-65 MH	broadband	Provides 3 dB enhanced power gain and directive gain over the 302A.
8-element ELPA	2-65 MHz	broadband	Provides 3 dB power gain over the 304A. Directive gains in excess of 14 dB with azimuth beamwidths narrower than 10 degrees can be produced.

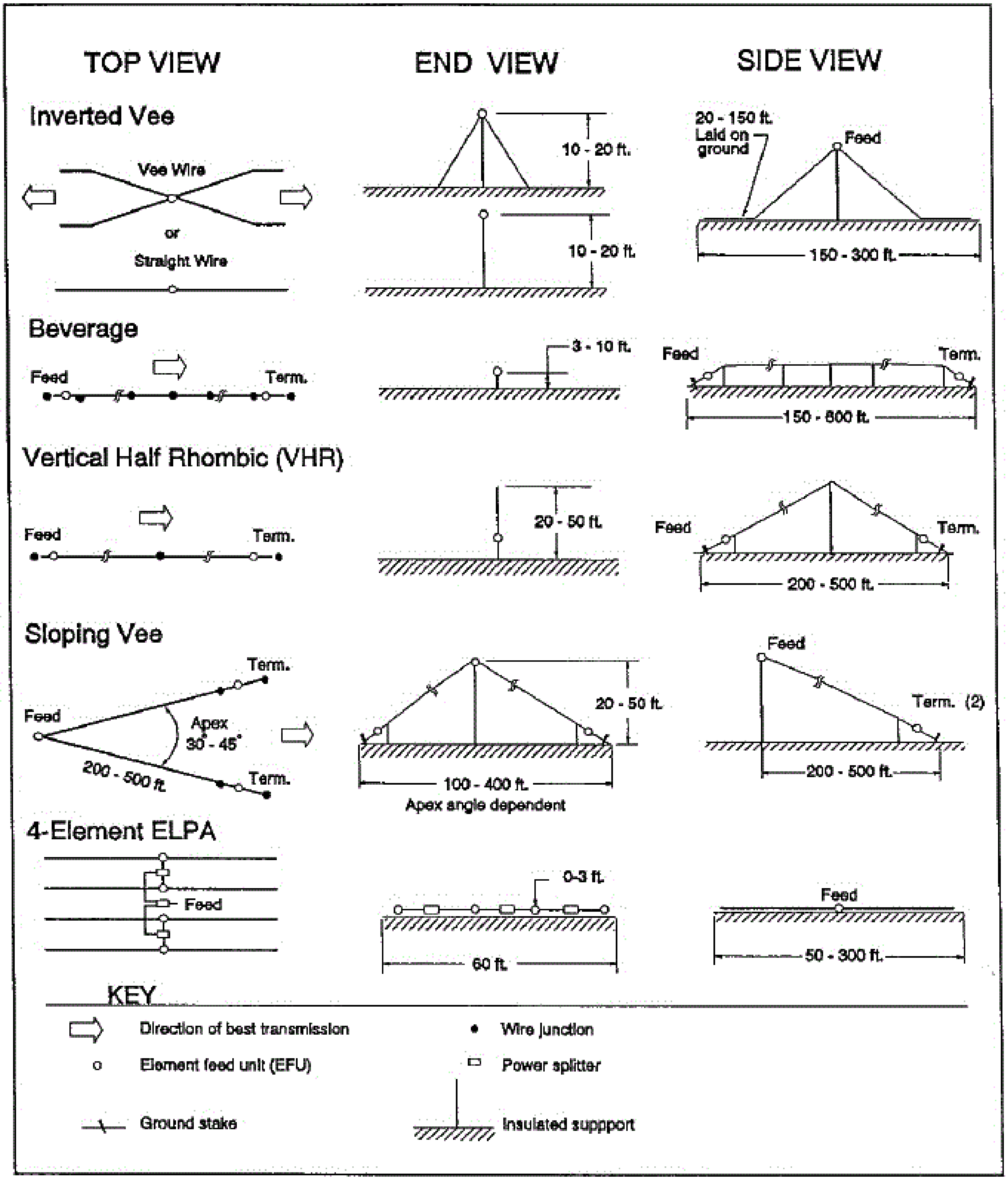


Figure 4-14 Pictorial summary of alternate ELPA 302A component configurations.

4.7.1 Multi-element ELPA deployments - Two 302As can be joined with two matched 20-ft. coaxial cables and the power splitter from a third 302A or an option kit to form an ELPA 304A, 4-element array. Figure 4-15 details the layout of a 4-element, standard deployment ELPA 304A. Similarly, these 304A combinations can be joined through their matched 40-foot feed cables to an additional power splitter to assemble an 8-element array. Through these combinations and appropriate element-to-element spacing (using cable option kits), directivities of up to 17 dB can be achieved with power gains of +3 dBi. Azimuth beamwidths as narrow as 6 degrees can be achieved with wide element-to-element spacings. Table 4-6 provides examples of azimuth beamwidths available with a 4-element array using cable option kits. Options also exist to direct these narrow beams through electronic steering techniques. See Appendix G for relevant Eyring publications and application notes.

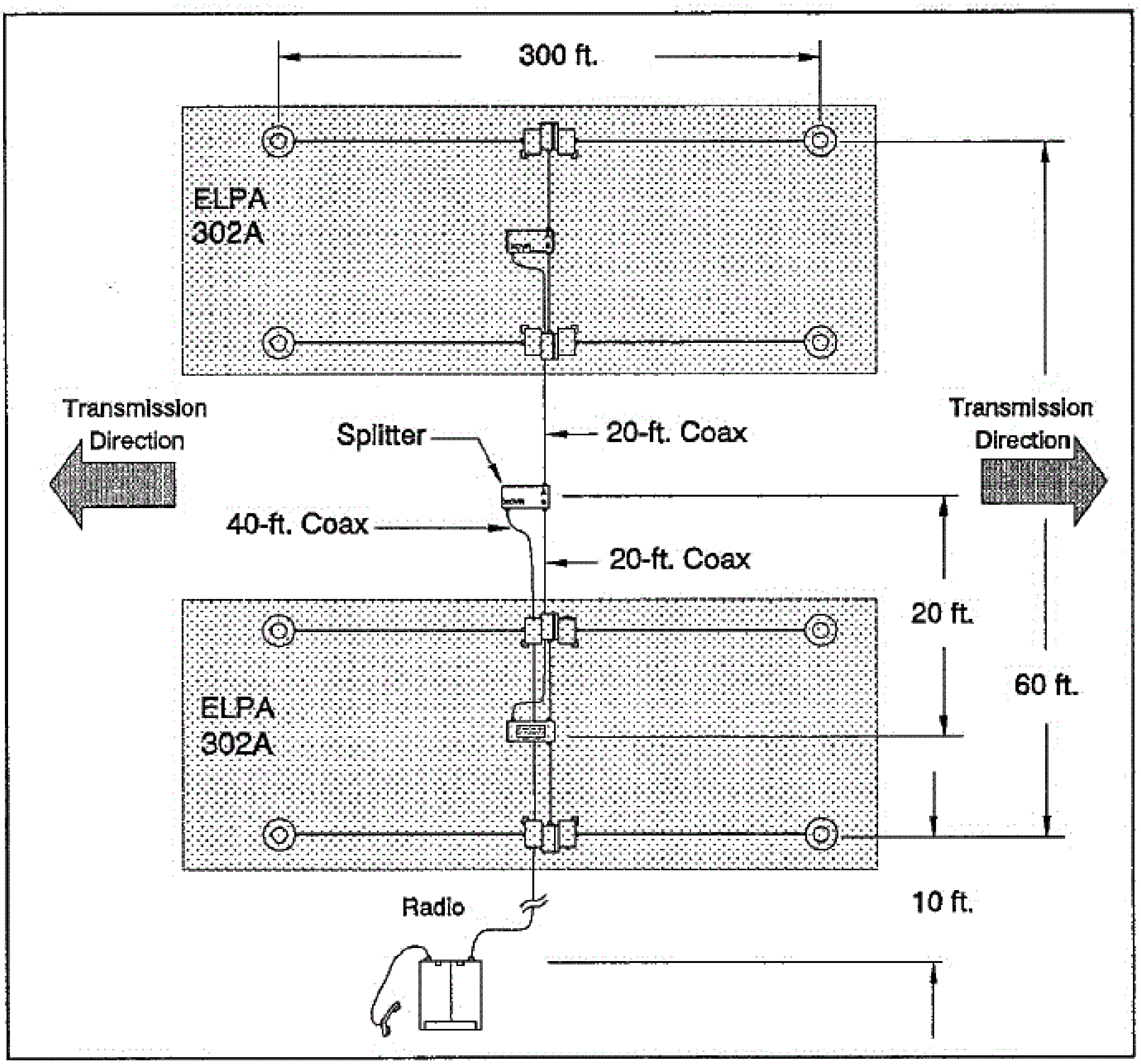


Figure 4-15 ELPA 304A formed from two ELPA 302As and a combiner kit.

4.7.2 EFUs as terminations - The Beverage, vertical half rhombic, and sloping vee alternate deployments all require end terminations. In most literature these terminations are resistors rated at 1/2 the power rating of the antenna's matching balun. The terminating resistors range in value from 300 to 500 ohms. The EFU's of the ELPA 302A kit can function as either a feedpoint or a termination for the alternate deployment antennas. To form a termination an EFU is connected as a load with its "Hi" or phase groove side to the radiating element and its "Lo" or near ground side connected to a suitable ground rod. The BNC feedpoint of the EFU is then connected through a coaxial cable to a 50 Ohm coaxial load. The load should be rated to dissipate up to 1/2 of the transceiver's actual average power rating or 1/2 of the EFU's power rating of 100 Watts (whichever is lower). A transceiver rated at 20 Watts peak envelope power (PEP) for SSB (voice) transmission and a 10 Watt average power rating would use a 5 Watt load. See Appendix F and G for additional details.

Table 4-6 Beamwidth characteristics for a 4-element array.

Standard 4-element single wire 150/150

Spacing	20 ft.	40 ft.	60 ft.
Array width	60 ft.	160 ft.	240 ft.
Frequency	**Azimuth beamwidths (at 20 degree elevation)**		
2 MHz	116 deg.	109 deg.	96 deg.
4	62	54	44
8	62	42	29
12	32	22	16
15	29	19	13
30	21	11	7

NOTE: The trend is for the azimuth beamwidth to narrow as the spacing between elements is increased.

4.7.3 Suspended EFU deployments - Alternate deployments typically require that the EFU be suspended rather than laid on the ground (e.g. tree or pole). Figure 4-16 illustrates the use of the EFU phase groove as an insulated cord attachment point that allows a secure attachment to the EFU. The cord is held in the groove by a slip knot or friction cinch. The recommended cord is 0.125 inch diameter nylon or Dacron® cord in a mission suitable color of olive drab or black. The coaxial cable is attached to the EFU at the BNC connector.

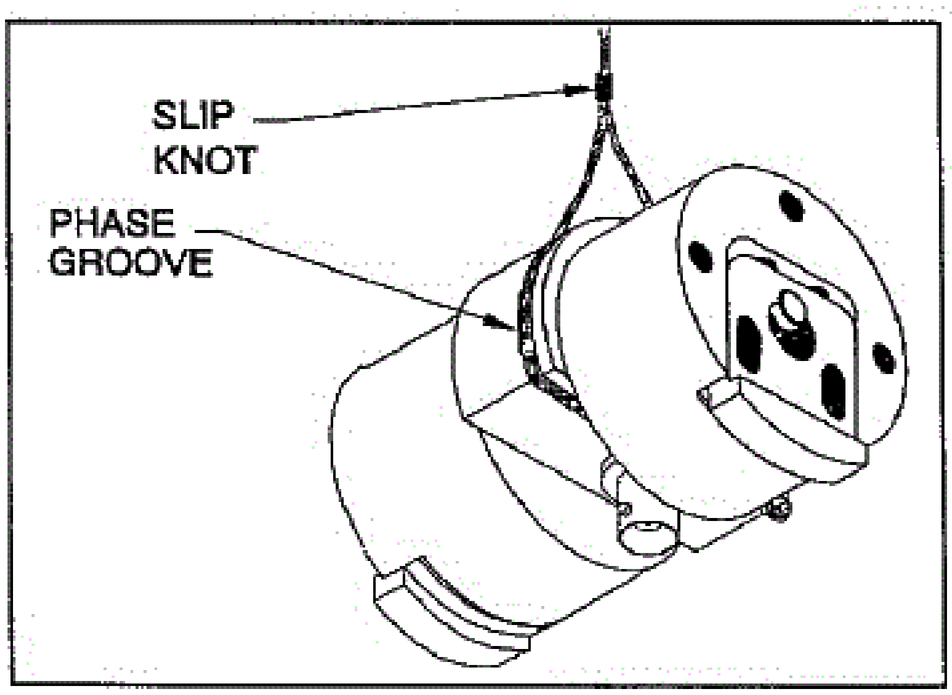


Figure 4-16 EFU suspension using the phase groove.

4.8 Antenna retrieval and packing

The ELPA 302A retrieval process can be as rapid as its deployment. However, care must be taken to retrieve the antenna components in an orderly sequence to allow packing in the bag. The preferred sequence of events is:

- Disconnect the element wires and the coaxial cable from each EFU.

- Clip the reel to be wound up onto the EFU, extend the handle of the reel and begin winding the element wire (Figure 4-7).

  NOTE: The wire should be wound with a slight tension. This tension can be supplied by wrapping the wire part way around the operators body, positioning the wire behind one's knee or with the tensioned wire guiding of an assistant operator.

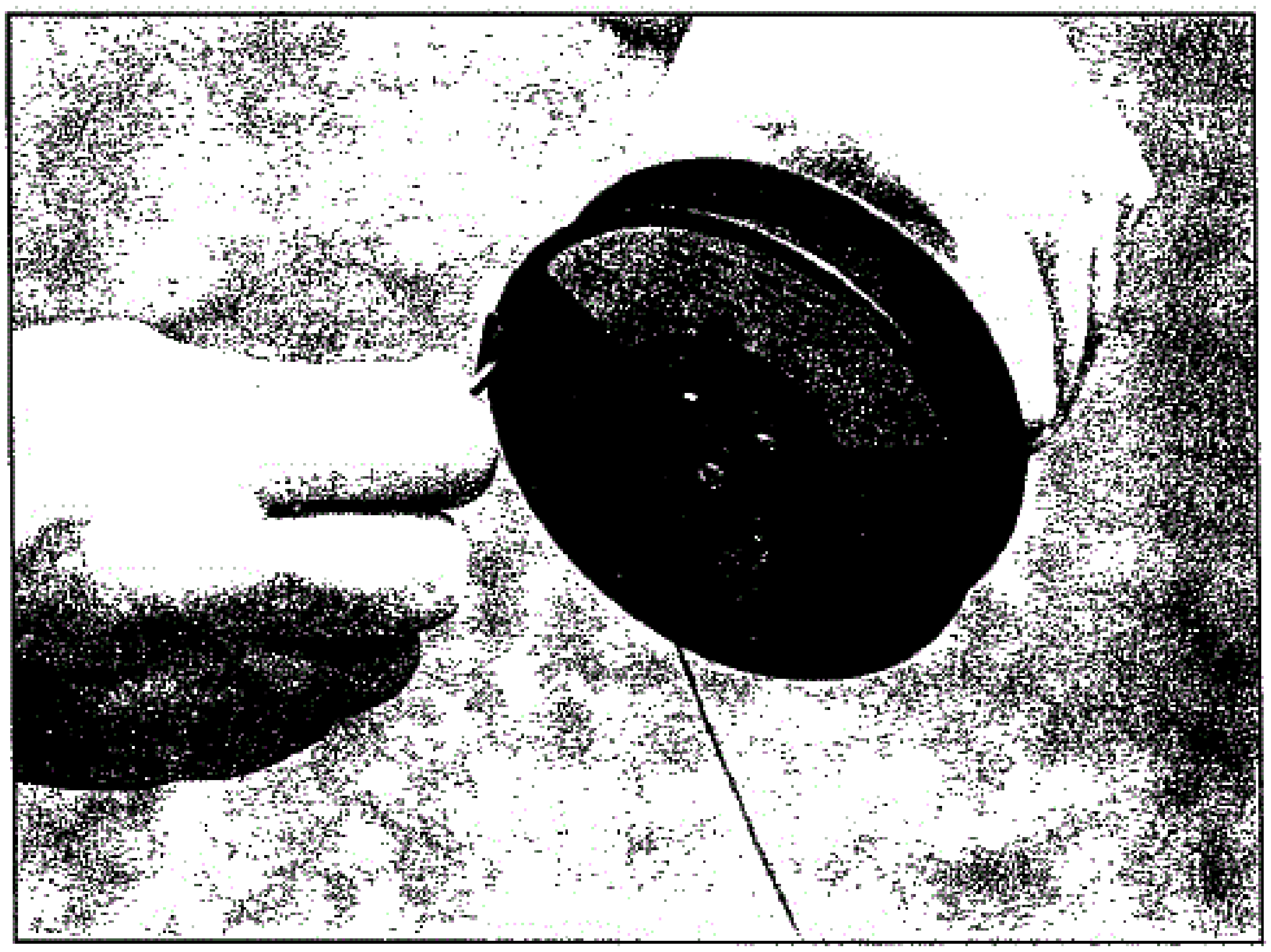


Figure 4-17 Wrapping element wire on a reel.

WARNING: It is essential that the wire be wound up in a straight line by spooling the reel to prevent twisting of the wire. Never hold the reel stationary to wrap or uncoil the wire from the reel. The wrapping action will twist the wire and will cause severe kinking of the wire.

- When the wire is fully retrieved, remove the reel from the EFU. To allow it to be used as a grip to wind the next reel.

- Unwrap about three turns of wire, place your fingers over the reel edge and then loosely rewrap the wire as in Figure 4-18.

- Twist the wire retaining hook to grasp the loosely rewrapped wires and then gently pull on the wires as your fingers are removed from the reel. This action will cinch the wires onto the reel.

- When all reels are wound and cinched, mount two reels on each EFU.

• Locate a 10-ft coaxial cable. wrap the cable loosely around the center of the EFU. Use the cable retainer strap to hold the cable about the EFU by pulling the cable retainer tab over the end of the BNC connector. See the example in Figure 4-19. Repeat for both EFUs.

WARNING: The cable strap is used to keep the loose cable from unrolling. Do not use the strap to cinch the cable down tightly. The reels can be popped off the EFU hubs and the retaining clips damaged.

• Store each fully assembled EFU package in the end pouches of the carrying bag.

• Place the power splitter in the center pouch of the bag.

• Wrap the 6-ft. cable into a 3 inch diameter coil. Secure it by capturing the BNC connector with the cable strap retainer as shown in Figure 4-20. Insert it in the center pouch with the power splitter.

• Fold the outer side flaps over the center reels and then lay down the instruction panel (the side flaps protect the instruction panel from excessive wear). Close the cover and mate the two cover snaps.

• **The ELPA 302A is now ready for transport.**

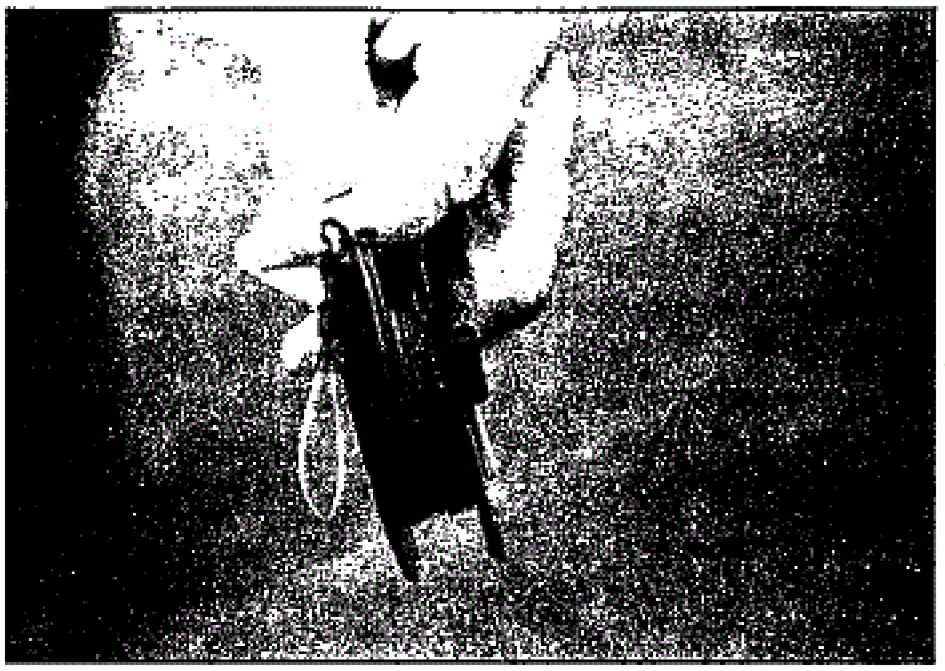


Figure 4-18 Use of hook to cinch element wires.

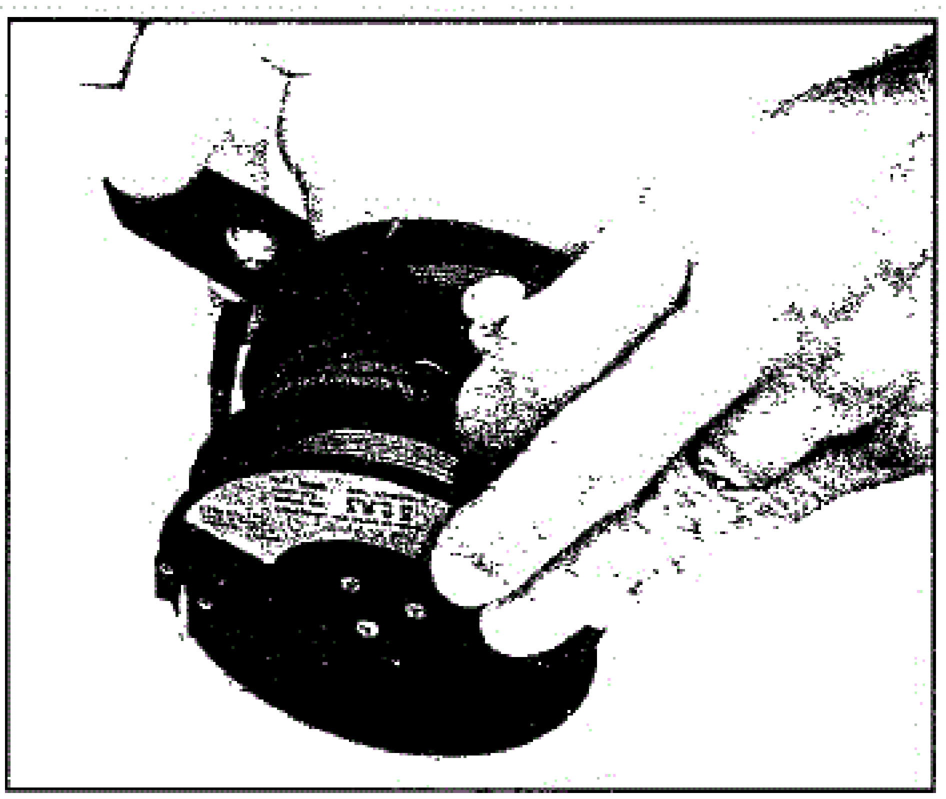


Figure 4-19 Use of cable retainer for 10-ft. cable.

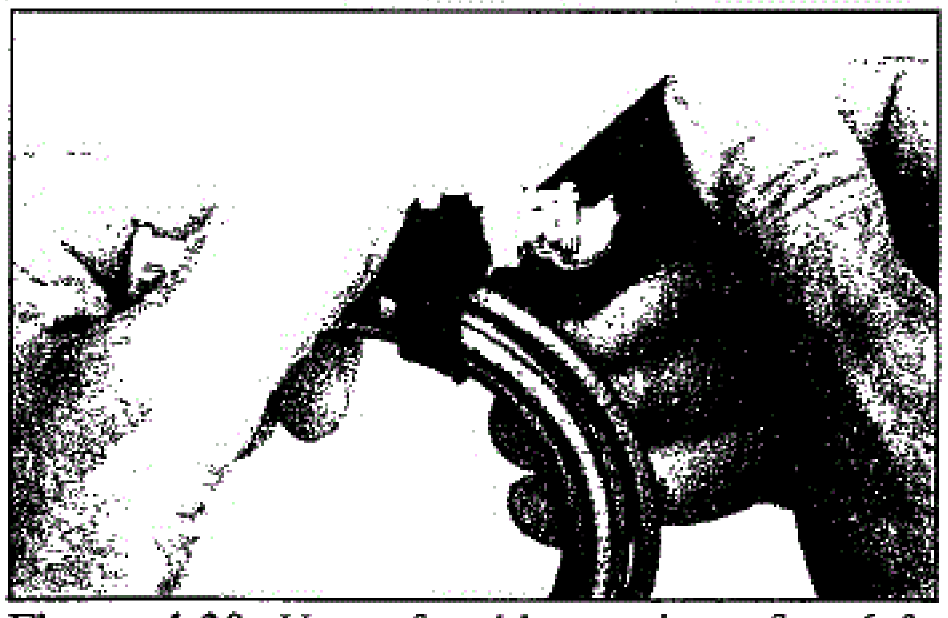


Figure 4-20 Use of cable retainer for 6-ft. cable.

The carrying bag packing process is graphically summarized in Figure 4-21 which provides an exploded view of the 302A packaging.

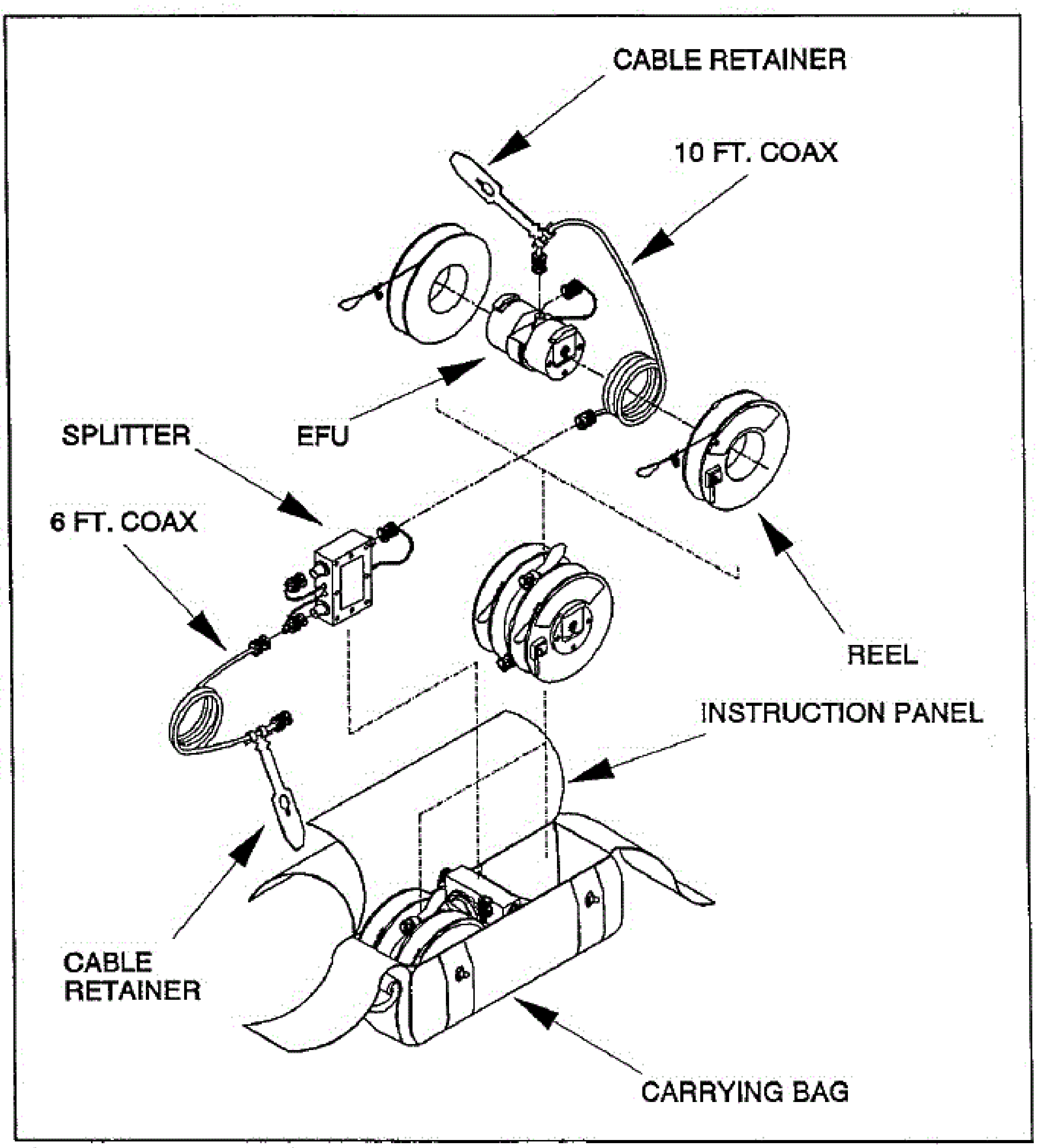


Figure 4-21 Exploded view of 302A carrying bag.

5.0 OPERATION

5.1 Transceiver connections

5.1.1 Normal connection - Connect the deployed ELPA to the coaxial output (antenna) connector of the communications transceiver. Determine the power output capability of the transceiver.

> **NOTE:** A single ELPA element is rated at 200 Watts peak or 100 Watts average. The 2-element ELPA 302A is rated at 400 Watts peak and 200 Watts average. These rating are conservative for ambient temperature ranges of 23 deg. C (73.4 deg. F).

5.1.2 If the transceiver has a built in tuner option - As a general rule, select the direct output connector or set the panel switch that bypasses the tuner (manual tuners should be set to their feed-through position).

5.2 HF/VHF Frequency hopping

For frequency hopping systems the 75/75 center-tapped vee layout is recommended for the best overall range with the most uniform elevation pattern power gain over a 4 to 50 MHz range. ELPA antennas in the form of 502, 504 and 508 antennas (higher power versions of ELPA 302A, 304A and 308A) have be tested successfully with several high speed frequency hopping and spread spectrum systems.

5.3 Adaptive HF systems

ELPA 302A type antennas have been effectively used with AN/ARC-190(V) frequency adaptive HF radios using SELSCAN® processors, AN/TRQ-35(V) Chirpsounders® and other adaptive radio systems. The 75/75 center-tapped vee layout is recommended for the 4 to 30 MHz range. The vertical "fan beam" pattern of this compact ELPA configuration provides uniform elevation pattern coverage over a wide frequency range. It enables reception of propagation conditions with little antenna (elevation pattern) or tuner (insertion loss) bias.

5.4 Receive-only operation

The most important feature of a receive-only antenna is its directive gain since the antenna operates as a "spatial filter" to select a region of space to monitor. In this role both the VSWR and power gain of the antenna are less critical to the optimum performance of the receiving system. *In this role the ELPA does not represent a compromise in antenna performance.* The ELPA is actually an optimum receive antenna for long range skywave propagation paths. The narrow azimuth beamwidth and the side nulls of the ELPA can be used to enhance communications in spatially congested areas of the spectrum.

The ELPA is competitive with active loop arrays and typically displays a lower noise floor with robust environmental advantages (e.g. static and lightning survivability). Multi-element 304A and 308A ELPA configurations can effectively complement high profile, high power, wide beam tactical transmitting antennas by enhancing their receiving capability.

The ELPA should generally be deployed in ground contact unless there is an advantage in creating a 3 to 10 dB front-to-back ratio elevation pattern that arises from the elevated wire asymmetry (see section 4.5.2 and Figure 4-11). Smaller configurations of 2-element single wire antennas such as the 50/50 or 25/25 are well suited for receive-only applications. These sizes are suggested to maintain a smooth elevation pattern over a wide frequency range.

5.5 VSWR and antenna tuners

The transceiver's automatic antenna tuner should not be used unless a high VSWR is indicated. The tuner can add additional losses to the transmission circuit when it matches to the ELPA. Some automatic tuners may have a problem* matching to the ELPA when it is operating as an electrically long antenna at frequencies well above its lowest frequency of operation (set by element length). At its lowest frequency of operation the ELPA may be assisted by a tuner if the transceiver indicates that a high VSWR is detected. A tuner can also be of assistance with some alternate deployments of the ELPA (e.g. inverted vee). A tuner, with a wide matching range, can be used to successfully tune a full size 150/150 vee ELPA down to 1.6 MHz. If your tuner cannot be bypassed and you suspect that a problem in tuning is occurring, take the following sequence of steps as required to operate:

- Set up the standard single wire deployment of the ELPA to allow length changes and try all frequencies of interest.

  NOTE: Successful tuning with one set of ground conditions does not guarantee continued success but suggests that length changes may solve the problem.

- If a frequency cannot be tuned shorten the antenna elements in about 10 ft. to 20 ft. increments until it tunes.

- If two elements have been used, switch to a single element and repeat the length adjustment test.

  NOTE: At some point the ELPA will appear to be an electrically small dipole with a high impedance matching balun. If the tuner does not show a match point anywhere, the tuner may not be functioning properly. This can be further verified if the tuner can not be used to tune other antennas (e.g. whip).

  WARNING: The performance of transceiver/tuner/feed cable/antenna combination can be specific to an individual transceiver's internal adjustments. This is true for all transceivers, not only those used with an ELPA.

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*The problem is characterized by the inability of the transceiver to find a tuning point within its normal antenna matching range. In some cases the tuner's control processor will time out and indicate that a tuning point cannot be found. This problem is more likely to occur if the transceiver is of a very compact design. Smaller radios are required to make design tradeoffs which may be limited to the matching of a short, highly capacitive, 10-ft. whip antenna. The ELPA presents an electrically long, inductive load that may be outside of the tuner's matching range.

5.6 Propagation conditions

The ELPA 302A can be expected to perform well under average propagation conditions. In a receive mode the ELPA can be expected to perform with advantages over a monopole or dipole due to its pattern directivity. In a transmit mode the ELPA can be expected to perform 5 to 15 dB below the *peak expected performance* of a 0.25 wavelength monopole or 0.5 wavelength dipole (0.125 wavelength height). In real world propagation environments the power gain of the ELPA does not often represent a severe tradeoff for a propagating channel path. Comparisons with other antennas under the same conditions should confirm this during training periods.

> **NOTE:** When an ELPA is being used to communicate with another station of equal power it is possible that the ELPA signal may appear to be "in the noise." This may be due to the lower power gain of the ELPA 302A antenna. This becomes noticeable when propagation conditions are marginal. *It is also likely that the other station is receiving with a low directivity antenna in the presence of a significant noise environment. If possible, try an ELPA or another directive antenna at this location.*

To assist in communications planning using propagation prediction programs, antenna gain tables have been developed by Eyring for input to both IONCAP* and PROPHET** propagation analysis programs. Details can be provided upon request.

5.7 Atmospheric and discharge noise

The received ELPA noise level will be lower than a monopole or dipole. This is due to two factors. First, the antenna picks up less noise due to its directional "figure-8" azimuth pattern. Second, the low profile of the ELPA minimizes pickup of very local, low angle noise sources (this may be evident in an urban environment but undetectable in a rural area).

Discharge noise (static) created by wind-induced electrical charge on the antenna elements should be lower on the ELPA than for other wire antennas. The construction of the ELPA provides a low resistance DC drain path between all of the antenna elements and the system earth ground at the radio or lightning/EMP protection points (see 5.8.5). This advantage should also exist for alternate deployments which use EFU's as terminations. Normal termination resistors and typical baluns isolate the antenna element with several hundred Ohms of DC resistance to ground. Beverage, vertical half-rhombic, and sloping-vee antennas having resistive isolation can experience more significant static discharge noise than those employing DC coupled EFUs.

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* IONCAP is an Ionospheric Communications Analysis and Prediction program developed by the National Telecommunications and Information Administration. Details are available through the National Technical Information Service by ordering report PB84-111210. Eyring supports IONCAP through a library of antenna type 18 data files generated by a test validated antenna modeling program, PAT7.

** Advanced PROPHET is a program developed by the Navel Ocean Systems Center, San Diego, CA. The Eyring PAT7 modeling program can output files suitable for entry into the PROPHET antenna library for transmit or receive applications.

5.8 Safety

5.8.1 Shock and RF burns

The EFU is a voltage step-up transformer. The posts of the EFU and the exposed parts of the element wires near the EFU present a shock and RF burn hazard. Even the insulated section of the element wires can present an RF burn hazard for an operator.

WARNING: DO NOT MAKE CONTACT WITH THE ELEMENT WIRES OR EFU POSTS OF AN ENERGIZED ANTENNA.

NOTE: For a 400 Watt peak power transmitter, with its power fully transferred to each EFU (200 Watts peak) driving 2:1 VSWR loads (worst case analysis), a peak potential of 424 Volts can be measured between the EFU posts (134 Volts for a 20 Watt transmitter).

These voltages are sourced from a high impedance, limited current source with a frequency ranging from 2 to 65 MHz. These radio frequencies represent a physical hazard that is significantly less than these same voltages at the AC power line distribution frequency of 60 Hz.

5.8.2 RF radiation hazard - The distributed field of the ELPA 302 lowers the risk of radiation exposure hazards *well below that of other tactical antenna using the same input power levels.* The safe, exposure level for a continuously operating transmitter (200 Watt average) is 5 feet from the antenna radiating elements. Thus the operator can place a transceiver at the center of the ELPA 302A without a hazard. A compact 20 Watt (peak) manpack transceiver presents no radiating hazard to the operator*.

5.8.3 Thermal hazard - When the ELPA 302A is operating at maximum continuous input power the power splitter and EFUs can become warm. Under some operating conditions the surfaces can approach 100 deg. C. (212 deg. F.)

5.8.4 Mechanical hazards - In many operating environments the concealment of the ELPA 302A can be so good as to present a trip and entanglement hazard to the operator. In cases when this is considered a problem and not an advantage, the operator can flag the presence of the wires with brightly colored survey ribbons or mine field flags.

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* Based on a *worst case* field calculation for a 6 minute average exposure to a continuous transmission at 2 MHz using ANSI STD C95.1-1982. The ANSI guidelines indicate a significant decrease in the hazard at and above 3 MHz.

5.8.5 Static build up, lightning and EMP protection - In general the static build up*, lightning and electromagnetic pulse (EMP) hazard presented by the very low profile of the ELPA 302A is less than with conventional antennas. *The ELPA presents DC paths** to the shielded feed cable common for all antenna elements.* The standard deployment forms of the ELPA rely on the radio systems ground connection or the addition of a ground point for inline protective devices.

For enhanced field protection the following parts can be added to the ELPA 302A:

• Lightning only [turn on 7 nS after 600 VDC is reached by 1 kV/ns waveform] - protection of the transceiver by insertion of the coaxial protector at the "XCVR" port of the power splitter for a two port antenna and at the EFU (preferred but physically tight connection for the specific protector) or the radio terminals. The protector is grounded to a copper ground rod by a short length of tinned copper braid. The parts kit is Eyring part number 200-4367-10 and contains:

1 PolyPhaser BNC in-line (male-female) suppressor Model No. IS-50BX-CO-MA
  Power rated 1.5 to 50 MHz at 2000 Watts
  Power rated 50 to 220 MHz at 375 Watts
1 Copper ground stake assembly

• Lightning and high altitude electromagnetic pulse (HEMP) [turn on 1.25 nS after 330 VDC is reached by 1 kV/ns waveform) protection the transceiver and power splitter. The connections should be the same as for the lightning only case plus protectors should be located at each EFU (preferred) or on the "A" and "B" power splitter ports. The parts kit is Eyring part number 200-4367-11 and contains:

3 PolyPhaser BNC in-line (male-female) suppressor Model IS-NEMO-BMA
  Power rated at 1.5 to 50 MHz at 500 Watts
  Power rated 50 to 220 MHz at 200 Watts
3 Copper ground stake assemblies

These kits can be obtained from Eyring on special order or the coaxial protectors can be special ordered with BNC connectors from:

PolyPhaser Corp.
2225 Park Place
P.O.Box 9000
Minden, NV 89423
(702) 782-2511 Phone, (702) 782-4476 FAX

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* Static build up is minimized by the low resistance DC drain path construction of the ELPA (See Appendix D ELPA 302A schematic). The attachment of the antenna's coaxial feed cable to the radio will bring the antenna to the DC potential of the radio and its ground system.

** A DC drain path design slows the electrical potential buildup on the antenna during wind storms and advancing electrical storms.

6.0 ELPA QUESTIONS AND ANSWERS

This section provides narrative answers about ELPA troubleshooting, operation guidelines and applications that are beyond the scope of main discussion sections of this manual. The Questions are arranged by topic.

6.1 Trouble shooting and maintenance

6.1.1 Can an ELPA be tested with a DC continuity checker? - Yes, but only at a basic level. To a simple DC continuity checker or Ohm meter the coaxial connectors of the power splitter will appear to be shorted together. The wire attachment posts (output) of an EFU and the input coaxial connector will also appear to be shorted together. At RF frequencies, these points will appear as connections to transformers with a measurable impedance. If a DC check of an ELPA component indicates an open, the component is defective. See Appendix D for schematic.

6.1.2 How can I be sure the phase grooves are oriented correctly? - Visual inspection of the antenna layout with comparisons to the layout diagrams of section 4.0 should resolve all field phasing questions . A phasing problem that is not resolved by this physical inspection process could only occur if an EFU were disassembled. A phase change for a unit requires a complete removal of the ferrite transformer and selective rewiring and lengthening of transformer leads. *It is not possible to accidentally change the phase of a unit by replacing the damaged Delrin® plastic end caps of an EFU.*

If a 2-element deployment has improperly oriented EFUs a relative field strength meter test off the ends of the antenna elements will verify the problem. Opposing EFU orientations will give a much lower field strength reading than that of a single element while proper phasing will increase the signal strength by 3 dB (50%) over that of a 1-element antenna. Opposing EFU layouts will severely degrade antenna gain (relative field strength) but will not necessarily degrade the antenna's input VSWR. Therefore, VSWR is not a check for phase groove orientation.

6.1.3 Can an ELPA 302A be tested with a directional RF power meter? - Yes, an RF power meter such as the Bird model 43 thru-line Wattmeter can be used to determine if each element is receiving a nearly identical forward power level. If each unit has a similar reflected power level the VSWR of the units can be calculated. The values should match within 10% if the elements are over identical ground conditions. The sum of the forward element power values should nearly equal the input to the power splitter. Perform this test at a high frequency for the layout size you have chosen (i.e. for a 150/150 standard deployment, test above 6 MHz).

6.1.4 Can the end clips of the EFU be removed for cleaning? - Yes, each end clip is held to the EFU hub with two stainless steel screws, two spacers and two washers (6 pieces.). This allows cleaning access to the antenna element connection post. In most cases the post area can be cleaned by removing the two screws and pivoting out the clip without completely removing it. The springs that hold the clip firmly against the post are located in guide holes inside of the clip. *The springs are not captured in the clip and can be removed.* The springs rest flat on the clip notch base (no seating holes). Use care in reassembly to seat the springs properly (they can kink in the reassembly process if not resting flatly on the notch base).

6.1.5 How can an EFU or power splitter be "burned out" by high power operation? - The ferrite devices of an ELPA have two high temperature failure modes. The first is reversible and occurs when the ferrite core reaches its Curie temperature of several hundred degrees Centigrade (well above any environmental ambient temperature). This is the point where the ferrite material loses its desirable electrical properties. If this core temperature is reached, the transceiver will fault with a high VSWR indication. Cooling of the over-heated EFU or power splitter for 10 to 15 minutes may clear this problem. In the second failure mode, the ferrite core heats too rapidly for the core heat sinking capability and cracks. The high VSWR reading will be permanent and the unit will require a transformer replacement. A properly working power splitter has an insertion loss of less than 0.5 dB above the 3 dB (50%) power split to each port when the unmeasured port is terminated in 50 Ohms. The VSWR of any port with the other two ports terminated in 50 Ohms is 1.5 or better over a 2 to 65 MHz range (return loss ≥ 14 dB).

6.1.6 How can an EFU be tested? - The VSWR of an EFU into a matched 450 ohm resistive load should be 1.5 or better over a 2 to 65 MHz range. In the field the 450 ohm load can be a group of carbon (non-inductive) resistors assembled to form a several watt load suitable for the available test power levels. The test load can also be another good EFU terminated with a 50 ohm dummy load of suitable power rating. If an EFU is used as a test load, its posts must be hooked up to the EFU under test with short leads and with the phase groove ends matching each other. The VSWR should be 1.5 or better over a 4 to 65 MHz range (return loss ≥ 14 dB).

6.1.7 What is the effect of the phase groove on the radiation pattern? - The phase groove's effect is on the main beam of the low angle radiation pattern. The pattern is typically 1 dB higher on the phase groove side for ground contact deployments. The only serious phase groove problem is due to opposing orientations of the EFU.

6.1.8 If the ELPA is broadband, why does it need length adjustment for VSWR? - The ELPA allows more layout flexibility because it uses distributed loading to achieve its broadband characteristics. The loading of an antenna element relates to the electrical characteristics of the soil under the antenna. Dryer soil may require a longer antenna element to operate at a lower frequency than if the soil were more moist. *The variable length of the ELPA allows shorter layouts to be used by the operator when only high band frequencies are required.* Adjustment may only be needed for operation on the lower band edge of the recommended wire length/frequency bands of soil conditions are very dry.

> **NOTE:** Some broadband antennas use pre-loading resistors (4 to 6 dB attenuation) ahead of their antenna elements to provide a stable, low VSWR match to the transmitter. Other designs use resistive radiating elements and/or resistive terminators connected to ground stakes.
>
> The ELPA (in its primary deployment modes) does not require that stakes be driven several feet into the soil to provide a grounding point for the connection of resistive terminators. ELPAs generally exhibit better power gain than pre-loaded antennas at all frequencies. ELPAs will be better than most end-terminated antennas at low frequencies.
>
> ELPAs can be end terminated for compact layouts with the tradeoff of increased setup time, increased parts count and a greater kit weight (see Section 4.6.5 and 4.7.3).

6.2 Siting and environmental

6.2.1 How critical is the aiming of an ELPA? - At low frequencies it is desirable to aim the 2-element ELPA within 50 degrees of the desired communications location since the 3 dB (50% power) azimuth beamwidth is 100 degrees. At 65 MHz the beam narrows in azimuth to a beamwidth of 25 degrees for a 20 ft. element-to-element spacing. The aiming accuracy should be within 12 degrees.

6.2.2 Can an ELPA be buried? - The ELPA 302A is not designed as a buried antenna*. The 302A uses a matching network and element wire combination that was optimized for surface environments. The ends of the element wires can be buried to increase ground coupling to lower the low frequency VSWR. In the special case of extremely dry environments (e.g. desert sand) the effect of shallow burial should be minimal on the performance of NVIS (2 to 6 MHz) operation. High band HF (8 to 30 MHz) and VHF operation is not recommended.

6.2.3 Is the ELPA hermetically sealed for use in contaminated environments? - Yes, the ELPA EFUs have silicone "o-ring" seals at all penetrations. The power splitter has an epoxy sealed case with "o-ring" sealed connectors. Each of the units can be immersed in a cleaning solvent. The Delrin® EFU end clip assemblies can be disassembled in the field for cleaning. The wire assemblies and cables are covered with nylon or Teflon® surfaces with PVC shrink tubing boots. For hazardous contamination, as may occur in nuclear, chemical, or biological environments the wire assemblies may be considered disposable since contaminants may be drawn into the air space between the wire jacket, the shrink boots and the wire stranding. The cable assemblies are gasket sealed to the manufacture's connector specification but may become contaminated. Both disposable wire and cable assemblies are recommended for hostile environments.

6.2.4 Can the ELPA be laid on a roof? - No, in terms of the standard ELPA operating principles. The ELPA needs to be in close proximity to the soil to be properly loaded for broadband operation. It is possible for an ELPA to function on a roof but it will match to the desired frequency without VSWR adjustment as a matter of luck rather than its proper functioning as a broadband antenna (on a roof with steel decking it will not function at all). If roof top operation is desired, Section 4.7 and Appendix F on alternate configurations should be reviewed. Especially note the inverted-vee the vertical half-rhombic antenna configurations. A vertical half-rhombic antenna can be formed by passing the element wire over the roof of the building and using it as an insulated support (wood or non-metallic construction).

6.2.5 Can the ELPA be set up as an omni-directional antenna? - Yes, to form an omni-directional antenna a 90-degree power splitter must be substituted for the splitter supplied with the ELPA 302A. The 302A cannot be directly used as an omni-directional antenna by just crossing its elements. Without using the 90-degree splitter the gain will be lower than that of a single element and *the pattern will not be omni-directional.* Contact the factory for more details

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*A factory level design optimization can adapt the 302A type of antenna to work well in a buried environment by selecting different wire/insulation characteristics and by optimizing the matching network.

on alternate deployments. Note that this is only required for low angle communications paths (groundwave, LOS, skywave). For NVIS paths the ELPA is omni-directional. It should be noted that the addition of the 90-degree power splitter can improve NVIS communications by circularly polarizing (right or left hand) the ELPA's pattern to minimize the fades due to the Faraday rotation effect.

6.2.6 Can the ELPA be used in Arctic environments? - Yes, the ELPA has been used in these environments by military units. The materials used to construct the 302A have been chosen for operation in temperature extremes. The RG-400 /U Teflon® cables will remain flexible at sub-zero Arctic temperatures. The nylon jacketed element wires will become stiff but remain manageable. The cable retaining hook was designed to allow wire retention at these temperatures.

6.3 Field expedient deployments and performance extensions

6.3.1 Can I substitute common wire for the element wire? - Yes, it should be insulated, stranded, and a stripped end should fit easily (#18 AWG wire or smaller - #16 AWG is a tight fit and not recommended) into the post clamp of the EFU. WD2, two conductor field wire has been tested with the antennas and makes a good disposable element for the 302A. Both conductors should be twisted together at their connection point to the EFU post.

6.3.2 Can I obtain a higher strength wire for the ELPA? - Yes, A stainless steel wire is available for the ELPA 300 series. Do not use just any type of stainless steel wire since the resistance of the wire varies with different types of stainless steel.

6.3.3 Can I substitute coaxial cables? - Yes, but if the cables are to replace the matched 10-ft. cables that feed the EFUs they must be the same length (+/- 6 in.) and must be the same type of cable. Acceptable types for the 302A are RG-55, RG-58 A/U, RG-223 A/U, RG-142 B/U, and RG-400 /U. Do not mix cable types when feeding the array elements. The cables must have the same propagation velocity by design to have the same electrical length. The physical, measured length and the electrical length are not the same for different cable types. The effect of non-matched cables is strongest at the VHF frequencies for the ELPA 302A. Note also that the double shielded Teflon® RG-400 /U cables used on the 302A are specified for their ground contact durability and all temperature handling characteristics. Cables like RG-58 will give limited service in an ELPA application.

6.3.4 Can a BNC "T" replace a splitter? - No, the splitter contains a 2:1, compensated impedance matching network. Use a single element ELPA if the power splitter is not working or available. A "T" can be used in an emergency with about a 1 to 2 dB loss, dependent on the VSWR presented by the EFUs to the splitter. See the schematic in Appendix D.

6.3.5 Can ground rods be substituted for 1/2 of an ELPA element? - Yes, it is possible to replace an element wire with a connection to a ground rod. This can only be done for the "low," non-phase groove side element of the ELPA. This configuration will work best if the rod is several feet long and in good contact with moist soil. See section 4.7.3.

6.3.6 Can resistive terminations be used to shorten the required length of an ELPA? - Yes, the termination can be a terminating resistor assembly and a grounding stake. This is done with a loss of power gain at some frequencies but may improve the VSWR at the lowest frequency of operation. It is also possible to operate an ELPA like a Beverage antenna (see Section 4.6.5 and Appendix F).

6.3.7 Can the ELPA 302A be set up to operate at higher power levels? - No, the 302A is already optimized to handle 400 Watt peak and 200 Watt average power levels. If higher power operation is required the ELPA 502 is recommended for 2000 Watt peak and 1000 Watt average power levels. Additional options exist by using two ELPA 302As with ELPA 500 series power splitters to form a high power 304A-H (800 Watts peak) or a 308A-H (1600 Watts peak). Contact Eyring Inc. for more details.

6.3.8 What is the most rapid deployment technique? - The 1-element 150/150 standard deployment is rated as the most rapid with a typical deployment time of 2 to 3 minutes for one operator from the time the 302A bag is opened. This time can be improved upon if the frequency of operation allows a 75/75 layout or smaller. Deployment and retrieval time can also be improved upon by using disposable wires with weighted ends that can be thrown into position and abandoned.

6.3.9 Can ELPA 304A wide-spaced arrays be constructed in the field? - Yes, option kits are available with packaging and accessories that may make this task easier but their is no reason that they cannot be field constructed. A 304A can be assembled from two complete 302A kits and the power splitter from a third 302A kit. The feed cables to the two 302As must be matched in length and be the same type number of cable (e.g. RG-58 A/U) so that the electrical lengths are the same. If the final array is to have an element-to-element spacing that is greater than the standard 20 ft., the feed cables to each EFU need to be extended in matched lengths. An array with a 40 ft. spacing uses 20-ft. cables between each EFU and splitter of the 302A modules. A 40-ft. cable joins each 302A to the center, feedpoint splitter (see Figure 4-15 and Table 4-6).

6.4 Performance comparisons

6.4.1 Can an ELPA be modeled for comparison with other antennas? - Yes, but great care must be taken in the modeling process. The ELPA can be modeled with the Eyring analytic modeling programs PAT6 or PAT7 on a personal computer. The ELPA can also be modeled with NEC-3I, an advanced numerical analysis code with the capability to model ground interactions of insulated antenna wires near real ground. However, due to the sensitivity of these computer modeling programs to small changes in parameters such as element wire height, diameter and insulation thickness, *they should not be used for performance predictions without validating comparisons to measured antenna data* (power gain, pattern shape and VSWR). Eyring maintains a large validation library of helicopter measured antenna pattern data on ELPAs and other conventional tactical antennas. Pattern examples can be found in Appendix E.

6.4.2 Can ELPA specifications be compared to those of other antennas? - Yes, if the other antenna is described in the same terms and environment as the ELPA. Often the specifications of other antennas are in an idealized modeling framework that presents the antenna characteristics in an optimistic manner when compared with measured data.

If VSWR is to be compared, it is necessary to know the measurement reference point. ELPA VSWR measurements are conservative. They are based on measurements taken at the EFU or power splitter input port (labeled "XCVR"). If the ELPA antenna is connected to a transceiver through a 50-ft. feed cable the VSWR will be typically lower than the ELPA specification sheet values and the values plotted in Appendix E.

If the ELPA gain is to be compared to other antennas, the definition is very important. The ELPAs are specified in this manual in terms of directivity, directive gain and power gain (see section 1.6.1 and Appendix A). Power gain and directive gain are specified for a particular azimuth and elevation angle (20 degrees, 90 degrees or zenith). The values are also measured or calculated over stated ground conditions of conductivity and dielectric constant.

As a general observation the actual ELPA performance is at or above its specification performance which is validated by measured test data. When other antennas are brought into the measured data evaluation frame of the ELPA, the performance differences are typically smaller than might be expected. Appendix E provides some measured data examples of ELPA performance.

6.5 Principles of operation

6.5.1 What kind of antenna is an ELPA? - In textbook terms, a 1-element ELPA is classed as a balanced feed, non-resonant traveling wave, wire antenna with distributed loading of its radiating elements. Multi-element ELPAs are elementary array structures with low element-to-element coupling. This low element-to-element coupling allows the use of multi-element arrays within a small area to enhance transmitting efficiency.

6.5.2 Why is an ELPA different from a dipole laid on the ground? - The difference is in the length of the antenna elements and the impedance matching technique used for an operating frequency. The comparisons can be summarized as follows:

Bandwidth

Dipole - narrowband, tuned to resonance at a single frequency

ELPA - broadband, non-resonant traveling wave antenna

Operating lengths and heights for 2 to 65 MHz over real ground conditions

Dipole - 0.47 wavelength with total lengths as a function of frequency from 234 ft. to 7.2 ft. and 0.125 wavelength operating heights from 61.5 ft. down to 1.9 ft. The electrical element length is based on tuned wavelengths at the operating height (Note that dipoles at 2 MHz are seldom, placed higher than 30 ft. off the ground. These numbers are presented to provide a common reference perspective).

ELPA - 0.75 wavelength or longer (1 wavelength optimum power gain) in close proximity to the ground with total lengths of 300 ft. to 50 ft. and typical operating heights of less than 0.01 wavelength with heights of 2 ft. down to 0.01 ft. The electrical element length is based on a shorter near ground wavelength due to a slower wave propagation velocity at ground level.

Matching impedance at frequency of operation

Dipole - 50 to 72 Ohms, low impedance, resonant current maximum at feedpoint

ELPA - nominal 450 Ohms, high impedance, voltage maximum at feedpoint

Maximum pattern power gain

Dipole - at 0.47 wavelength resonance in air at a height of 0.125 wavelengths over real ground. Pattern peak is at 90 degrees.

ELPA - above resonance at approximately a 1 wavelength operating point (the dipole, 0.5 wavelength resonance condition is a lower gain point for wires at ground level). The pattern peak is near 90 degrees for the 1 wavelength operating point and at lower angles for higher frequencies.

Polarization

Dipole - horizontal off sides and overhead. Vertical polarization off of the ends (the gain is well below the horizontal pattern).

ELPA - vertical polarization off ends and horizontal overhead. The horizontal polarization gain off the sides is quite low when compared to the vertical polarization gain.

6.6.3 Can an ordinary dipole be matched with an antenna tuner to operate like an ELPA? - In terms of technical principles*, yes. In practice, for the tactical environment, it is difficult and unlikely with current military equipment. Here are some possible reasons:

Tuner design - The tuners provided in most tactical radios are designed to match to antennas that are electrically small or capacitive at the frequencies they are required to tune (i.e. 10 ft. whip). As a design tradeoff to size and anticipated use, they often do not have sufficient built-in incremental capacitance to match an inductive, electrically long antenna such as a 3/4 wavelength dipole or a random length long wire (e.g. a barb-wire fence). Thus the electrically long "ELPA mode" of a dipole is one of several antenna configurations that modern, compact tuners may not be able to match without multiple trials of wire and feed cable length adjustments.

Inventory antennas - A typically military dipole is the AN/GRA-50 dipole with 234-ft. of un-insulated wire (resonant in air down to 2 MHz) and 40 to 50 ft. of RG-58 coaxial feed cable . This dipole antenna could operate as an ELPA at frequencies above 5 MHz (based on its length) with a tuner and then only if the tuner could be prevented from matching to the resonant mode of the ground coupled dipole which represents a lower power gain operating point than that of the ELPA.

Without 76 feet of additional length the AN/GRA-50 antenna would only provide resonant, low gain, low profile modes. The feed from the tuner to this antenna should also only be 2 feet or less to minimize the significant feed cable losses that are present when a tuner is used to match a high impedance load through a 50 Ohm cable. This is a common problem with tuner matched dipoles which can lose 5 to 10 dB or more in combined tuner/coaxial transmission line losses at low frequencies (this is not well documented in the HF operating literature).

Mechanically the inventory antennas would be disposable in ELPA type service since their lightweight components, made for suspension in the air would be unlikely to hold up in the hostile ground contact environment (e.g. the use of RG-400, double braided, Teflon® core cable is a required feature of the ELPA 302A).

Matching network or balun - A matching device, similar to the ELPA EFU is necessary for simple military dipoles such as the AN/GRA-50, which do not use a balun. To function as an ELPA, a network, similar in design to an ELPA EFU would have to be employed. The use of the ELPA matching network is critical to achieving the best operating efficiency close to the ground.

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* This information is offered for technical clarity since the operating design and packaging techniques of the Eyring low profile and buried antenna designs are protected by issued U.S. patents and pending international patents.

Multi-element systems - The simple dipole and tuner equivalence for an ELPA *can only be contemplated for single element antenna systems.* Multiple tuners would be required for a multi-element system,

The multi-element ELPA designs such as the 304A or 308A can exhibit 6 or even 9 dB of efficiency over that of the dipole/tuner system. Moreover the pattern directivity of a multi-element ELPA can produce highly directive beams of 12 dB or more with power gains of 0 to +2 dBi.

Directivity - The directivity of a single ELPA element at its maximum power gain point is slightly higher than that of a standard 1/2 wave dipole in the air. When a dipole is brought near the ground it will take on the directivity characteristics of an ELPA at its lowest operating frequency. A 1-element ELPA has a directivity of about 5 dB when compared with about 4 dB for the elevated dipole. When the ELPA is configured with multiple elements it increases its directivity over that of a dipole. Each doubling of elements adds about 3 dB of directivity to the ELPA. Layout asymmetry and frequency vs element length effects can add up to 4 dB to an antenna configuration. The 302A can be configured to have a 3 to 7 dB directivity advantage over a dipole.

7.0 WARRANTY AND RETURN POLICY

Eyring warrants all ELPA products against defects in material and workmanship for a period of one (1) year from the date of purchase. Scratches, bends, broken connectors or wires etc. caused by field usage are not covered under this warranty. Opening the sealed electrical components (power splitters and EFUs) voids the warranty.

If the customer should receive a component that they think is defective, they should contact Eyring with the system serial number (located on ELPA 302A carrying bag cover), individual part number and serial number of the component(s). This information is needed to issue a return material authorization number (RMA).

Phone (801) 375-2434, FAX (801) 374-8339 or write to:

Eyring Communication Systems Division
ELPA Warranty Support
1455 West 820 North
Provo, UT 84601

8.0 REFERENCES

8.1 Supporting documentation and references

The following references were either used directly in preparing this manual or strongly influenced the perspectives presented in it.

1. "Broadband HF Antenna Testing," D.L. Faust and M.B. King, Proceedings of RF Technology Expo 86, Anaheim, California, pp. 625-631, January 30, 1986. Also available as Eyring Document No. 800-0758.

2. "Gain and Pattern Measurements of a Low Profile HF Antenna Array," D.L. Faust and O.N. Skousen, Presented at the 2nd Annual Review of Progress in Applied Computational Electromagnetics Newsletter, Vol. 1, No. 2, pp 31-46, December 1986.

3. "Selected Pattern Measurements of Four Full-scale Tactical HF Antennas," D.L. Faust, Presented at the 2nd Annual Review of Progress in Applied Computational Electromagnetics, Monterey, California, March 1986. This paper was updated in December of 1986 as Eyring Document No. 900-0009.

4. "Full-Scale HF Antenna Test Approaches Applicable to Numerical Model Validation", D.L. Faust and M.B. King presented at the 2nd Annual Review of Progress in Applied Computational Electromagnetics at the Naval Postgraduate School, Monterey, CA, March 18-20, 1986. This paper is available as Eyring Doc. No. 900-008.

5. "Comparison of Four Tactical Antennas by Chirpsounder® and Elevation Pattern Measurements," D.L. Faust, Eyring Doc. No. 900-0011, March 1986 (preliminary).

6. "Selected Pattern Measurements of Four Full-Scale Tactical HF Antennas", D.L. Faust, Presented at the 2nd Annual Review of Progress in Applied Computational Electromagnetics at the Naval Postgraduate School, Monterey, CA, March 18-20, 1986. This paper is available as Eyring Doc. No. 900-009.

7. "The Low Profile Antenna/Rollout HF Antenna: A New Tactical Communications Option," D.L. Faust, Presented at HF Radio Clinic - 86, St. Louis, Missouri, pp 165-186, September 17, 1986. This paper is available as Eyring Document No. 900-0013. It is published as part of the AFCC, Scott AFB, HF Radio Clinic Proceedings released January 1987.

8. *Antenna Engineering Design Handbook for Buried Linear Arrays*, April 1988, Eyring Document No. 300-0072, prepared under the Hardened Antenna Technology Program for Rome Air Development Center, Griffiss AFB, NY, Contract No. F30602-85-C-0282

9. "A Buried Antenna Analytic Modeling Program - PAT6," R.B. Gilchrist, P.O. Berrett, B. Grose, M.B. King and D.L. Faust, Presented at the 5th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, California, March 1989.

10. *Eyring Low Profile and Buried Antenna Modeling Program - PAT6, User's Manual,* M.B. King, R.B. Gilchrist, D.L. Faust, March 1990 (preliminary), Eyring Document 300-0085.

11. *Operators's and organizational maintenance manual, Radio Set AN/PRC-104A*, TM 11-5820-919-12, Department of the Army, Washington, DC, 15 January 1986.

12. *Field Antenna Handbook*, ECAC-CR-83-200, Department of Defense, Electromagnetic Compatibility Analysis Center (ECAC), June 1984. Guidelines in this handbook can be used to set up alternate deployments of vertical half rhombic, inverted-vee and sloping-vee antennas.

13. *Tactical Single-Channel Radio Communications Techniques*, Department of the Army Field Manual FM 24-18, December 1984, Chapter 3, Chapter 7 and Appendix N. Appendix N introduces NVIS communication techniques

and is a republication of an article by D.M. Fiedler and G.H. Hagn, titled "Proposed modes and antennas for beyond-line-of-of-sight (BLOS) omnidirectional skip-zone-free HF communications that appeared in the *Army Communicator* Vol. 8, #3, Fall 1983-- see errata in the following issue which was not applied to the Appendix N of FM 24-18. (see references 1 and 2 under section 8.2 for further supporting details).

14. **Compendium of High Frequency Radio Communications Articles**, A.S. Christinsin, Air Force Communications Command Technical Report, 1 August 1986

15. "Characterization of a high-frequency vertical half rhombic", M.D. Fanning, W.P Wheless Jr., D.L. Faust and M.B. King, presented at the 6nd Annual Review of Progress in Applied Computational Electromagnetics at the Naval Postgraduate School, Monterey, California, March, 1990.

16. **Numerical Electromagnetics Code (NEC) - Method of Moments**, G.J. Burke and A.J. Poggio, vol 2, Naval Ocean Systems Center Technical Document 116, January 1981. A variation of this code known as NEC-3I (insulated wire adaptation) is suitable for ELPA modeling with validating test data.

17. Eyring measured antenna pattern data base - containing over 8,000 antenna high resolution, power gain pattern measurements on ELPAs, buried antennas, monopoles, dipoles and tactical antennas. The patterns were acquired with a helicopter-towed beacon measurement system.

8.2 Technical publications on HF tactical Communications.

These papers, and additional papers and reports reference within them are some of the few published papers that contain performance measurements in the tactical environment.

1. "Measured Relative Responses Toward the Zenith of Short-Whip Antennas on Vehicles at High Frequency", G.H. Hagn and J.E. van der Laan, IEEE Transactions on Vehicular Technology, Vol. VT-19, No. 3, August 1970. pg 230-236.

2. "On the Relative Response and Absolute Gain Toward the Zenith of HF Field-Expedient Antennas--Measured with an Ionospheric Sounder", G.H. Hagn, IEEE Transactions on Antennas and Propagation, Vol AP-21 , No. 4, July 1973, pg 571-574.

3. "Measurement Techniques for HF Tactical Antennas", G.H. Hagn and L.O. Harnish, Presented at the Technical Conference on Tactical Communications, The Next Generation, Fort Wayne, Indiana, 22-24 April 1986.

8.3 General antenna references

These annotated items are offered to add depth to topics that have been introduced in this manual:

1. The primary reference on the traveling wave antenna concept is a paper by: H.H. Beverage, C.W. Rice and E.W. Kellog, "The Wave Antenna, a New Type of Highly Directive Antenna," Transactions of the AIEE, Vol. 42, pg 215, 1923.

2. An excellent text book reference on the topics of traveling wave antennas and linear arrays can be found in: J.D. Kraus. *Antennas*, 2nd Edition, McGraw-Hill Inc., New York, N.Y., 2nd edition 1988. Chapters 2,4,5, and 11. This is a recent update of the most widely referenced standard text in antennas since 1950.

3. For a user oriented, "amateur radio style" presentation the reader is directed to: *The ARRL Antenna Book*, 15th edition, The American Radio Relay League, Newington, CT, 1988. Chapters 2 and 13.;and also the **ARRL Handbook for the Radio Amateur**, (yearly edition) sections on antennas and antenna projects.

8.4 Selected codes, abbreviations and definitions

8.4.1 ELPA component layout codes and abbreviations - The use of this abstract coding has been minimized in this introductory manual. These codes will be of value when describing multi-element, multi-length, variable width and elevated wire configurations. This notation allows an unambiguous characterization of an ELPA configuration.

Antenna layout configuration abbreviations

Format: **nE f/b w hn Dd**

nE = Number of elements n

f = Front deployment length in feet. Staked deployments are described with the length of the wire suspended given in feet between (). This element is oriented in the direction of transmission to a distant station.

b = Back deployment length in feet. Staked deployments are described with the length of the wire suspended given in feet between ().

w = Wire layout is designated **S** for single element wire or **V** for a dual wire or center-tapped wire element layout that starts at the EFU and spreads to an end-to-end spacing of approximately 6 feet at the wire ends.

hn = Height of wire is designated **G** for ground contact or **S** for standard 2-foot high staked deployment that typically elevates 2/3 of the front (phase groove) element. The balance is laid on the ground for termination. A non-standard staking height is given as a number **n** in feet after the S.

Dd = Distance **d** between elements in feet. If this parameter is not indicated the default distance is 20 feet between wire elements of the multi-element array (on some data sets this may be symbolized as **dW** where the **W** is the width).

Example:

2E 150/150 S G	This is the standard 2-element 150/150 single wire, ground contact deployment of the Model 302A. The distance between the elements is 20 ft.
2E 150(100)/150 S	This is the standard deployment with the front 2/3 of the elements elevated or staked 2-ft. high.
2E 75/75 V G	This is the 2-element 75/75 center-tapped vee, ground contact deployment.
2E 75/75 V S	This is the 2-element 75/75 center-tapped vee, elevated

	wire (staked) deployment. The ()/() notation of the suspended wire length is implied as the standard 2/3 element length elevation on each side. The exact definition could also be written 2E 75(50)/75(50) V S.
1E 150/150 V G	This is the 1-element 150/150 vee, ground contact deployment.
4E 75(50)/75 V S D40	This is a 4-element 75/75 vee with 50 ft. of each front element elevated. The element-to-element spacing is 40-ft. the total width of this array is 120 ft.

8.4.2 Abbreviations and manual definitions - These entries cover the majority of items used in this manual. For further definitions the reader is referred to the references listed under Section 8.3.

AWG - American wire gauge

ELPA - Eyring Low Profile Antenna

Bandwidth - This is defined as the frequency range over which the feedpoint VSWR can be adjusted to below 2.

Beamwidth - This is the width in degrees of a pattern lobe measured between its 3 dB down points (50% power). The beamwidths used in the specifications of this manual are 3 dB beamwidths. Some beamwidth definitions use a 6 dB reference (50% voltage).

BNC - This is an industry standard coaxial connector

CW - Continuous wave transmission. This is also designated an A0 transmission and is typically used to send Morse code.

Curie point - The point at which a ferromagnetic material loses its ferromagnetic properties.

dB - decibel, 0.1 bel, a unit of relative signal strength comparison. Antenna gains in dB are

dBm - dB (above or below) a 1 milliWatt power level. It this manual and typical RF usage, the reference is further defined in terms of 50 Ohm transmission line impedances.

dBi - dB (above or below) an isotropic reference.

Delrin® - This is an acetal resin developed by DuPont Corporation. It has excellent low temperature toughness as well as excellent resistance to environmental factors. Its useful temperature range extends beyond the specified range of -40 °F to 180 °F (-40 °C to 82 °C).

Directivity - This is the maximum directive pattern gain achieved by the antenna structure. This figure is expressed in dB and is always greater than 0. A point source, spherical antenna pattern has a directivity of 0 since it emits in all directions. An ideal, surface mounted, omni-directional antenna (hemispherical pattern) has a directivity of 3 dB.

EFU - Element feed unit. This is an ELPA unique term that applies to the matching network that attaches to the antenna elements. The EFU is a voltage step up autotransformer. The standard ELPA 302A device has a 50 Ohm input impedance and a nominal 450 Ohm output impedance. The EFU's function is similar to that of a Balun.

EMP - Electromagnetic pulse.

Feedpoint - For ELPA measurements this is defined as the connection point of the coaxial feed cable from the radio to the EFU for a single element antenna. For multi-element antennas it is defined as the input to the power splitter. Some antenna VSWR specifications are based on placing the feedpoint at the end of a specified length of feed cable.

FSK - Frequency shift keying. This is a data transmission mode.

HF - high frequency, the standard definition is 3 to 30 MHz, In common usage this typically covers from 2-30 or in some cases 1.6 to 30 MHz.

Isotropic reference - This is a reference frame that defines a spherical surface in which all points have the same value. In terms of an antenna's radiation pattern, an outward bulge of the spherical surface represents a positive gain above the isotropic reference surface. If the peak of the bulge is 50% or 0.5 times higher than the isotropic surface the peak is described as having a 3 dBi gain. The "3" is the logarithmic notation for a 50% increase above the reference surface. The "dB" is the abbreviation for decibels, a unit of relative signal strength. The "i" indicates that the relative units of decibels are with respect to the isotropic reference frame of 0 dB (also defined as 100% radiation efficiency).

Load - This term describes an RF dissipative non-radiating device. Typically a 50 Ohm coaxial resistive device defined with an RF power handling capacity in Watts.

LOS - line of sight

MHz - megaHertz

Null - The absence of signal. In antenna terms this a point where the signal pickup is significantly below (-6 dB or more) than that of the main beam.

NVIS - Near vertical incidence skywave,

nylon - a polyamide thermoplastic. Nylon has good environmental resistance and maintains its properties from -75 °F to 230 °F (-59 °C to 110 °C).

RF - Radio Frequency

SSB - Single side band

Splitter - Power splitter or power combiner as used in this manual. This is a 50 Ohm input device that splits an RF source into to equal components with a 50 Ohm output impedance. The device also works as a signal combiner. The power rating is based on units ability to dissipate heat associated with its insertion loss that is typically less than 0.1 dB (2.3% loss). An input of 0 dBm on the input of a power splitter will place a -3.05 dBm level on each output port terminated in 50 Ohms.

Teflon® - This is a tetrafluoroethylene polymer fiber developed by DuPont Corporation. This material is used in the construction of the RG-400 /U coaxial cable and in the jacketing of the internal wiring of the ELPA components. The useful temperature range is -94 °F to 392 °F (-70 °C to 260 °C). Teflon® is resistant to an extremely wide range of environmental factors.

Tuner - Antenna tuner (manual or automatic), antenna coupler or antenna matcher.

VHF - Very high frequency, the standard definition is 30 to 300 MHz. In military usage this typically refers to the

30 to 88 MHz tactical communications band.

VSWR - Voltage standing wave ratio

WD2 - Common two conductor, military telephone field wire.

XCVR - Transceiver

Vee - name for an element forming the letter "V"

9.0 INDEX

The index items listed here have been selected to provide ready access to details that are not directly accessed by the Table of contents. This index complements key abbreviations and manual definitions found in Section 8.4.2. The index does not include items in the Appendices.

Appendix A - Full Detail Specifications

Identification

Model:	ELPA 302A
Eyring P/N	200-4025-02
National Stock Number:	5985-01-322-0272

Electrical

Frequency range:	2 to 65 MHz (usable to 90 MHz)
Input RF Power:	400 Watts peak, 200 Watts average
Input impedance:	50 Ohms
VSWR:	2:1 or better is typical, layout dependent.
Pattern:	Bi-directional (elevation angle <60 deg.) Omni-directional (elevation angle >60 deg.)
Polarization:	Vertical (<60 deg.) Horizontal (>60 deg.)
Azimuth beamwidth:	100 deg. at 3 MHz 25 deg. at 65 MHz (Standard deployment)
Elevation beamwidth:	160 deg. typical coverage
Power gain (conservative):	Ground contact deployment -4 dBi at 65 Mhz, 20 deg. elevation -13 dBi at 15 MHz, 20 deg. elevation -12 dBi at 3 MHz, 90 deg. elevation -17 dBi at 3 MHz, 20 deg. elevation Elevated element deployment (2 ft.) 0 dBi at 65 MHz, 20 deg. elevation -6 dBi at 15 MHz, 20 deg. elevation -12 dBi at 3 MHz, 90 deg. elevation -17 dBi at 3 MHz, 20 deg. elevation
Directive gain:	Ground contact or elevated (staked) deployment 13 dB at 65 MHz 8 dB at 15 MHz 5 dB at 3 MHz

Mechanical

RF Connectors:	BNC, silver plated brass connectors, jacks, caps with gold plated center pin.
Coaxial cable:	RG-400 /U Teflon® cable, tan jacket
Element wire:	0.03 inch dia., 7x7 strand, phosphor bronze with a clear nylon jacket of 0.047 inch dia. 40 lbs. test. Attachment loops and center tap points use 0.031 inch dia, 3x7 strand stainless steel. Crimps tested at 25 lbs.
EFU post:	Nickel plated brass
Metal housings:	machined from T-6061 Aluminum and anodized brown.
Assembly hardware:	Stainless steel
Plastic housings:	machined from black Delrin®
Plastic "D" rings:	Cast 8020 Delrin®

Packaging

Style:	Soft canvas pack with non-reflective hardware
Overall size:	10.5 x 4.25 x 3.25 inches
Nominal volume:	0.084 cu. ft.
Weight:	5.3 lbs. (dependent on wire type and length)

Deployment

Maximum area:	1-element standard., 300 ft. x 0.5 ft. 2-element standard., 300 ft. x 20 ft. 1-element vee, 300 ft. x 6 ft. 1-element center-tapped vee, 150 ft. x 6 ft. 2-element center-tapped vee, 150 ft. x 26 ft.
Overall height:	0.0 ft. to 0.1 ft for ground contact. 1 ft to 3 ft. for staked deployment
Time (one person):	2 to 3 minutes for 1-element standard 4 to 5 minutes for 2-element standard 3 to 4 minutes for 1-element vee 4 to 5 minutes for 1-element center-tapped vee 5 to 10 minutes for 2-element center-tapped vee

Environmental

Operational/Storage:	-40 °F to 131 °F (-40 °C to 55 °C)
Deployment:	-4 °F to 131 °F (-20 °C to 55 °C)

Appendix B - ELPA 302A parts list and selected options

Number	Description	Part No.
1	**ELPA 302A**	**200-4025-02**
1	Carrying bag	200-4026-01
2	Element feed unit (EFU)	200-4032-01
4	Reel assembly w/150 ft of PB wire	200-4033-01
1	Splitter, power	200-4028
1	6 ft. coaxial cable with BNC male ends	200-4027-02
2	10-ft. coaxial cable with BNC male ends	200-4027-01
3	Cable retainer	200-4425
1	Operators manual	300-0086

Accessories

1	Lightning protection kit (transceiver feedpoint)	200-4367-10
1	EMP/Lightning protection kit (3 splitter ports)	200-4367-11

Replacement parts ****** Contact the factory for a replaceable parts and repair guide *****

ELPA 300 Series Options

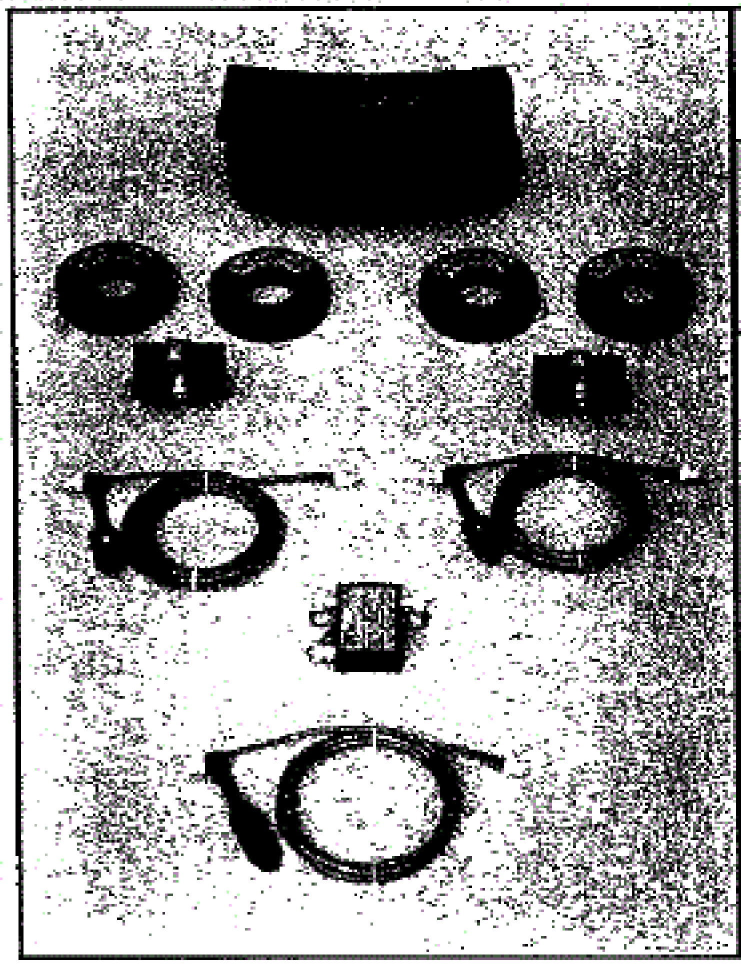
1	**ELPA 301A-U (ELPA and dipole feeds)**	**200-4458**
1	**ELPA 304A w/Alum. case**	**200-4452**
1	**ELPA 308A w/Alum. case**	**200-4453**
1	**Adapter kit to assemble 304A from two 302A units**	**200-4452-01**
1	**Adapter kit to assemble 308A from two 304A units**	**200-4453-02**
1	Alum. transport case w/uncut insert	200-4454
	Alum. transport case w/304A insert	200-4454-01
	Alum. transport case w/308A insert	200-4454-02
1	Stake kit w/hammer and extractor (500 series)	200-3864-03
1	Stake kit w.hammer and extractor (300 series)	200-3864-04
1	Beverage deployment kit (uses 302A element wires)	200-4455
1	VHR 500-ft deployment kit w/o mast (includes 200-4455)	200-4456
1	22-ft mast	200-4457-01
1	35-ft mast	200-4457-02

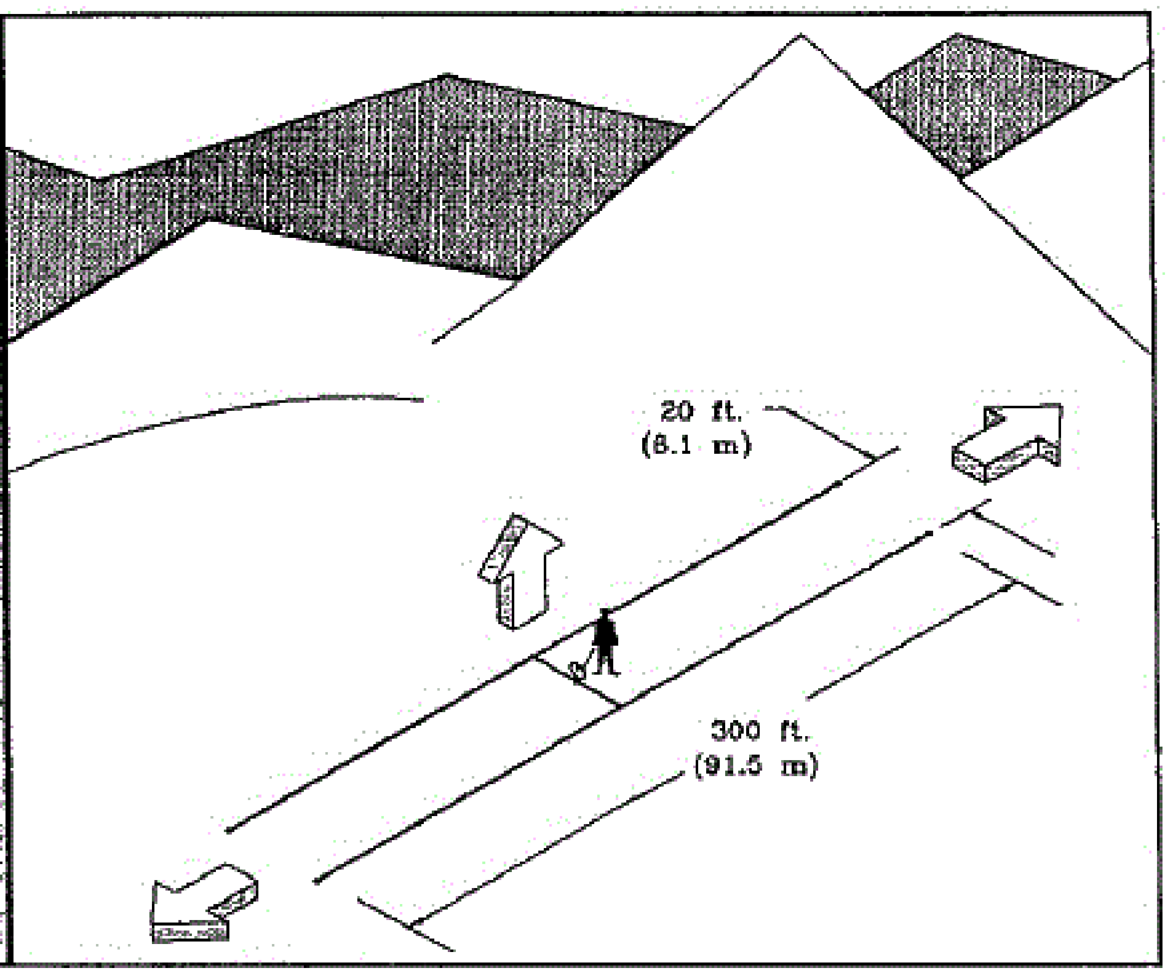
ELPA 302A Pocket Pack

EYRING *Creating Solutions™*

Document No. 900-0050A

HF/VHF Tactical Antenna





2-Element Model 302A Antenna

National Stock Number 5985-01-322-0272

- Low visibility, zero profile, on ground or optional 2-foot (58 cm.) height on stakes.
- Rapid deployment, 1 man under 5 minutes.
- Light weight, 5.3 lbs. (2.4 kg.)
- Compact, integrated component packaging, 10.5 x 4.25 x 3.25 in. (27 x 11 x 8 cm.)
- Adaptable, high reliability, modular design; functional as two independent antennas.
- Wide operational temperature range.
- Wideband, 2 to 65 MHz.
- Low VSWR, less than 2:1 typical.
- 400 Watt peak, 200 Watt average power.
- Groundwave, NVIS and skywave coverage from the vertical "fan" beam elevation pattern of the antenna.
- Bi-directional "figure-eight" or uni-directional "tear drop" low-angle azimuth beam pattern with medium (HF) to high (VHF) directive gain.
- Compatible with frequency hopping and spread-spectrum HF/VHF systems.
- VHF LOS and meteor burst compatible for special applications.
- Jamming and noise resistance of up to 20 dB provided by a low-angle, off-axis bi-directional azimuth pattern null.
- 4-element and 8-element combining kits for enhanced power gain and directivity.
- Beam steering and beam selection options.
- Connection, cable and tower kits allow operation as 300-foot (91 m) Beverage, 400-foot (122 m) vertical half-rhombic, 200-foot (61 m) sloping-vee or inverted-vee antennas.
- Field tested worldwide.
- Compatible and tested with AN/PRC-70, AN/PRC-77, AN/PRC-104A, AN/PRC-132, PRC-1099, RT-1616, AN/GRC-213, AN/PRC-319 and AN/PRC-515 transceivers.

U.S. Patents: 4,809,010 5,829,310 4,743,917 4,839,661 4,825,224 4,750,001; International Patents Pending

EYRING / 1455 WEST 820 NORTH / PROVO, UTAH 84601 / 801-375-2434 / TELEX 882-000 / FAX 801-374-8339

SPECIFICATIONS

Identification

Model:	ELPA 302A
Eyring Part No:	200-4025-02
National Stock No:	5985-01-322-0272

Electrical

Frequency Range: 2 to 65 MHz, usable to 90 MHz
Input RF Power: 400 Watts peak, 200 Watts average
Input Impedance: 50 Ohms
VSWR: <2:1, typical
Pattern:
- Bidirectional, elev. angle <60°
- Omnidirectional, elev. angle >60°

Polarization: Vertical, <60°; Horizontal, >60°
Azimuth beamwidth: 100° at 3 Mhz; 25° at 65 MHz
Elev. beamwidth: 160° typical
Power gain (conservative):
- Ground contact deployment
  - -4 dBi at 65 MHz, 20° elevation
  - -13 dBi at 15 MHz, 20° elevation
  - -12 dBi at 3 MHz, 90° elevation
  - -17 dBi at 3 MHz, 20° elevation
- Staked deployment (2 ft.)
  - 0 dBi at 65 MHz, 20° elevation
  - -6 dBi at 15 MHz, 20° elevation
  - -12 dBi at 3 MHz, 90° elevation
  - -17 dBi at 3 MHz, 20° elevation

Directivity:
- Ground/stake deployment
  - 13 dB at 65 MHz
  - 8 dB at 15 MHz
  - 5 dB at 3 MHz

Mechanical

RF Connectors: BNC
Coaxial cables:
- RG-400, Teflon® cable, tan jacket

Element wires:
- 0.032 inch dia., 7x7 strand, phosphor bronze with clear nylon jacket

Metal housings: T-6061 Aluminum
Plastic housings: Delrin®

Packaging

Style:
- Soft olive drab canvas pack with non-reflective black snaps and "D" rings

Overall size: 10.5x 4.25x 3.25 in.
Nominal volume: 0.084 cu. ft.
Weight: 5.3 lbs.

Deployment

Maximum area:
- 1-element std., 300 ft. x 0.5 ft.
- 2-element std., 300 ft. x 20 ft.
- 1-element Vee, 300 ft. x 6 ft.
- 2-element Vee, 150 ft. x 26 ft.

Overall height:
- 0.0 ft. to 0.1 ft. for ground contact
- 1 ft. to 3 ft. for staked deployment

Time for one person:
- 2 to 3 minutes for 1-element std.
- 4 to 5 minutes for 2-element std.
- 4 to 5 minutes for 1-element vee

Environmental

Operational/storage: -40° to 55° C.
Deployment: -20° to 55° C.

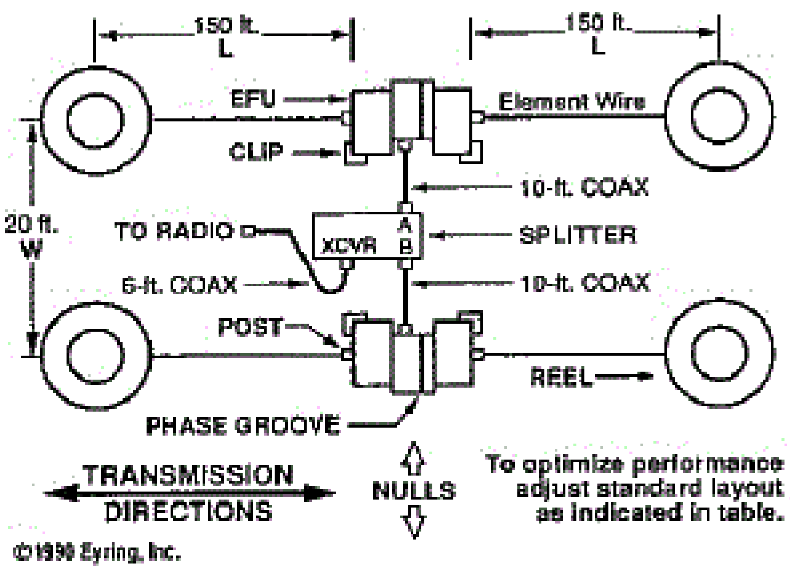
INSTRUCTION PANEL OF MODEL 302A BAG

ELPA 302A POCKET PACK ANTENNA LAYOUT INSTRUCTIONS

200W AVERAGE 400W PEAK 2-65 MHz WIDEBAND 2:1 VSWR TYPICAL–TUNER NOT REQUIRED

STANDARD 2-ELEMENT 150/150 SINGLE WIRE CONFIGURATION SHOWN–USABLE 2-65 MHz

The antenna will look like this when laid out on the ground.



To optimize performance adjust standard layout as indicated in table.

The antenna pattern is directional along the element wires for groundwave, skywave, (over 300 mi.) and 30-65 MHz VHF LOS. The pattern is omnidirectional for 2-8 MHz NVIS (under 300 mi.).

! Both phase grooves must be located on the same side of the antenna layout as shown.

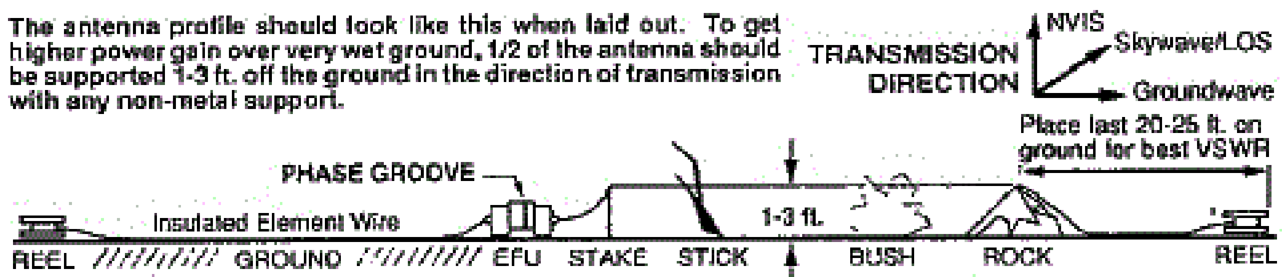
1-Element layout with direct feed to the EFU can be used in place of the standard layout to save time.

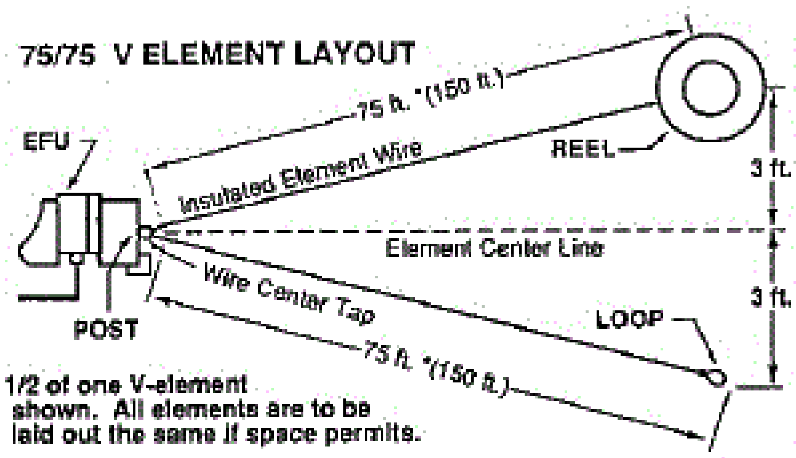
FREQUENCY	L	W
2-30 MHz	150 ft.	20 ft.
4-50 MHz	75 ft.	20 ft.
10-65 MHz	50 ft.	10 ft.
15-65 MHz	25 ft.	10 ft.

(See manual for other options)

OPPOSITE SIDE OF INSTRUCTION PANEL

The antenna profile should look like this when laid out. To get higher power gain over very wet ground, 1/2 of the antenna should be supported 1-3 ft. off the ground in the direction of transmission with any non-metal support.





1/2 of one V-element shown. All elements are to be laid out the same if space permits.

Use a V-element layout for 2-6 MHz operation of 1 or 2 elements within a limited layout area. A 1-element 150/150 V layout will improve the VSWR over sandy or rocky soils. Length changes of 10-20 ft. may improve VSWR at a single frequency.

The 150-ft. element is connected to EFU post at center of element. The reel and loop ends are spread about 6-ft. apart.

! *A 1-element 150/150 V layout uses all 4 wire elements of a kit with 1 EFU.

For more information on this Eyring Low Profile Antenna (ELPA), other tactical communications products, high survivability covert buried or robust pylon antenna designs. Contact:

Eyring Inc.
Communication Systems Division
1455 West 820 North
Provo, UT 84601 USA

Phone: (801) 375-2434 **Fax: (801) 374-8339**

"Antennas Designed from the Ground Up"

Detailed Literature, Technical Assistance and Demonstrations Available

Appendix D - ELPA 302A Schematic

Shown below is a ELPA 302A electrical schematic. The aluminum housings are shown in a simplified manner to allow tracing of the circuit paths. The phase grooves mark the high potential (inner coaxial conductor) side of the element feed unit (EFU) autotransformer. Note that the antenna does not require ground connections or terminations in this basic configuration. Connections for static drain, lightning or EMP protection are made at the radio or through the grounding point on inline coaxial protective devices (see Section 5.8.5).

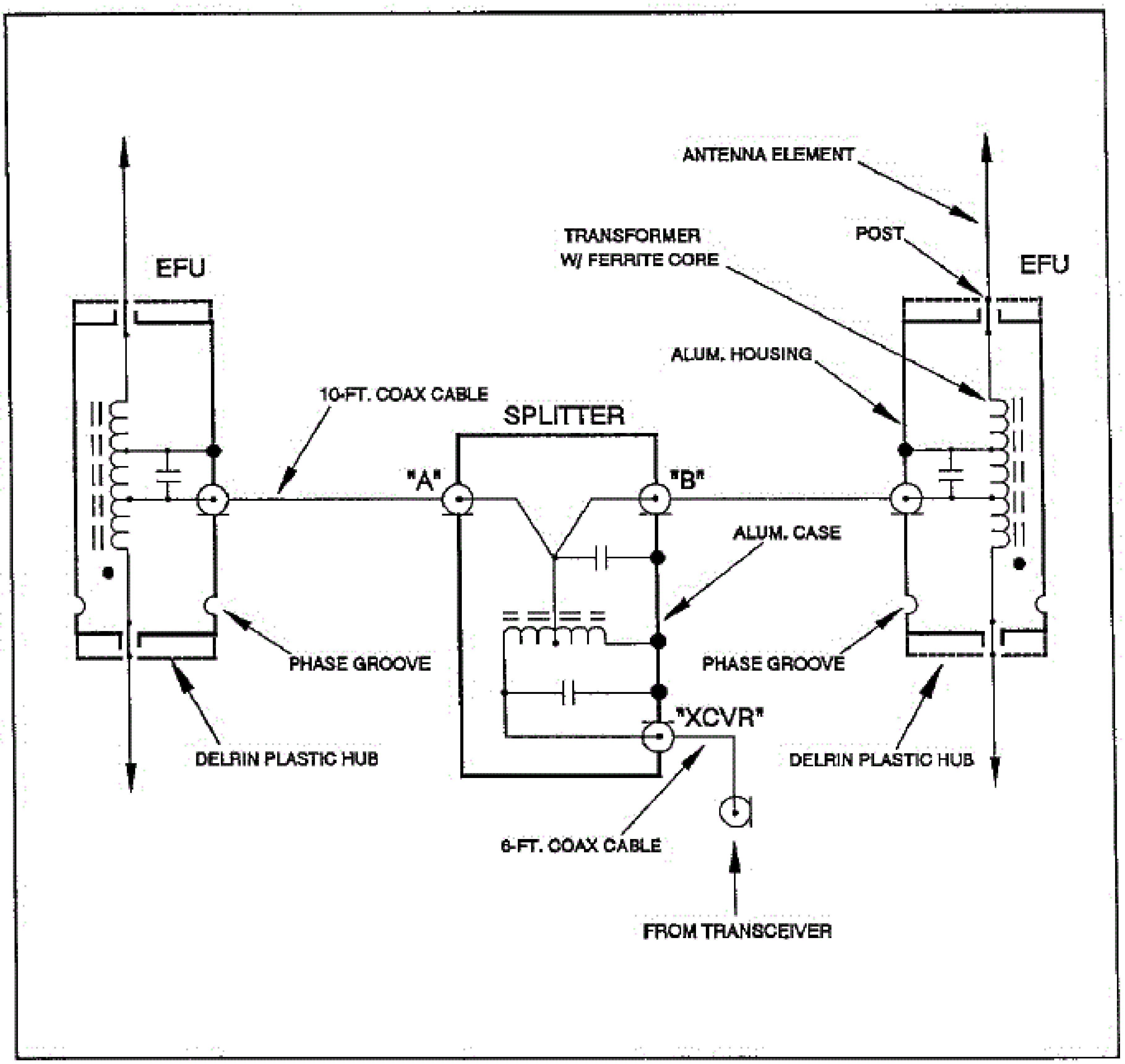


Figure D-1 Electrical schematic of ELPA 302A.

NOTE: Field testing with a DC Ohm meter or continuity checker will indicate that all terminals are "shorted" to the case "common" or shields of the coaxial feed cable. Field testing must be accomplished by comparison tests between components or RF instrumentation must be employed.

Appendix E - Measured antenna performance data

E 1.0 VSWR examples

E 1.1 Standard and vee deployments of a 302A ELPA.

The following data was taken at the Cedar Valley Utah antenna test range of the Eyring Communications Systems Division. The data was acquired with an Hewlett Packard 3577A network analyzer with a model 35677A S-parameter test set. The calibration point of the measurements was at either the antenna's EFU or power splitter. Therefore these measurements are conservative relative to the operational environment. Typically this will include either a 6-ft., 10-ft. or user supplied coaxial feed cable for the connection to the radio.

The soil conditions at the test site were characterized as very dry farm land (no irrigation). The measurements were taken during the late spring and early summer seasons. The electrical parameters of the soil were measured by an inverted monopole technique that uses a network analyzer for acquisition. Some selected values were:

Frequency	Dielectric constant, ϵ	Conductivity, σ
4 MHz	20.6	4.6 mS/m
6 MHz	15.2	6.6 mS/m
13 MHz	11.3	9.3 mS/m
19 MHz	10.5	10.1 mS/m
27 MHz	9.9	11.8 mS/m
49 MHz	6.2	11.2 mS/m

These ground values represent a lower bound on expected ground values. Therefore in many environments the ELPA will present lower VSWRs at lower frequencies than those measured here. The measured values presented here for the ELPA 302A were taken with earlier ELPA model 302 units which are electrically identical to the higher power model 302A.

In Figure E-1 the feedpoint VSWR is plotted for a 2-element standard ground contact deployment 150/150 model ELPA 302. This plot is contrasted with figure E-2 which plots the VSWR for a 75/75 center-tapped vee also on the ground. In these plots it can be seen that the center-tapped vee has a flatter VSWR characteristic over its useful operating range of 4 to 51 MHz (usable to 91 MHz) than the 150/150 standard configuration. The 150/150 standard configuration is usable down to 2.6 MHz with a VSWR of 3 or less. The low frequency capability of the ELPA can be extended under these ground conditions by configuring a 1-element 150/150 vee-wire antenna. The VSWR for the vee is plotted in Figure E-3. At 2.15 MHz the VSWR is 3 under these soil conditions. All three plots have an X-axis marker that indicates a 4 MHz boundary that is the lower frequency boundary of the 75/75 center-tapped vee element configuration. Figure E-4 compares the 1 to 11 MHz low frequency coverage regions of the 75/75 vee of Figure E-2 (solid line) with the extended coverage of the 1-element 150/150 vee antenna (dashed line).

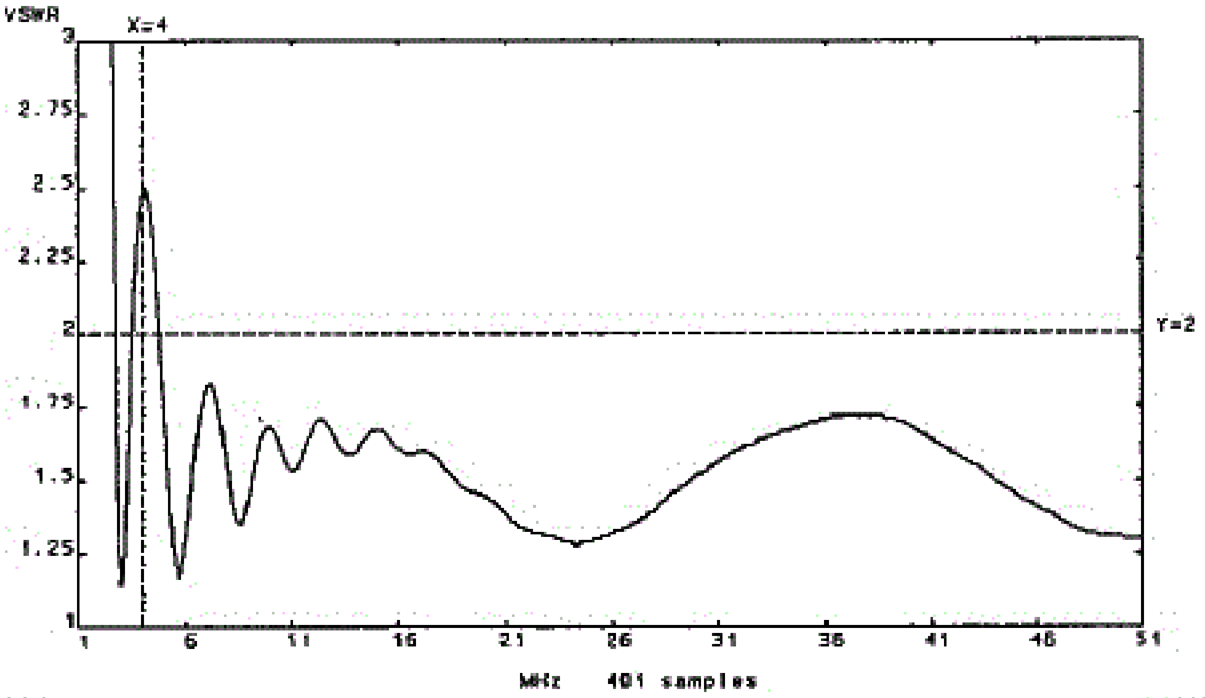


Figure E-1 Full range VSWR plot of standard single wire 2-element 150/150 ground contact deployment.

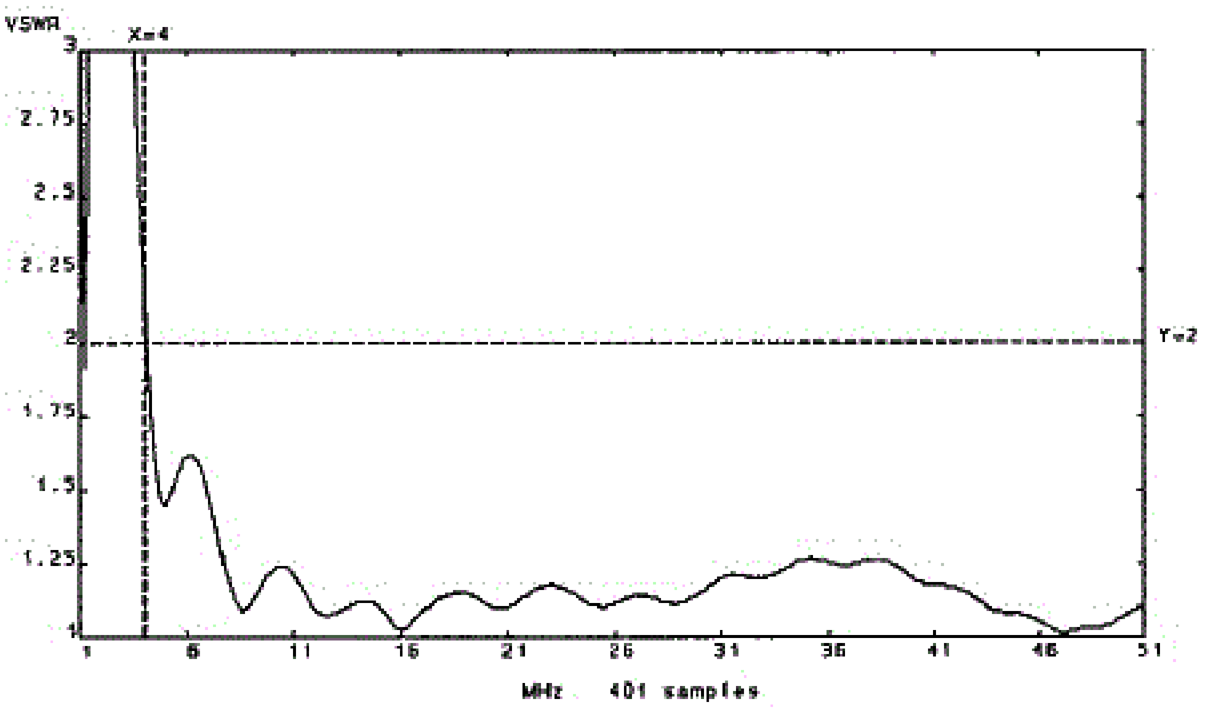


Figure E-2 VSWR plot of a center-tapped vee-wire 2-element 75/75 deployment.

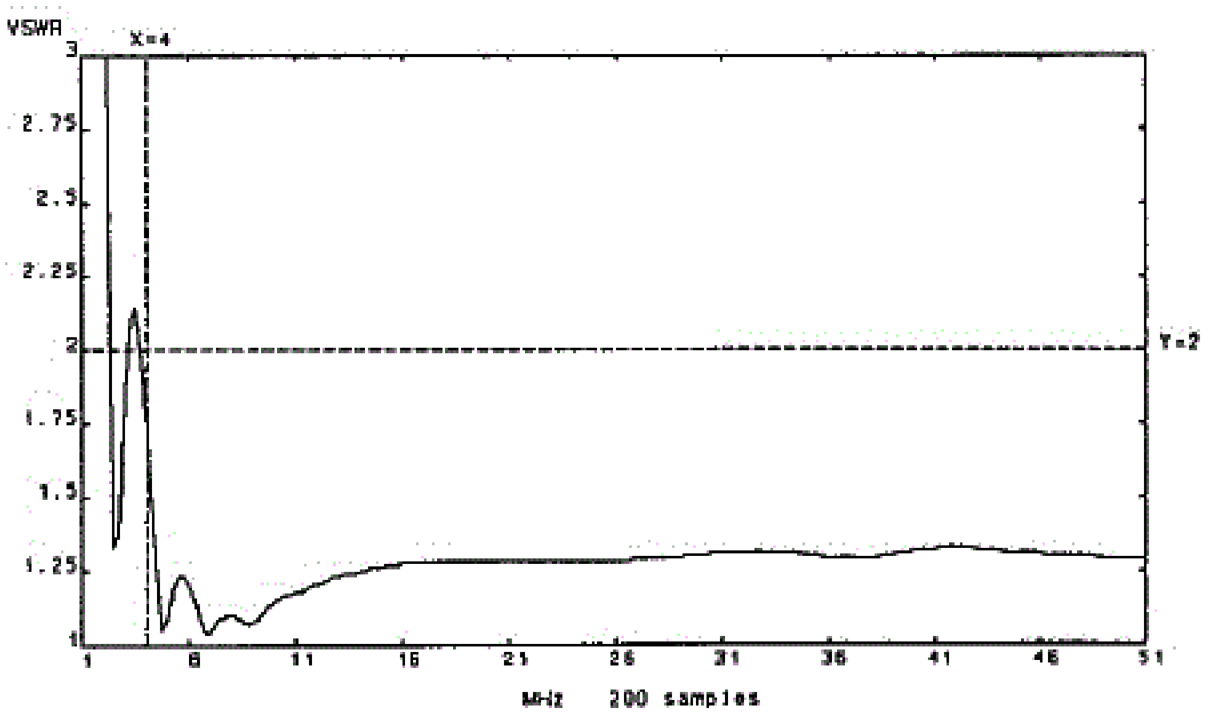


Figure E-3 1-Element 150/150 vee-wire antenna for optimum low frequency response.

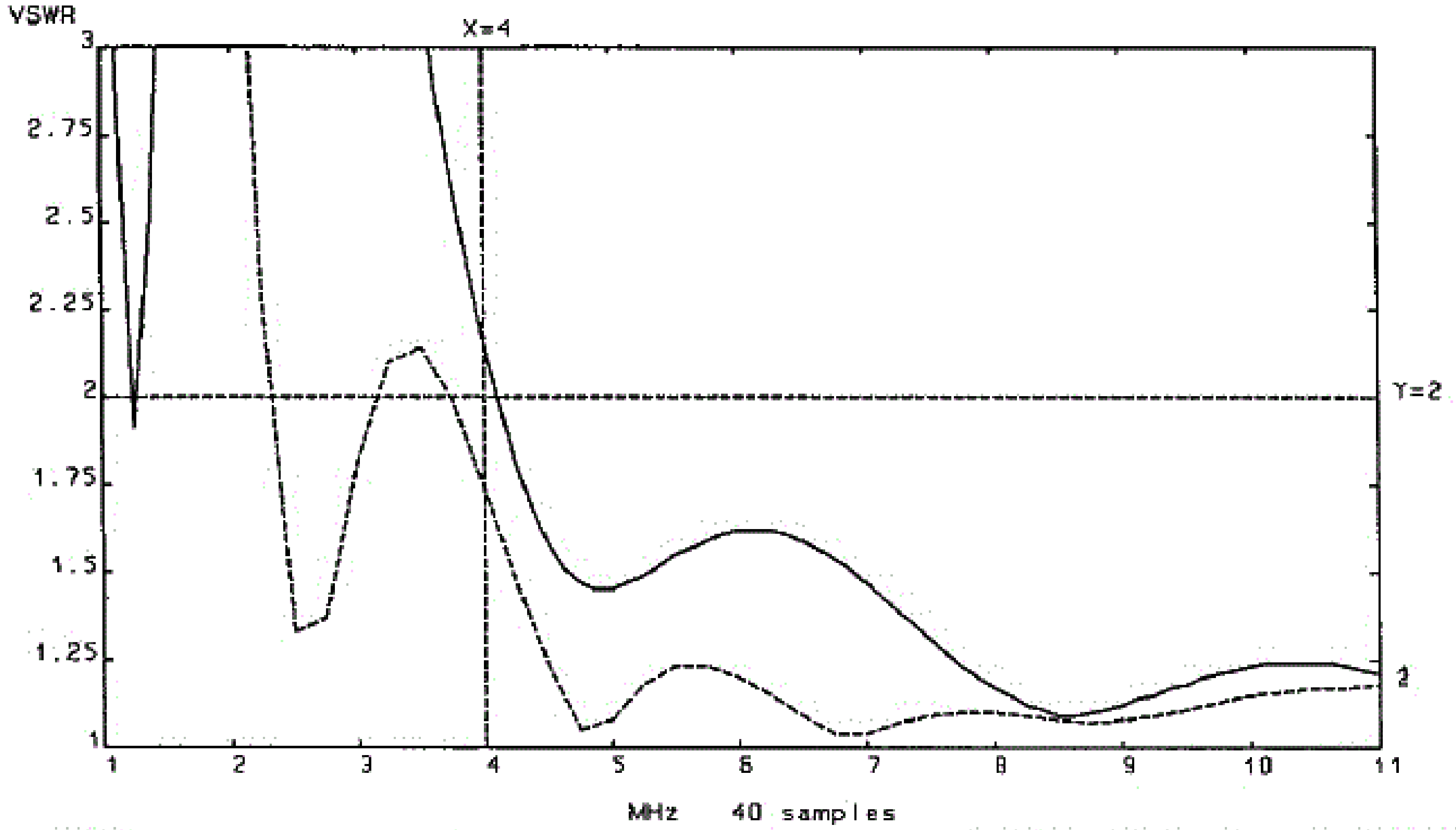


Figure E-4 Comparison of 2-element 75/75 center-tapped vee (solid) with 1-element 150/150 vee (dashed).

In Figure E-5 the VSWR of an elevated wire deployment of a 2-element 150/150 antenna is shown. This is the configuration described in Section 4.5.2, Figures 4-10. This plot can be compared to the ground contact deployment of Figure E-1.

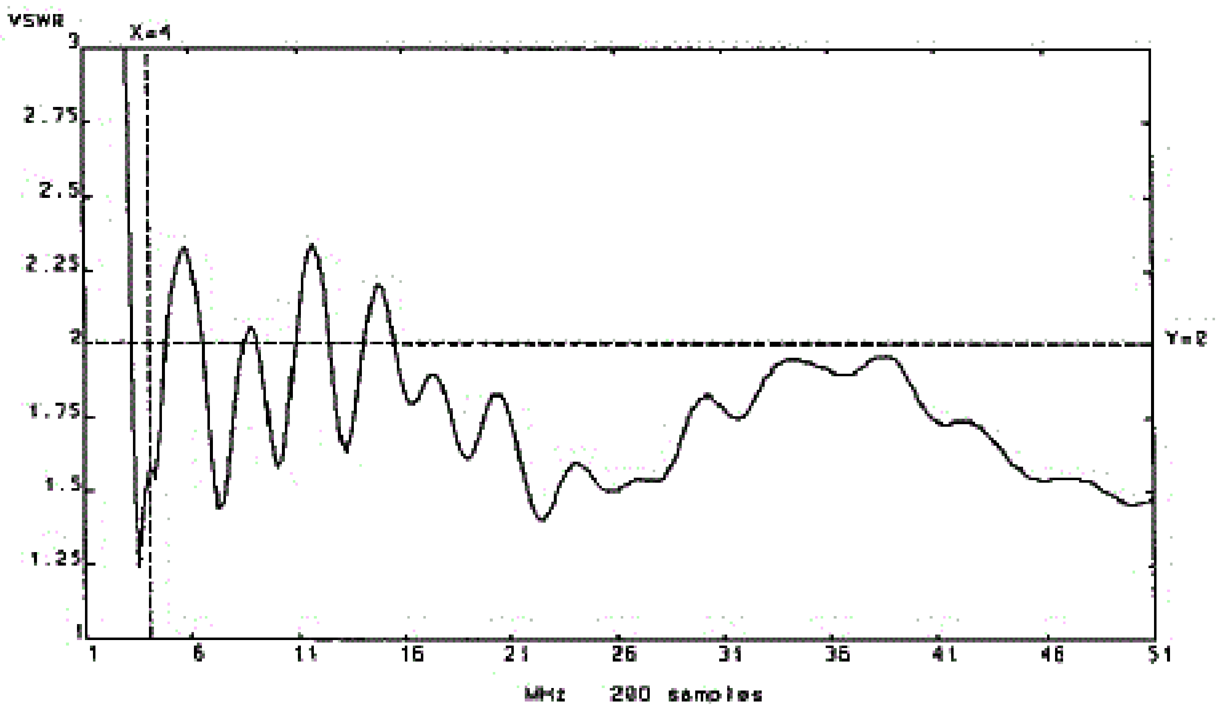


Figure E-5 2-element 150/150 single wire with elevated elements on one side (100 ft. elevated).

Figure E-6 displays the VSWR of a 2-element 50/50 single wire antenna. This antenna used the standard 20-ft. wide element-to-element spacing. The x-axis frequency marker is set at the 10 MHz frequency boundary suggested for this configuration. In Figure E-7 the VSWR of a 2-element 25/25 single wire antenna is provide for comparison. This antenna used a 10-ft. wide element-to-element spacing. The frequency marker is set at 15 MHz. In this example the soil conditions limit the low frequency range to 18 MHz for a VSWR of 2 and 16.5 MHz for a VSWR of 3.

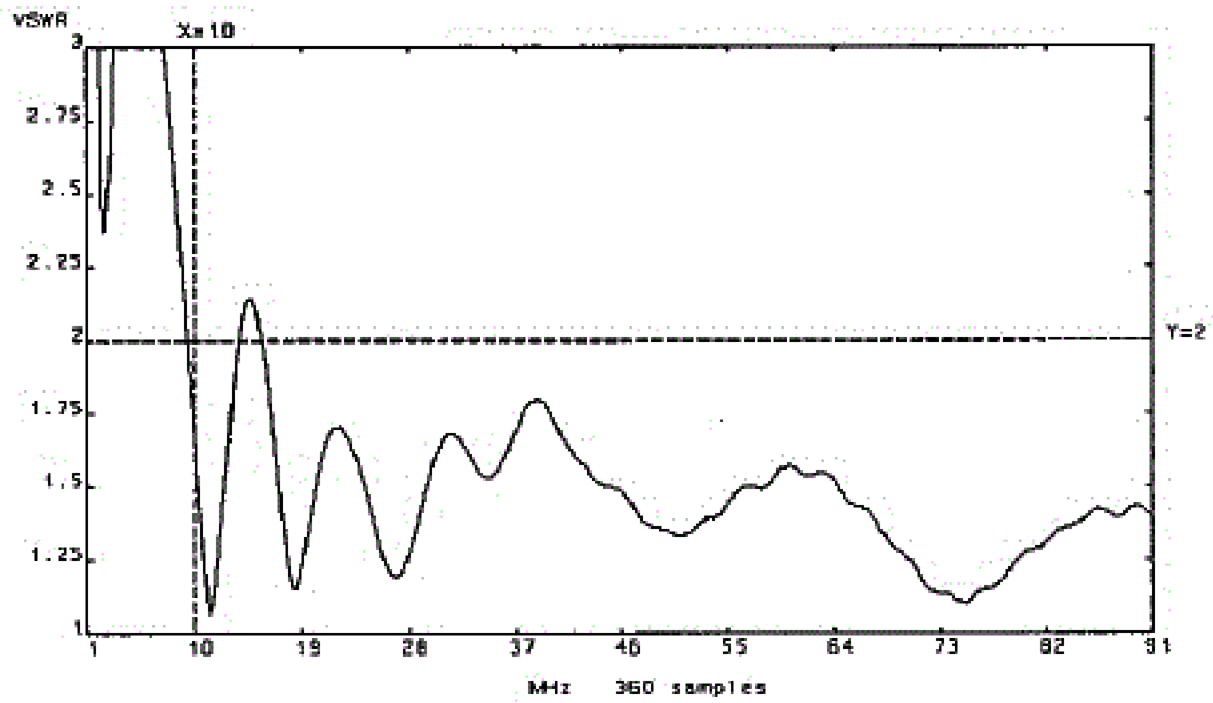


Figure E-6 Full range VSWR plot of a 2-element 50/50 single wire 20-ft wide.

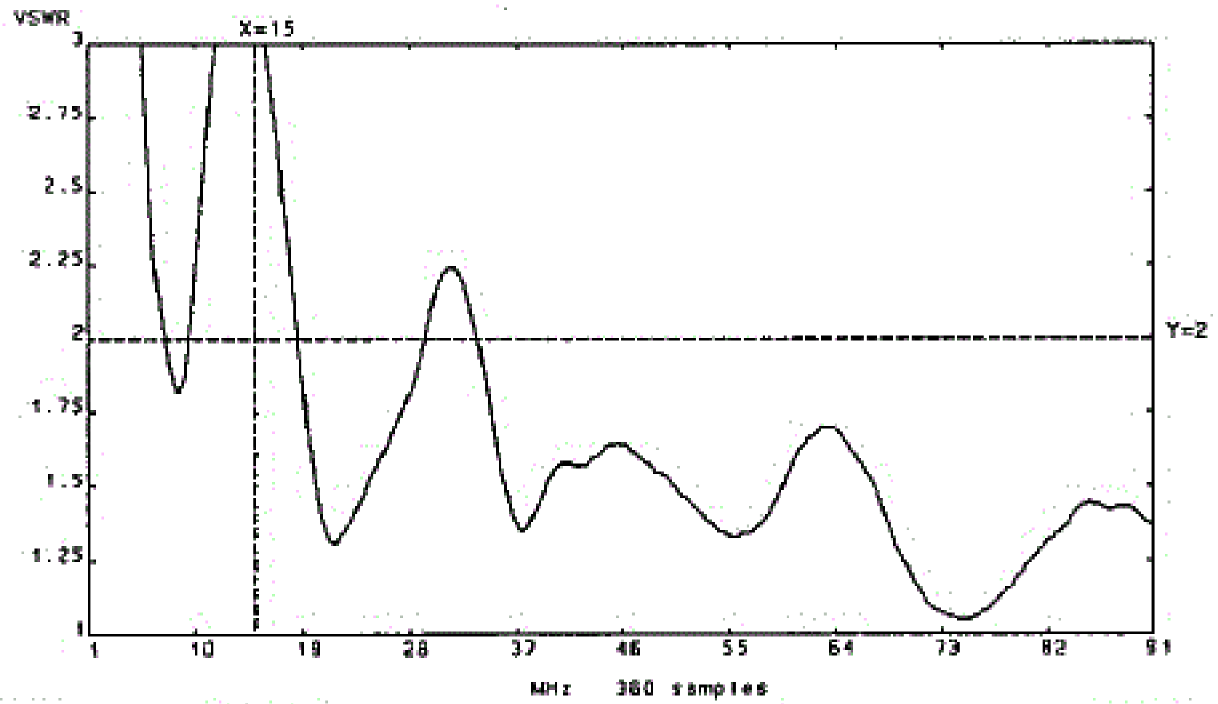


Figure E-7 Full range VSWR plot of a 2-element 25/25 single wire 10-ft wide deployment.

E 1.2 Alternate deployments of the ELPA 302A components

Figure E-8 is an inverted V formed from a 1-element 150/150 vee (Section 4.2.3) with the EFU suspended at a height of 10 ft and the elements stretched out with 20 to 30 ft. of ground contact. It can be seen that for the dry ground conditions of this test, the feedpoint VSWR is below 3 above 15 MHz and oscillates to lower values as the frequency varies. This broadband region of operation can be increases by increasing the percentage of element length in ground contact. Below 15 MHz and in regions with VSWRs above 2 the radio's tuner can be used for operation or the length of the antenna can be adjusted for a low VSWR.

Figure E-9 is a Feedpoint VSWR example of a Beverage configuration spanning 400 ft. with an average height of 6 ft. The usable frequency range cover 1.6 MHz to above 30 MHz. In Figure E-10 the center of the Beverage element wire is raised to create a 22 ft. high vertical half-rhombic again the frequency coverage starts at 1.6 MHz. The last Figure is E-11 and demonstrates a VSWR for the same configuration at a 30-ft. height.

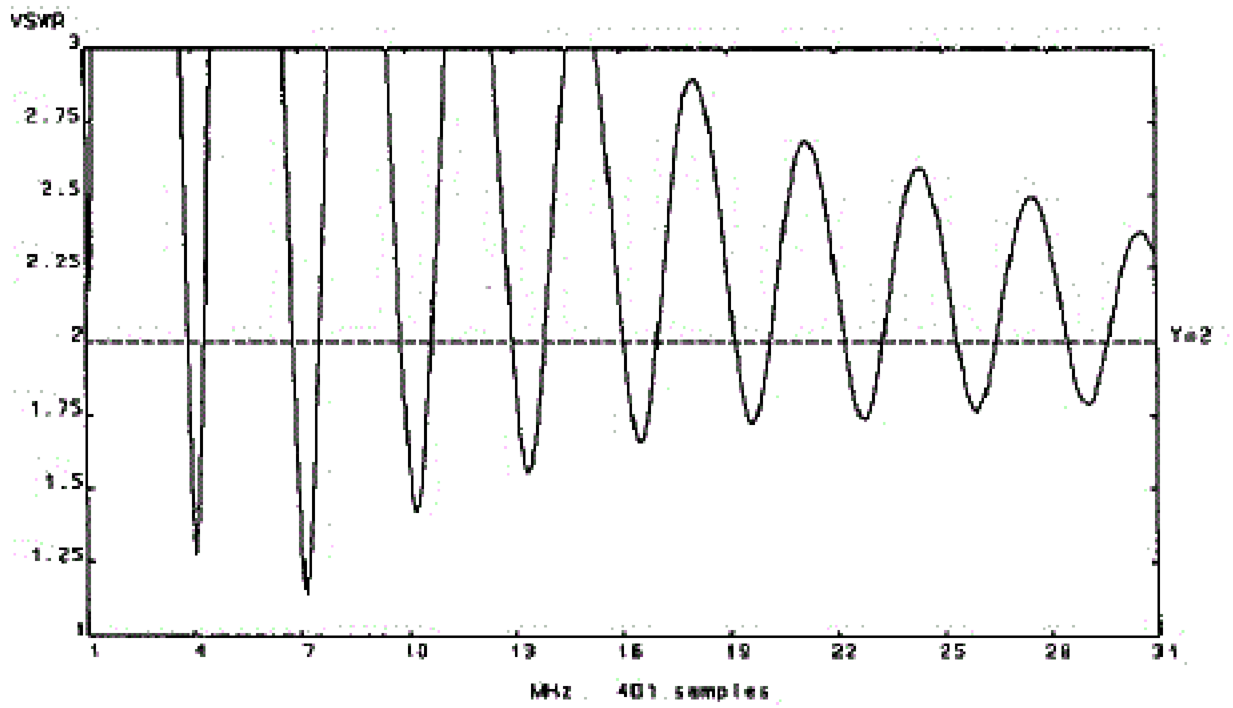


Figure E-8 Feedpoint VSWR for a 300-ft. span inverted vee using an EFU at a 10-ft height.

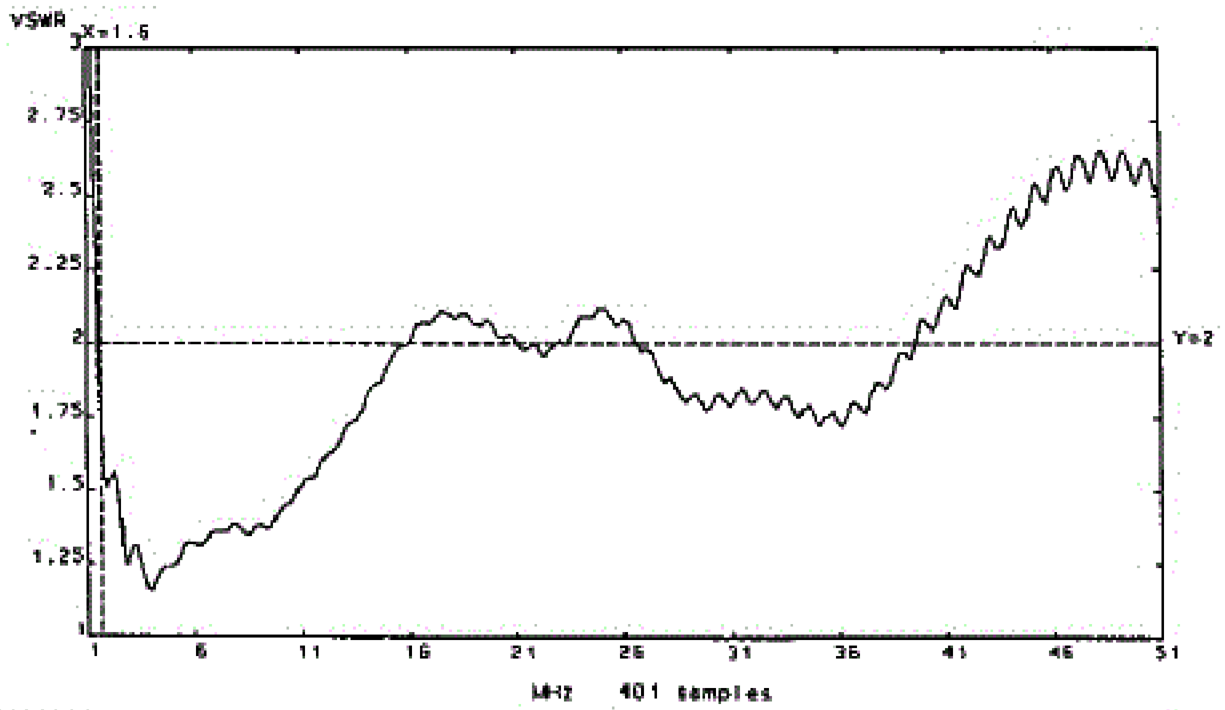


Figure E-9 Feedpoint VSWR of a 500 ft Beverage with a height of 6 ft.

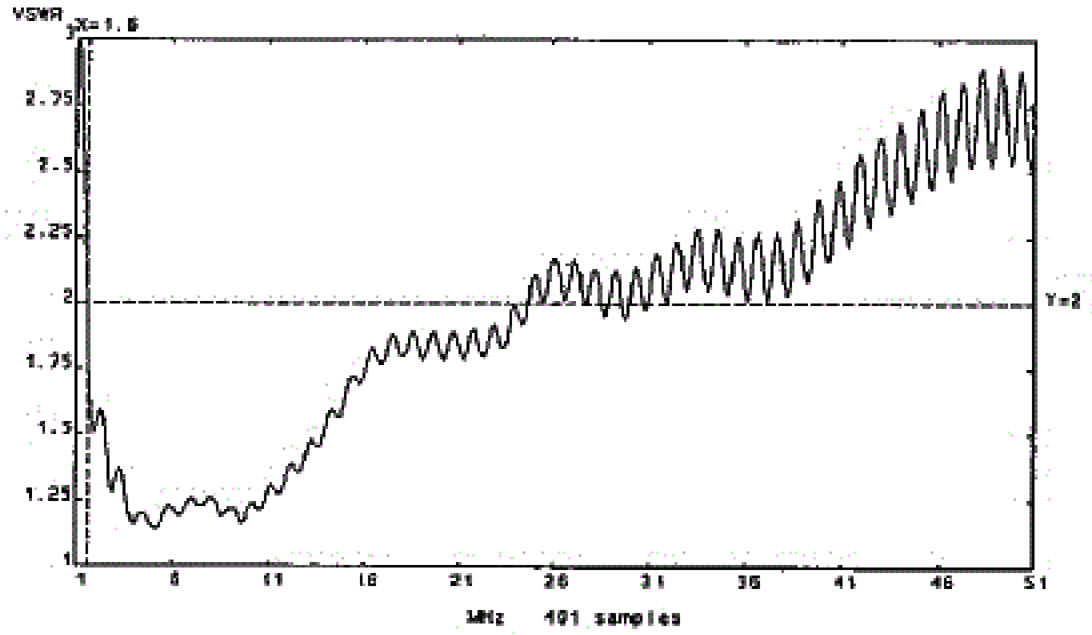


Figure E-10 Feedpoint VSWR of a vertical half rhombic with a span of 500 ft and a center height of 22 ft.

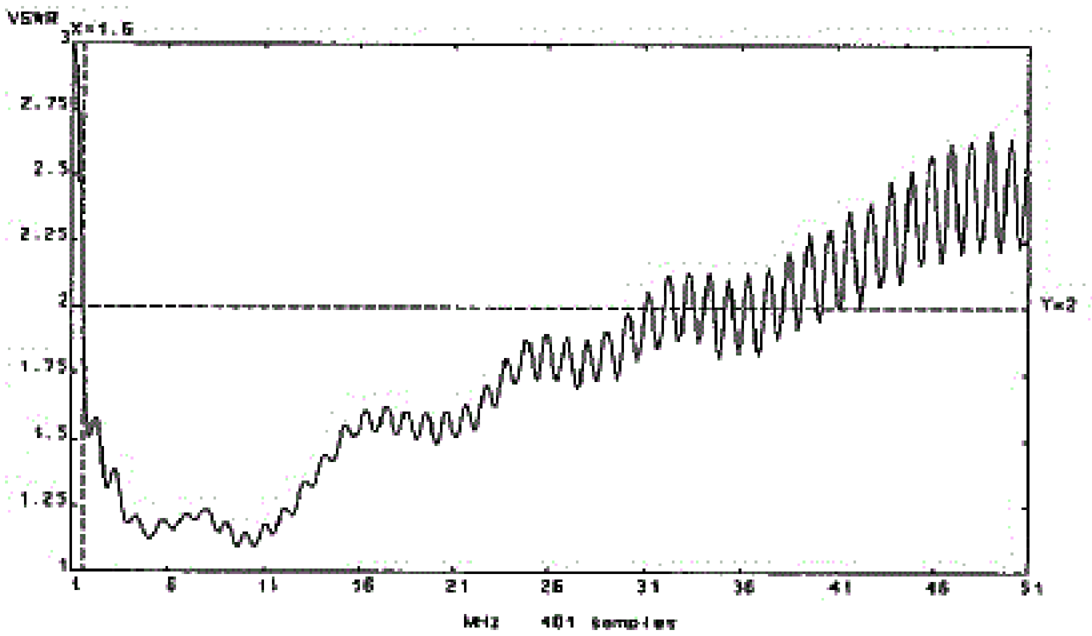


Figure E-11 Feedpoint VSWR of a vertical half rhombic with a span of 500 ft. and a center height of 33 ft.

E 2.0 Power gain pattern data examples for ELPA 302 antennas

The antenna pattern plots in this section are provided as a few samples of measured data taken on ELPA antennas and alternate configurations of ELPA antenna components (see Section 8.1 references and Appendices A and G for additional performance details). The power gain data accuracy presented here is on the order of +/- 2 dB or better. Comparisons between patterns of the same frequency and data set (e.g. the Figures provided for this appendix) are typically better than +/- 1 dB. The in-flight data repeatability* is better than +/-0.25 dB. The data was acquired with Eyring's multi-channel Broadband Antenna Test System (BATS) at the Cedar Valley Utah antenna test range. The pattern measurements are scaled to power gain (dBi) by a comparison measurement with a half-wave reference dipole positioned 0.2 wavelengths above native soil with measured ground characteristics**. The patterns were reduced from received signal strength records for each antenna under test that was illuminated by the test beacon. The elementary dipole test beacon was towed 200 ft. below a helicopter that was tracked from the ground. Up to 20 antennas were measured on each flight. Each pattern is corrected for flight geometry relative to its location. Details of the pattern tests are contained in items 1, 2, 3, 4, 6, 7 and 17 listed in Reference Section 8.1.

Antenna orientation symbols are presented to the side of each pattern to assist in visualizing the measured patterns with respect to antenna geometry. The symbols are based on the pictorial summaries of Figures 4-13 and 4-14. Superimposed patterns are geometrically corrected to allow accurate comparisons between antenna types.

> **NOTE:** When comparing this pattern data to text books, published papers and antenna specification sheets it is important to make comparisons of data under identical reference conditions.

Figure E-12 is an elevation plot of a 75/75 vee element ELPA 302 antenna at 3.1925 MHz. The deployment is an elevated configuration on stakes. This is an "end on view" of the ELPA pattern. The high-angle coverage of this pattern demonstrates ionospheric illumination suitable for NVIS communication paths. The measurement was made by illuminating the antenna with a horizontally polarized beacon towed above it by a helicopter. The pattern is valid from a 30 degree to a 150 degree elevation angle. The peak overhead power gain for this pattern is -10.5 dBi at 90 degrees (the specification for the ELPA is -12 dBi). Figure E-13 is for a similar ELPA 302 antenna deployed in ground contact. In this case the pattern power gain matches that of the ELPA on stakes within about 0.5 dB which is within the test error band.

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* This can be seen on azimuth patterns which have segments that were repeated by the continued flight of the helicopter along a circular flight path.

** See test documents listed in Section 8.1 and Eyring Communications Systems Division Document No. 900-0022B (Custom Services...) for testing information and test site summary information. Details on the antenna measurement beacon are contained in Eyring Document No. 900-0034B. Details on the ground measurement probe/network analyzer software are contained in Eyring Document No. 900-0036B.

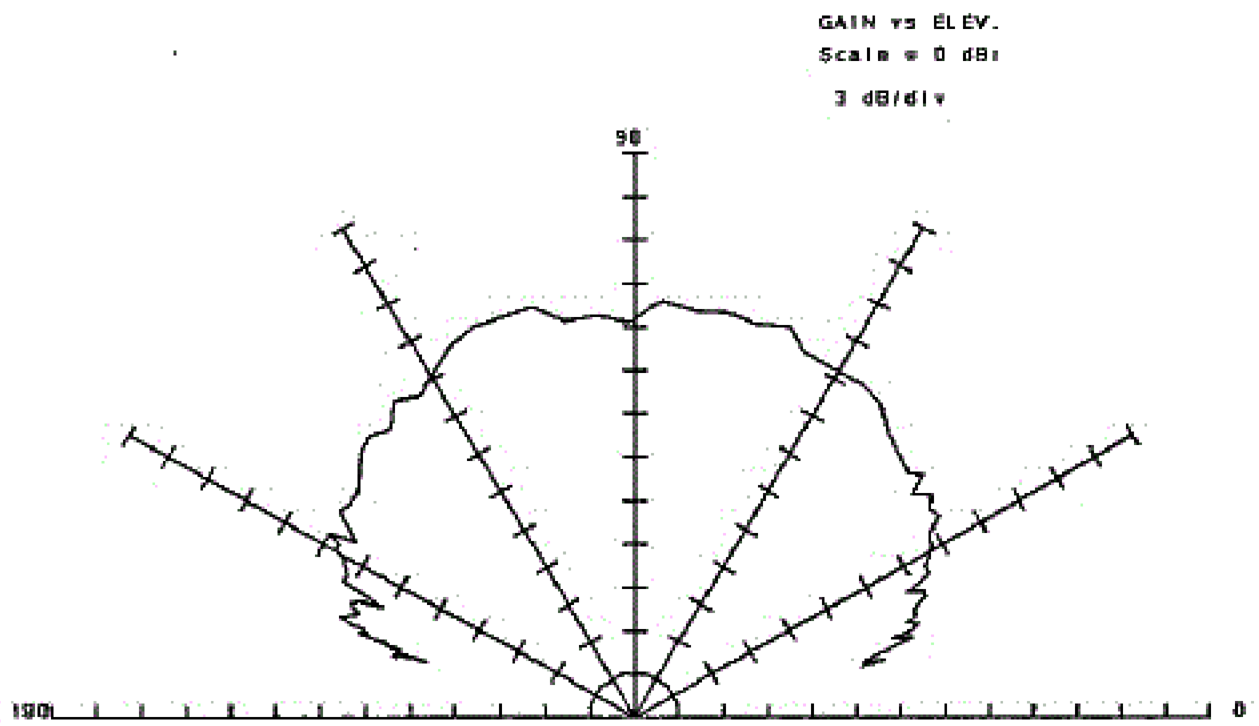
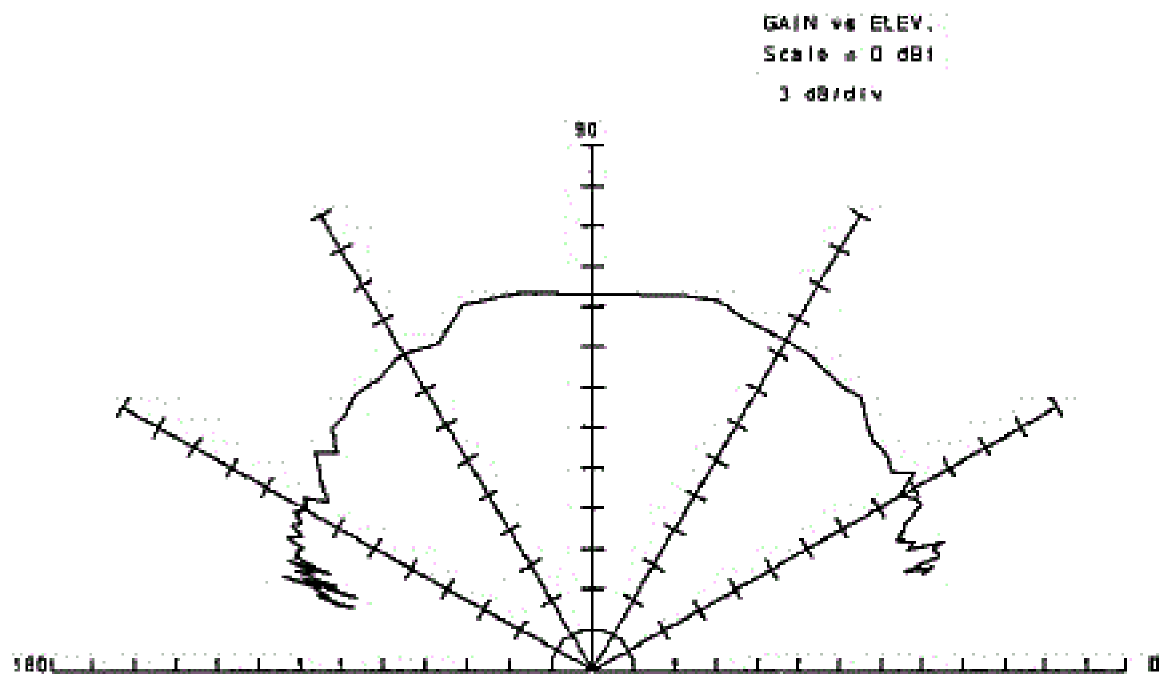


Figure E-12 On-axis elevation pattern of an ELPA 302 75/75 V S elevated on stakes for 3.1925 MHz.

ELPA on stakes
end view



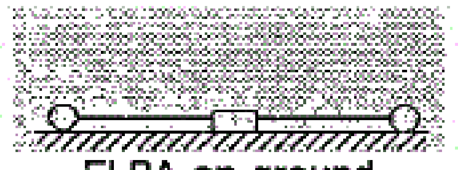


Figure E-13 On-axis elevation pattern of an ELPA 302 75/75 V G in ground contact for 3.1925 MHz.

ELPA on ground
end view

Figure E-14 is the vertically polarized azimuth pattern of an ELPA 302 for a 75/75 vee deployment in ground contact. The peak power gain of the pattern is -11 dBi at a 20 degree elevation angle for 15.3415 MHz. This exceeds the specification sheet value by 2 dB. Figure E-15 presents an elevated (staked) deployment of an ELPA 502 (functionally similar to the 302). Here the peak pattern gain is -4.3 dBi which is again above the specification of -6 dBi for this configuration. The elevated deployment has an average azimuth beamwidth of 52 degrees. The ground contact deployment has an average beamwidth of 50 degrees. Both patterns have null depths in excess of 18 dB for vertically polarized signals.

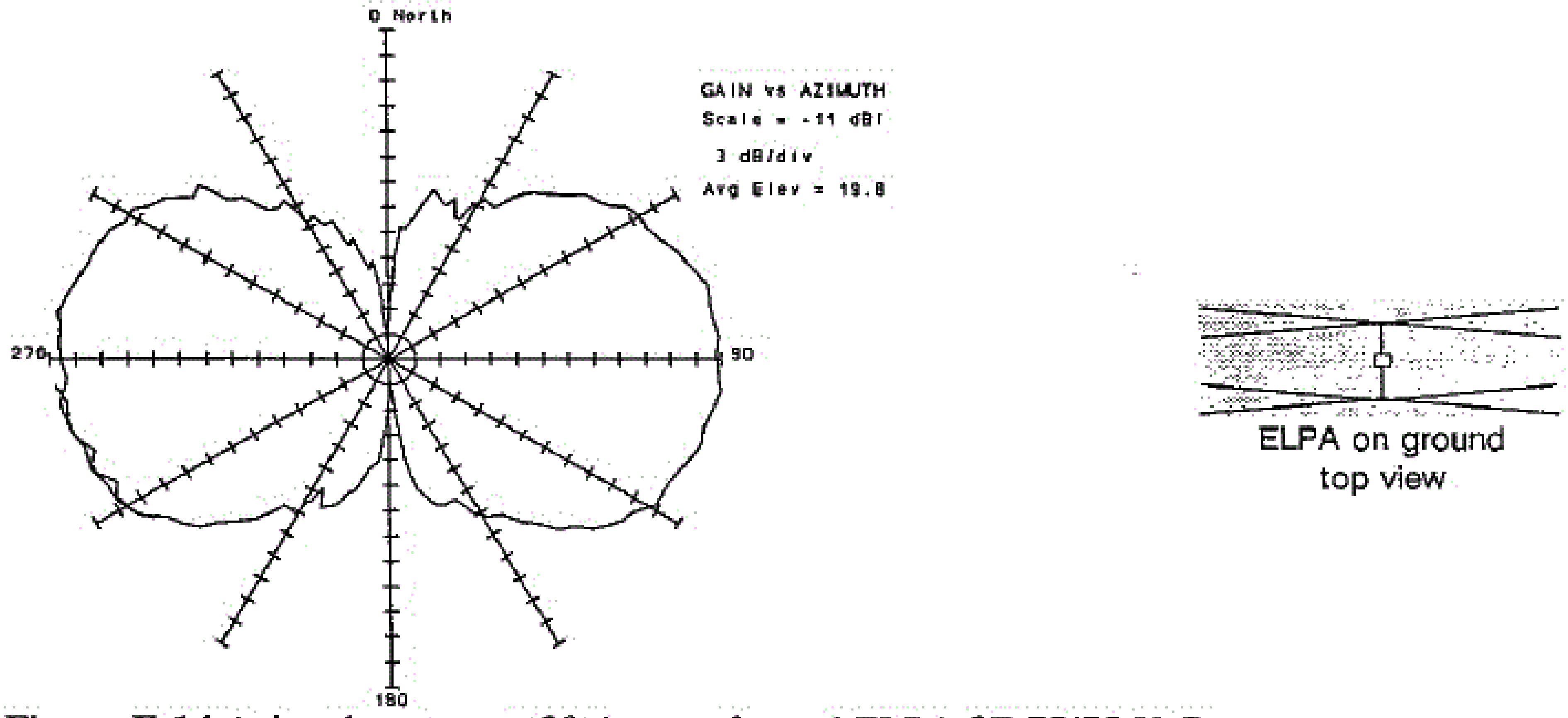


Figure E-14 Azimuth pattern at 20 degrees for and ELPA 2E 75/75 V G on ground for 15.3415 MHz.

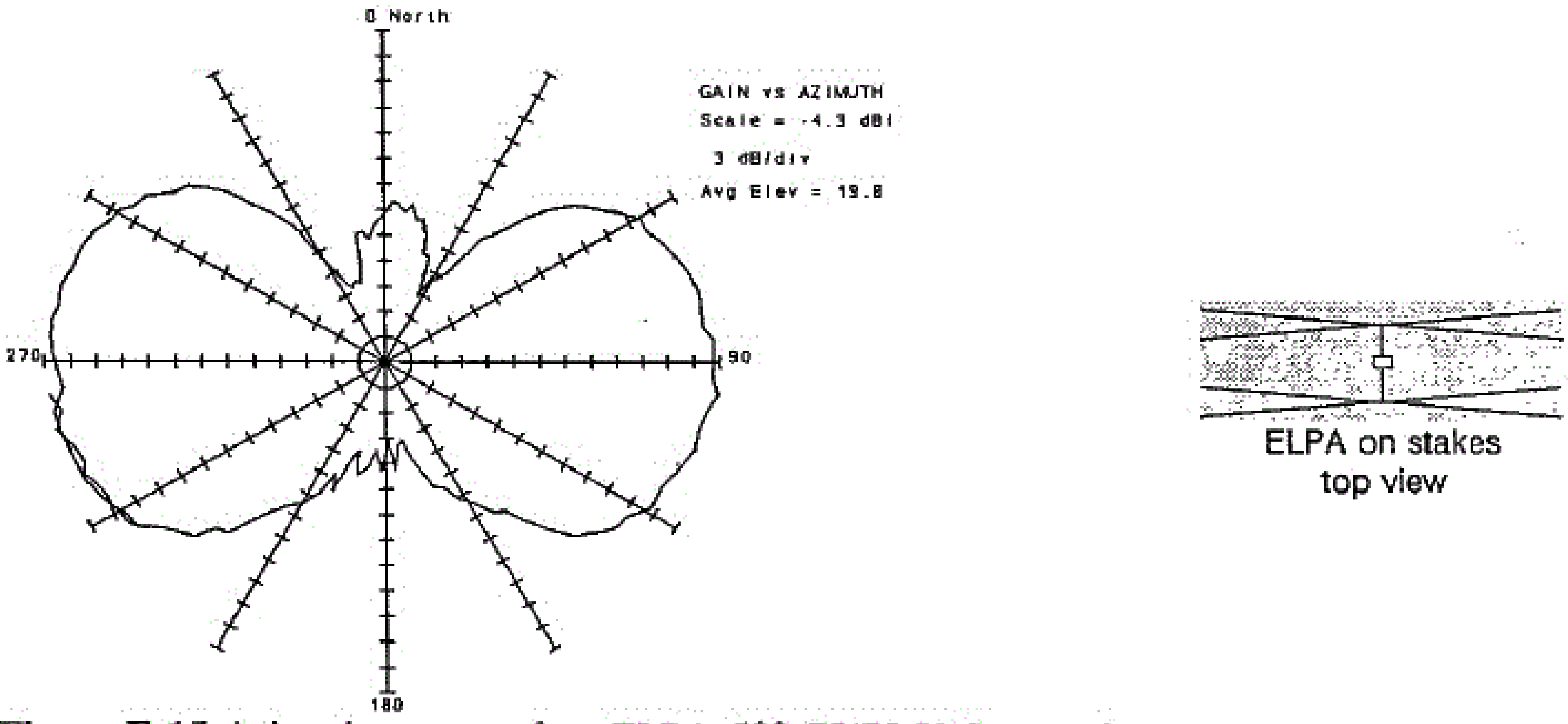
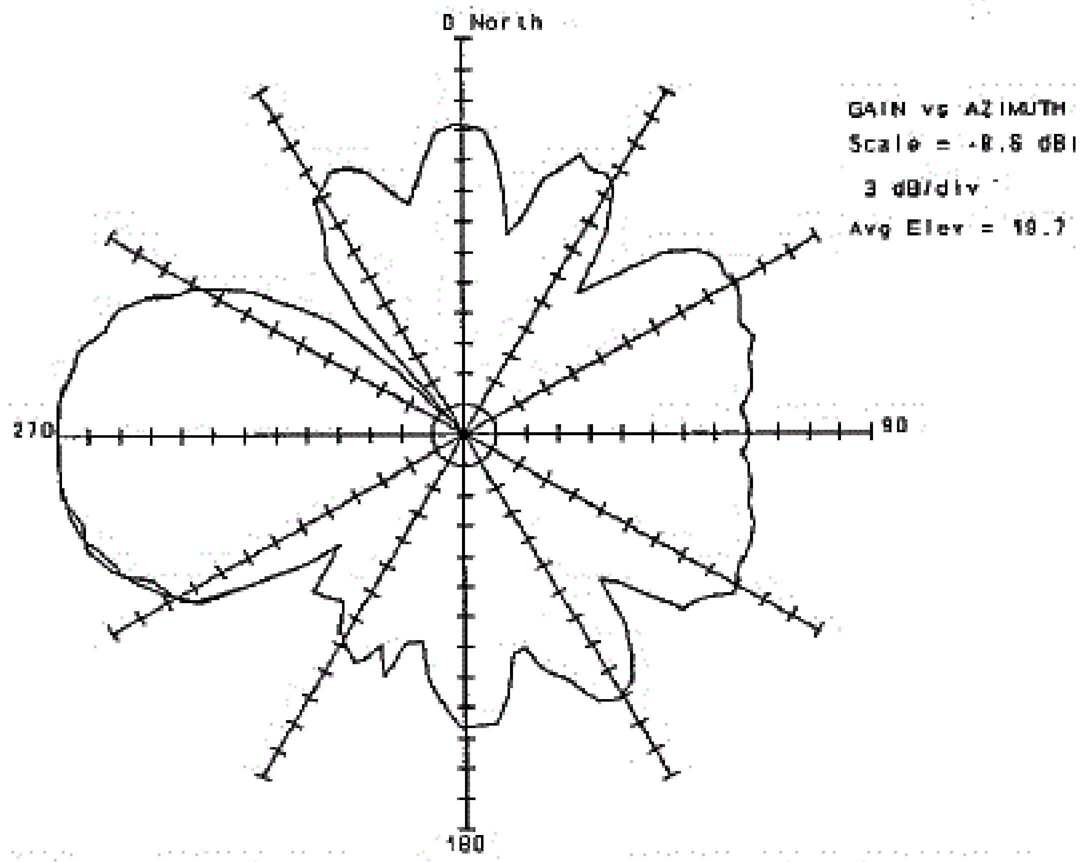
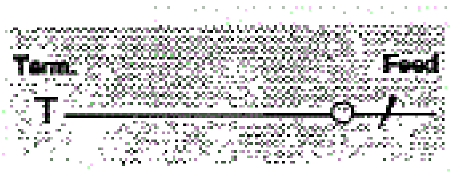


Figure E-15 Azimuth pattern of an ELPA 502 75/75 V S on stakes at 15.3415 MHz.

Figure E-16 is the vertically polarized azimuth pattern of a 1-element Beverage antenna constructed from a 2-ft. high, single 150-ft. element wire of an ELPA 301 with a resistive termination* . The power gain of -8.6 dBi at a 20 degree elevation compares favorably with the 2-element ELPA gain of Figure E-15 which is 4.3 dB higher. The gain of a 2-element beverage would be about -5 dBi. The 41 degree beamwidth for this uni-directional pattern provides a directive gain of about 12 dB. The front-to-back ratio at this pattern's elevation angle is 12 dB.





Beverage on stakes
top view

Figure E-16 Azimuth pattern of 3-ft. high, 150-ft. long Beverage antenna at 15.3415 MHz.

Figure E-17 demonstrates the vertically polarized VHF performance of an ELPA 302 75/75 V S at 49.65 MHz. In this case the ELPA pattern (dashed) is directly compared to the pattern of a 0.25 wave reference monopole (solid line) with a large ground plane. The monopole has an average power gain of +0.3 dBi. Relative to the monopole, the ELPA has a +0.3 dBi peak power gain with an average beamwidth of 25 degrees at an elevation angle of 20 degrees (12 dB estimated directive gain). The ELPA has both sides (37/37) of its elements elevated on 2-ft. high stakes for this test and presents a bi-directional "figure-8 pattern". The off-axis response in its null regions is 13 to 15 dB below the main beam peaks. Figure E-18 compares the gain of the 302 on stakes (dashed) to ground contact (solid). The ground contact power gain is 8 dB lower than that of the elevated elements . Note that the ground contact pattern retains its shape and features. It displays deeper side nulls (>18 dB) than the elevated wire example.

The absolute power gain scaling for these examples has been set to the reference monopole for both frequencies to allow comparisons between the 49.65 MHz and the 65.95 MHz test frequencies. The monopole to ELPA gain comparisons for each frequency are accurate to within +/- 0.5 dB for this data set.

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* An EFU terminated by a 50 ohm load could have been used in place of the resistive termination.

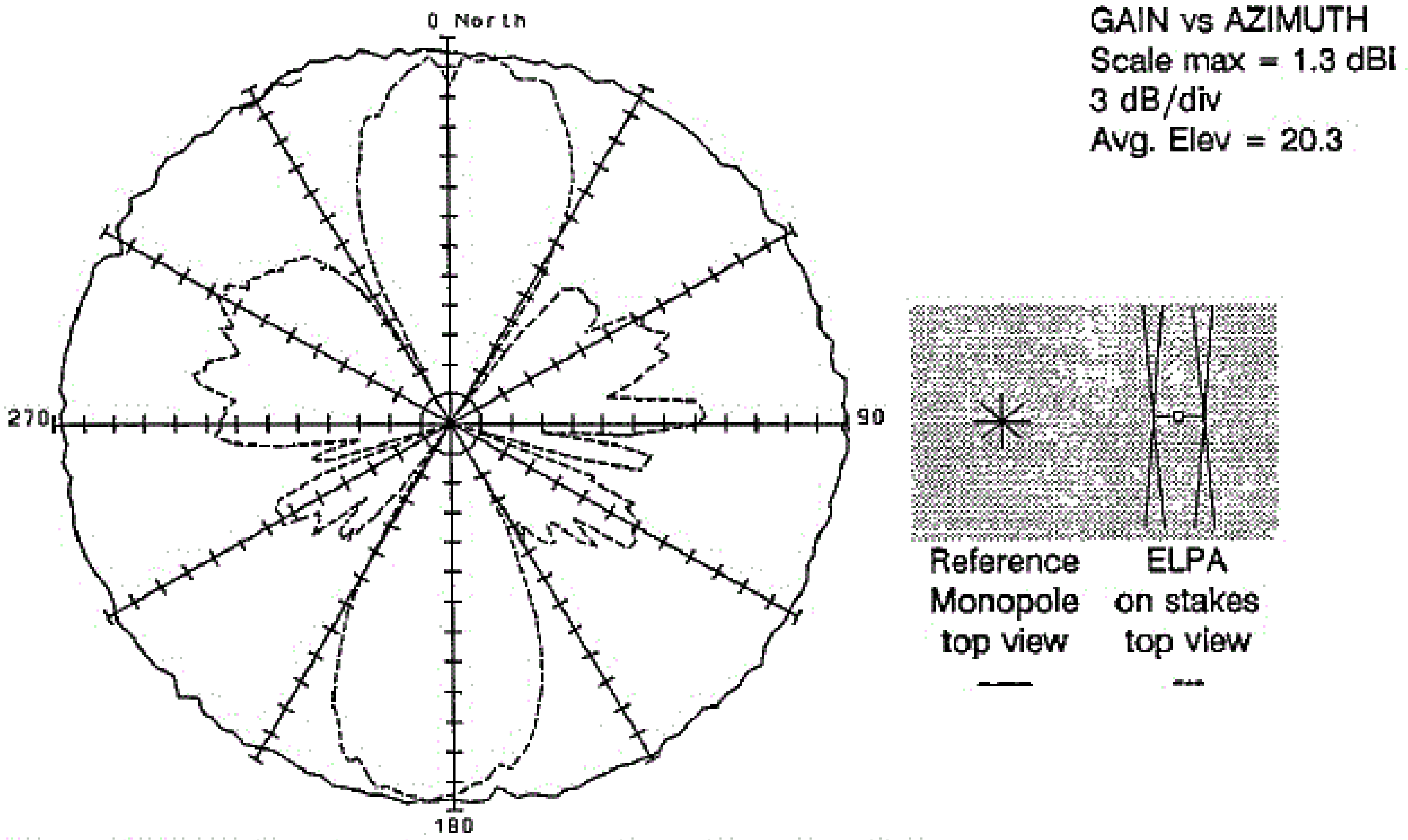

Figure E-17 Azimuth pattern comparison of an elevated ELPA 302 vs a monopole at 49.65 MHz.

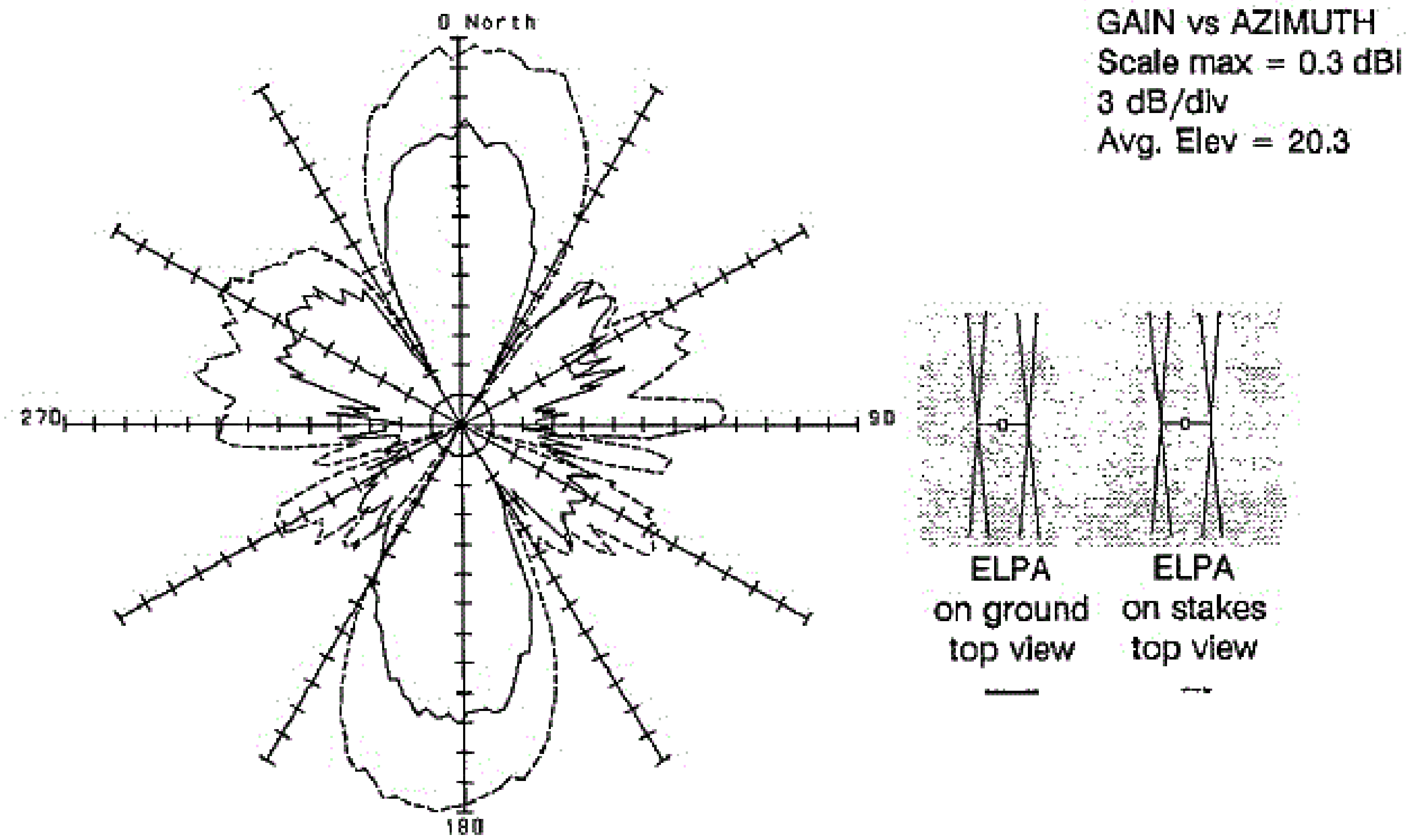

Figure E-18 Comparison of ELPA 302 elevated vs ground contact deployment at 49.65 MHz.

Figures E-19 and E-20 make the same comparisons at 65.95 MHz as E-17 and E-18 do at 49.65 MHz. Here the maximum gain of the monopole is scaled to +2.3 dBi with an average gain of +0.2 dBi. The elevated ELPA (dashed) has a +1.8 dBi peak gain with a beamwidth of 20 degrees at an elevation angle of 20 degrees (13 dB estimated directive gain). This beamwidth can be widened to about 30 degrees by decreasing the element-to-element spacing to 10 ft. In

Figure E-20 the elevated wire example has an 11 dB advantage over the ground contact antenna. The side nulls of the ground contact ELPA are 20 dB below the beam's peak directive gain.

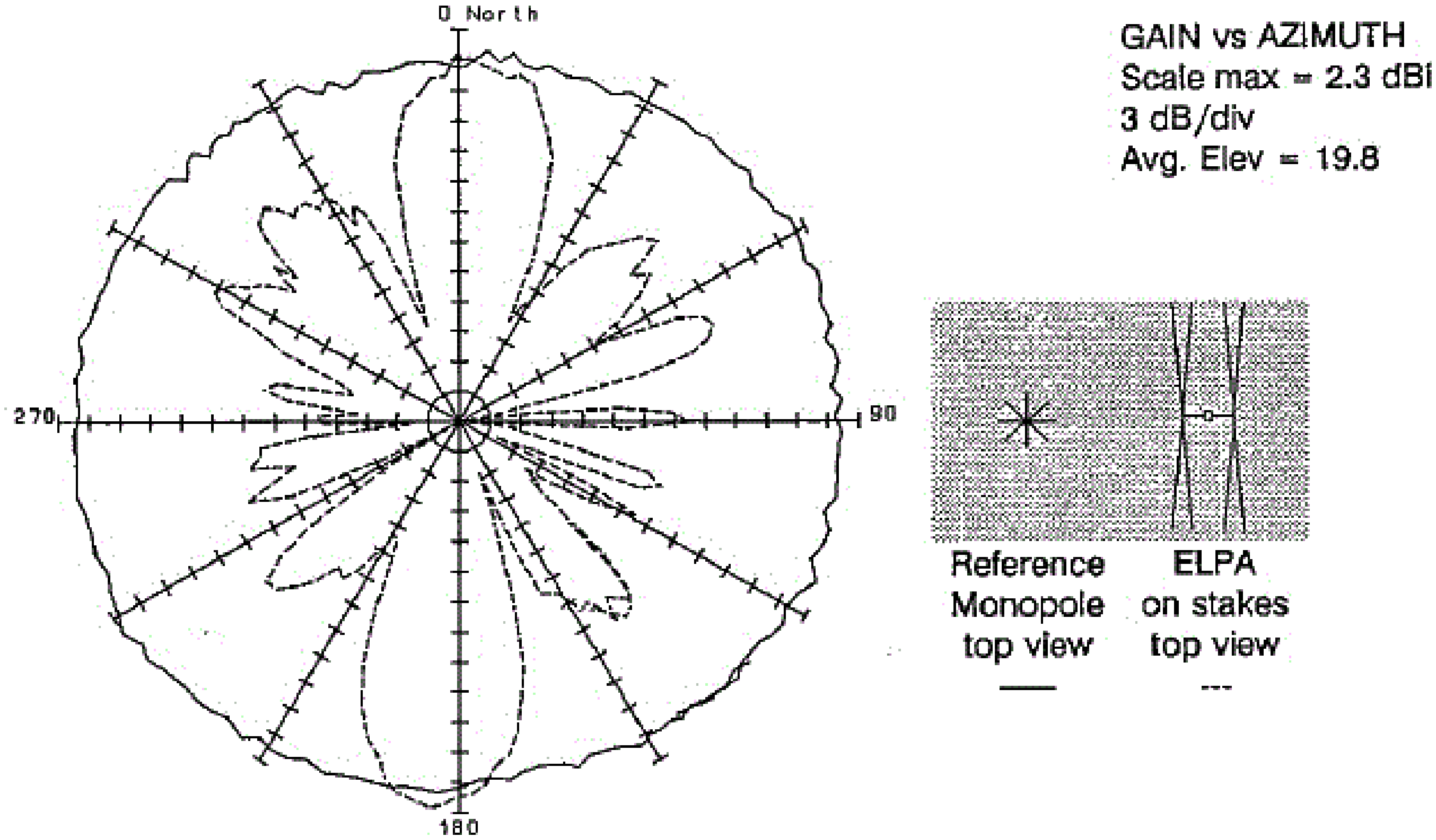

Figure E-19 Azimuth pattern comparison of an elevated ELPA 302 vs a monopole at 65.95 MHz.

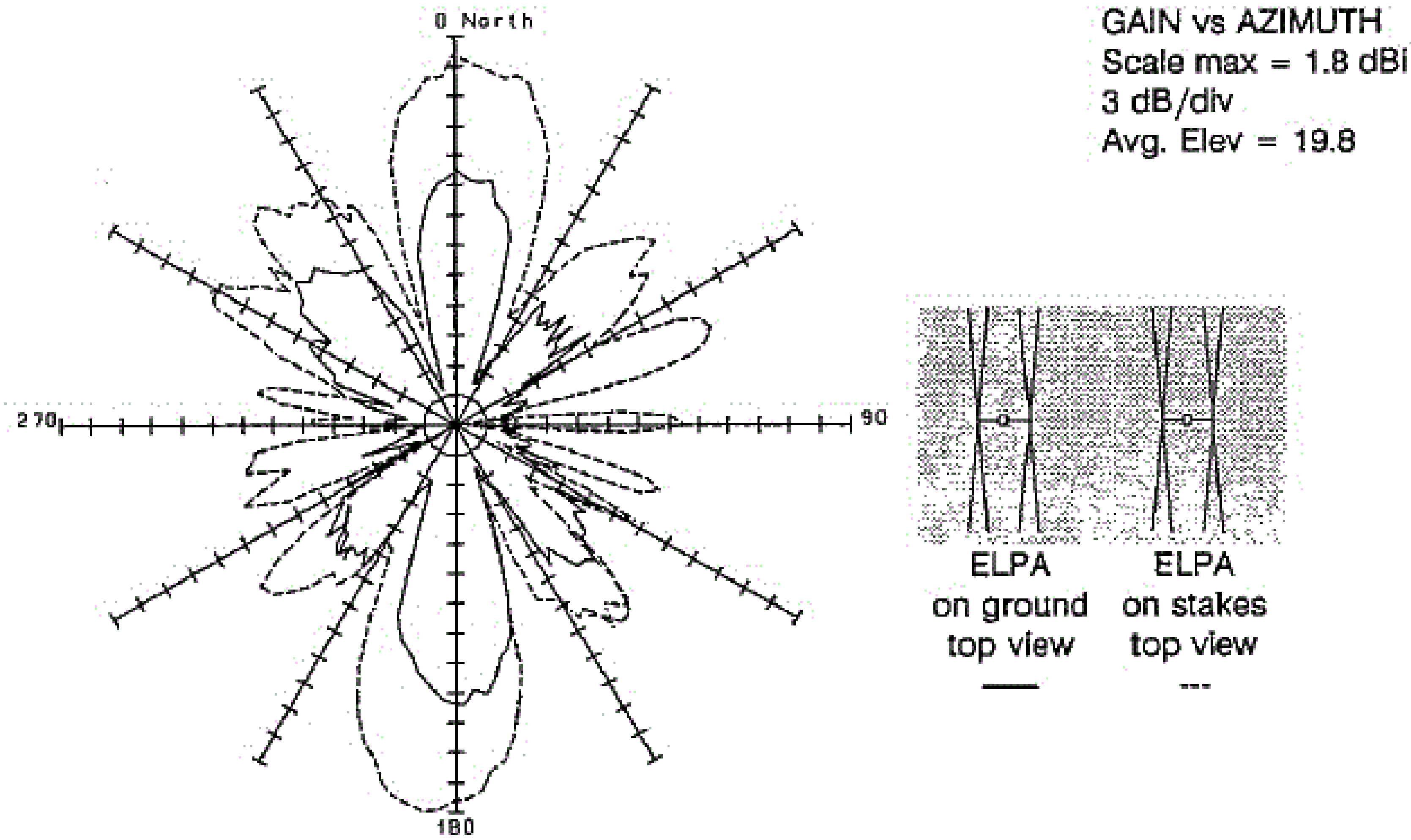

Figure E-20 Comparison of an ELPA 302 elevated vs ground contact deployment at 65.95 MHz.

It can be seen from the E-17 through E-20 pattern examples that the ELPA's directive patterns can have application for low probability of intercept LOS communication and electronic warfare jamming resistance. See manual Figures 3-1 and 4-12.

Appendix F - Alternate ELPA 302A deployments (9/90)

This appendix will be updated as alternate deployments are more fully documented for the ELPA model 302A. In the interim the reader is referred to the reference documents listed in Section 8.1 (items 12,13,14) and Section 8.3 (items 2 and 3). These references will provide details of the operational characteristics of the alternate antenna types listed. Contact Eyring for details on the performance and configurations of the 4-element and 8-element ELPAs as well as the update status of this Appendix.

F 1.0 Broadband inverted-vee field expedient antenna.

The inverted-vee configuration is a familiar field expedient antenna. In this adaptation an ELPA 302A EFU is substituted for the customary length of 300 to 450 ohm twin-lead feedline that is run to the center of the inverted-vee antenna. Figure F-1 demonstrates a simple suspension technique for the EFU. The EFU is connected to the radio through one or two 10-ft. lengths of coaxial transmission line that extend below the EFU.

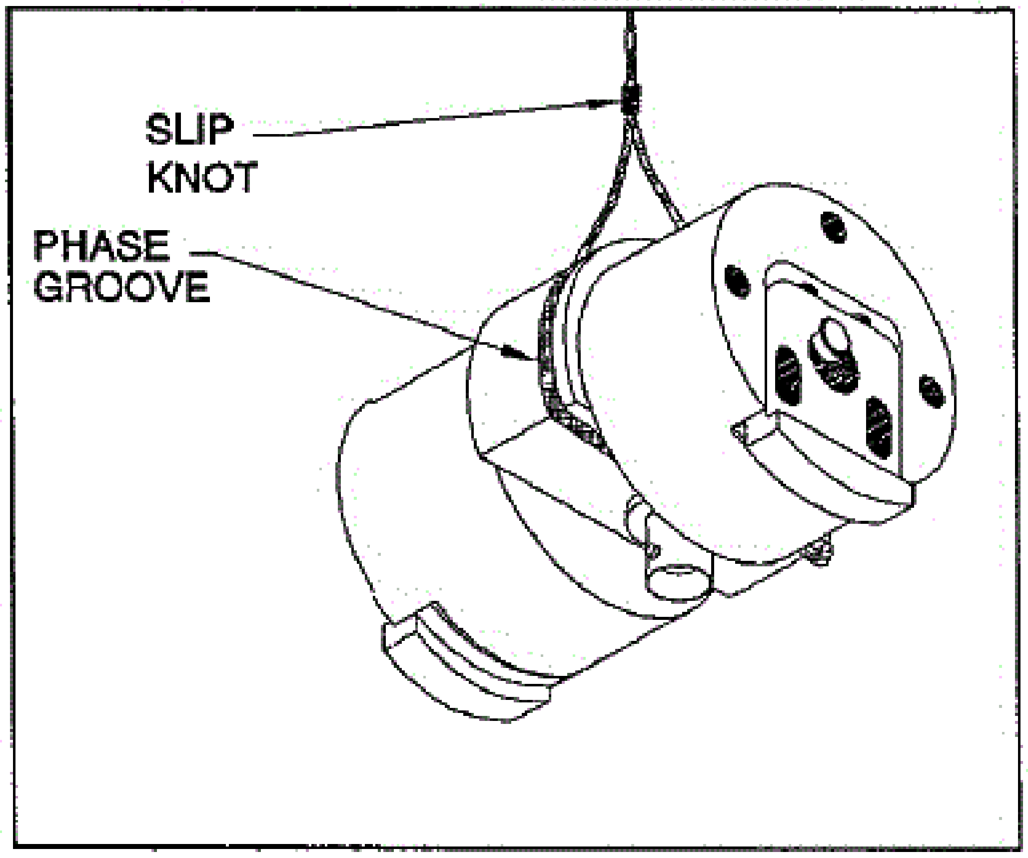

Figure F-1 EFU suspension using the phase groove.

Figure F-2 demonstrates the suspension of an EFU from a field expedient support such as a tree. The wire configuration for the inverted vee is identical to either the 1-element 150/150 standard deployment (Manual Section 4.2.1) or the 1-element 150/150 vee (Manual Section 4.2.3) which is the preferred wire deployment.

Unlike the ELPA mode, this elevated deployment will have only a limited broadband range starting between 8 and 18 MHz and then continuing to beyond 65 MHz. Below or near 8 MHz (depending on what percentage of the element lengths are in ground contact) the antenna will need length adjustments to provide a low VSWR to the radio or the radio's tuner will have to be used. If an automatic tuner does not find a match with the first element length and ground contact configuration, try it again with a 10 to 20 ft. change in length. At some point the tuner should find an antenna impedance within its matching range.

For an inverted vee configuration the following items are required (* items are user supplied):

1	Element feed unit, 1/2 of ELPA 302A kit
10 to 30 ft.*	0.125 inch cord, EFU suspension cord
2 to 4	Element wire reels w/150-ft. wire
2	10-ft. coaxial cables
1*	BNC (female-female) splice adapter to join coax cables

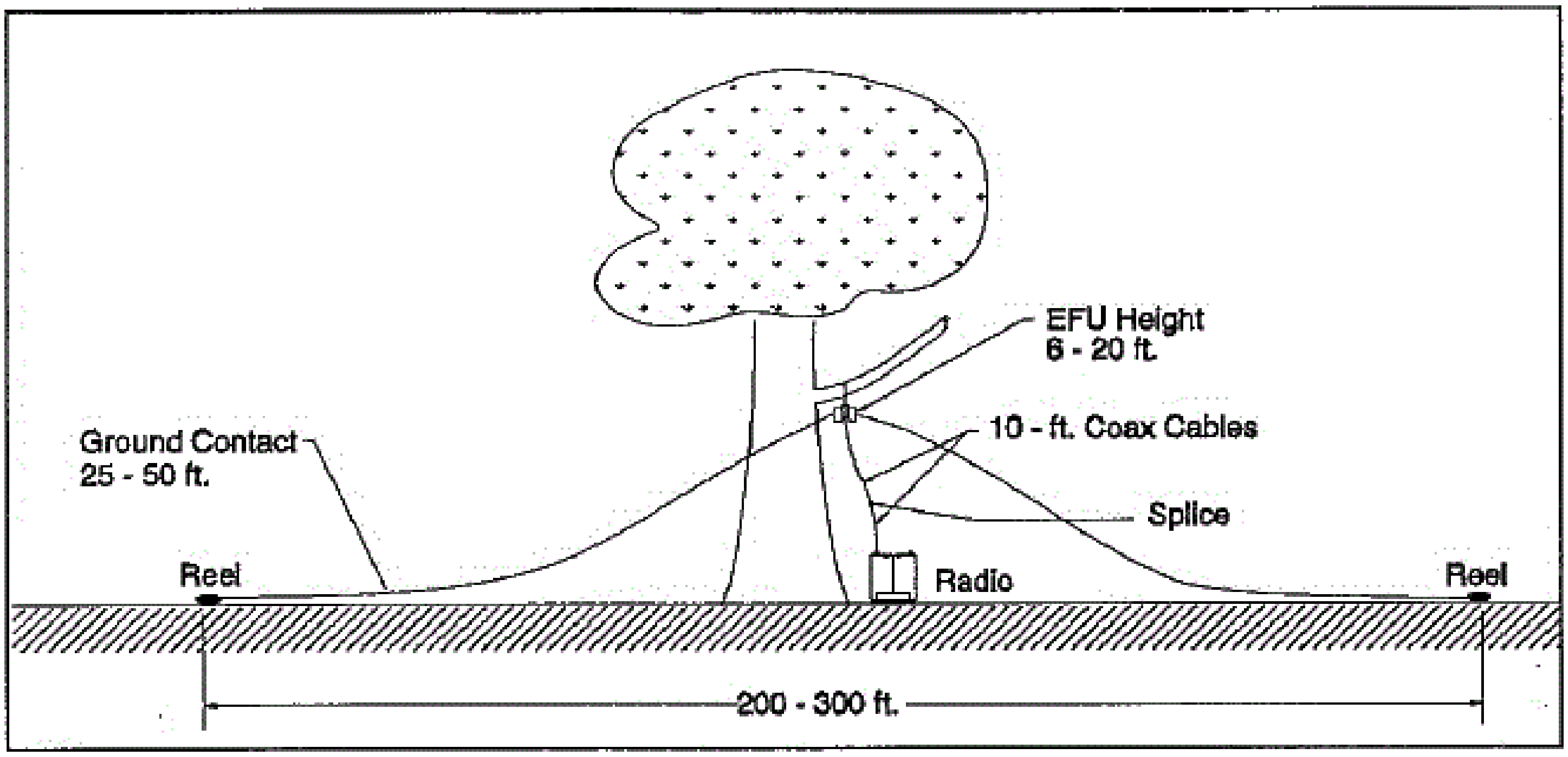

Figure F-2 ELPA as an inverted vee antenna.

F 2.0 Beverage and vertical half-rhombic deployments

The Beverage and vertical half-rhombic (VHR) deployments are identical in their feed and termination techniques. They differ only in terms of their wire support technique and height. Therefore the Beverage is a standard starting point for a VHR configuration. Figure F-3 details the use of an EFU as a feedpoint for either height of antenna. The EFU is optionally suspended by its groove on a cord tied to the insulator. In Figure F-4 the EFU is used as a terminator by connecting its coaxial BNC port to a 50 Ohm load rated at 1/2 the average output of the radio's transmitter to a maximum of 50 Watts (Radios up to 100 Watts average, 200 Watts peak).

Simple Beverage configuration - the following items are required (* items are user supplied or part of the Beverage kit):

1	Element feed unit (from ELPA 302A kit)
1*	50 Ohm, 50 Watt coaxial load, BNC (female)
2*	2 ft., 0.125 inch cords, EFU suspension cord
2*	wire insulators
2	10-ft. coaxial cables (from ELPA 302A kit)
1*	splice, BNC (female-female), adapter to join coax cables
2*	Ground stakes w/clamp and 6-ft wires
1*	100 to 500 ft. of #18 wire
3 (min.)*	6 ft. insulated support posts (feed, middle, end) with rope guys and stakes
1*	Tool kit with hammer
1*	Lightning protection kit

The vertical half-rhombic deployment requires an additional item

1*	20 to 50 ft. non-metallic center support with guys and stakes

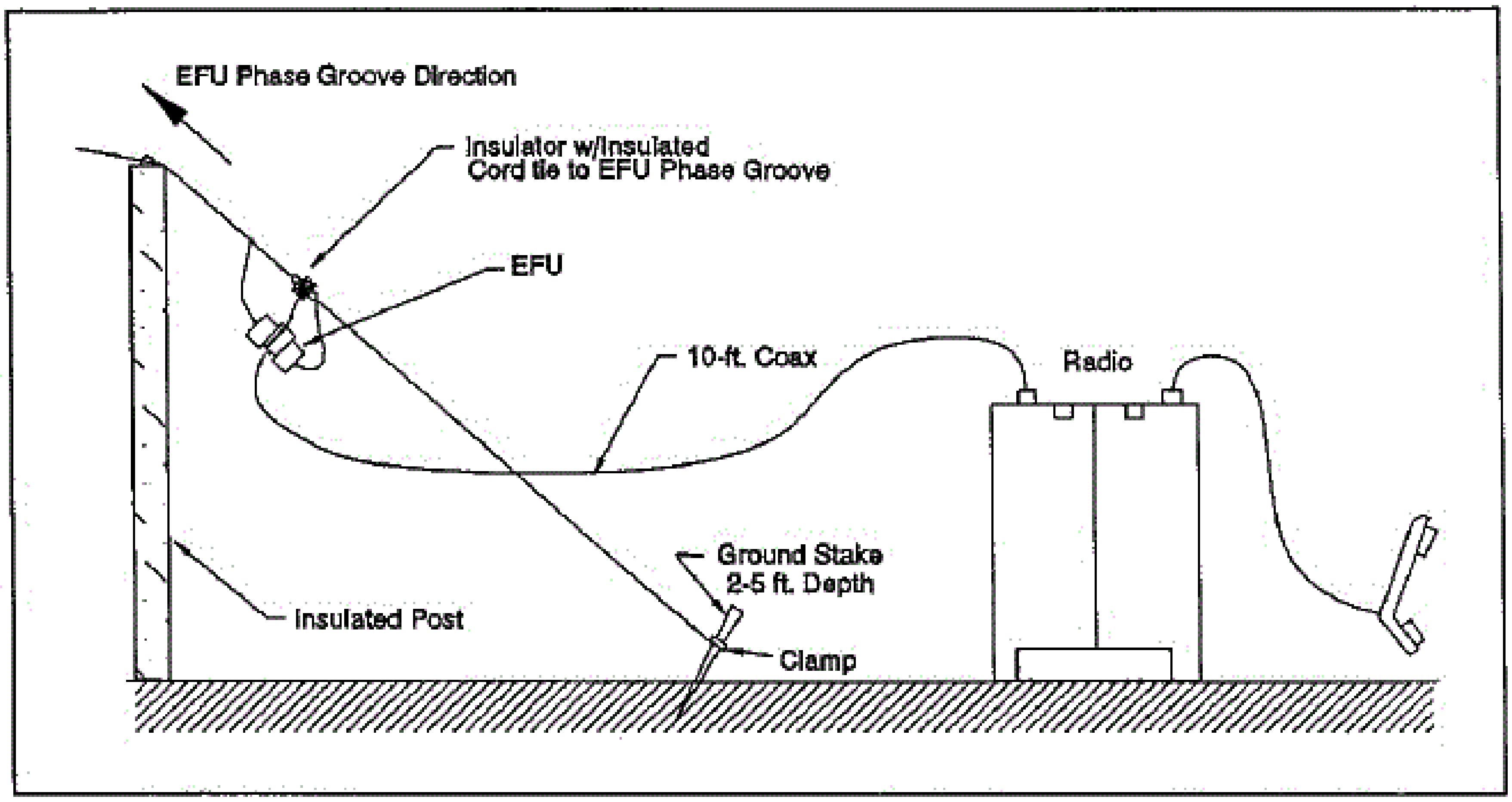

Figure F-3 Using an EFU as a long-wire antenna feed.

NOTE: The phase groove side of the EFU should connect to the antenna element wire. The "Lo" side of the EFU should connect to the ground stake.

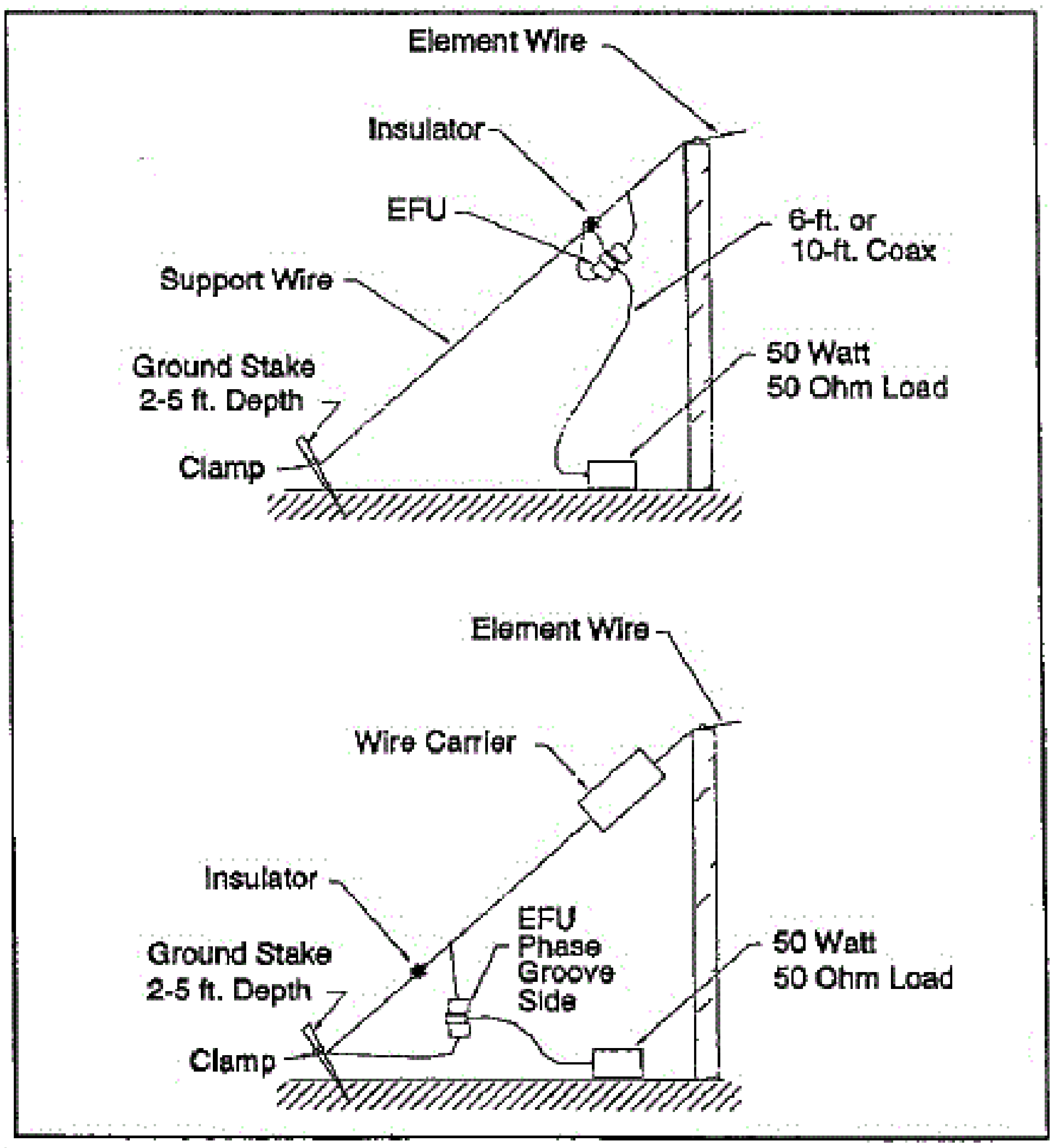

Figure F-4 EFU used as an element-wire termination.

Figure F-5 provides a simple view of VHR geometry. The field expedient tree of this example can be formally replaced by a 20- to 50-ft. non-metallic post (e.g. wood, fiberglass). The wood building example of Figure F-6 is an alternate field expedient support. Insulated posts at the feed and termination points are desirable to add support to the wires and to minimize the end sag of the wires. The supports are not required for the useful functioning of the VHR antenna but will improve the power gain at some frequencies. Details of typical deployment lengths vs antenna patterns and gains are provided in items 3, 12 and 13 of Reference Section 8.1 and as part of the alternate deployment kit.

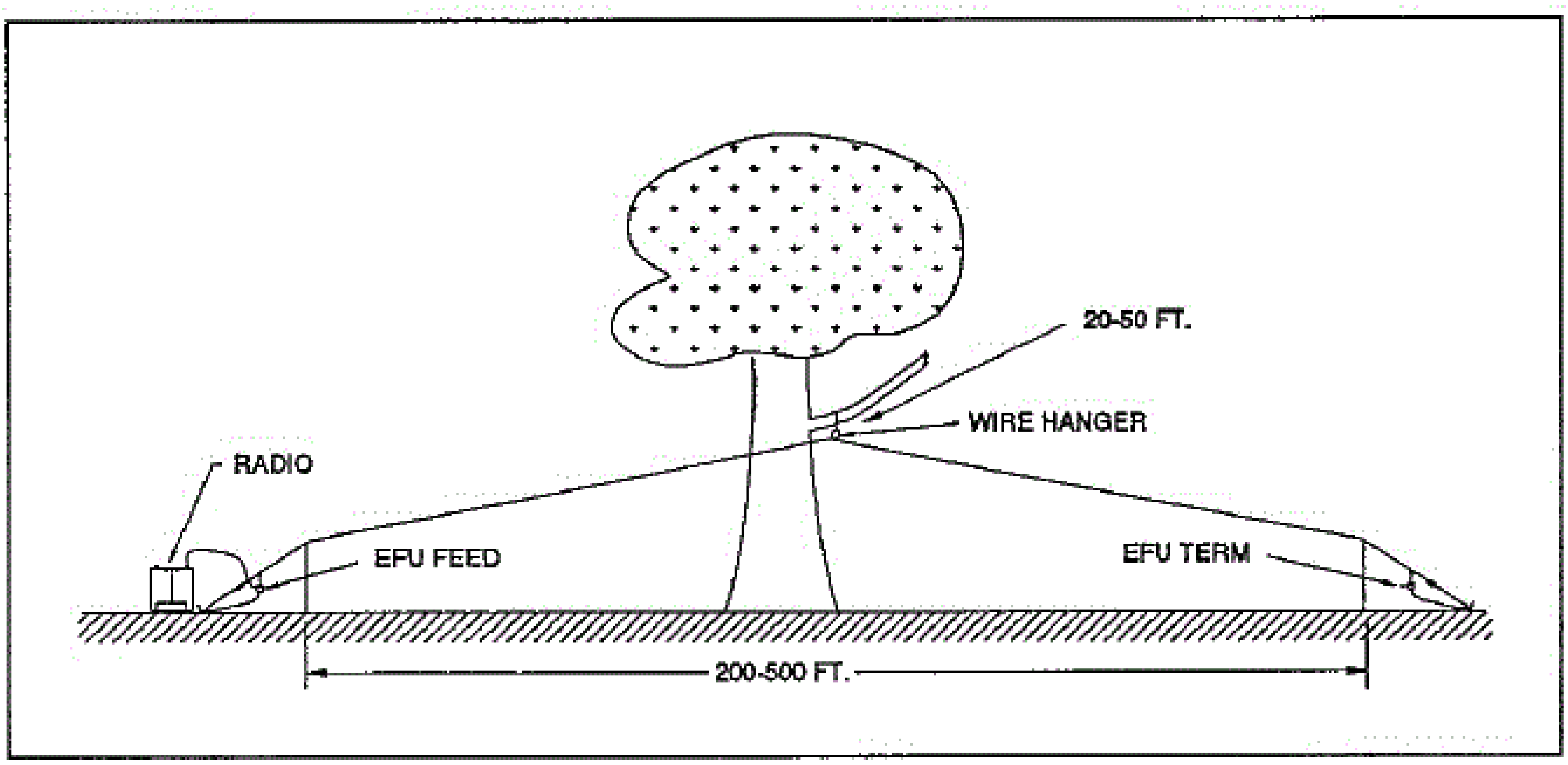

Figure F-5 Vertical half-rhombic antenna.

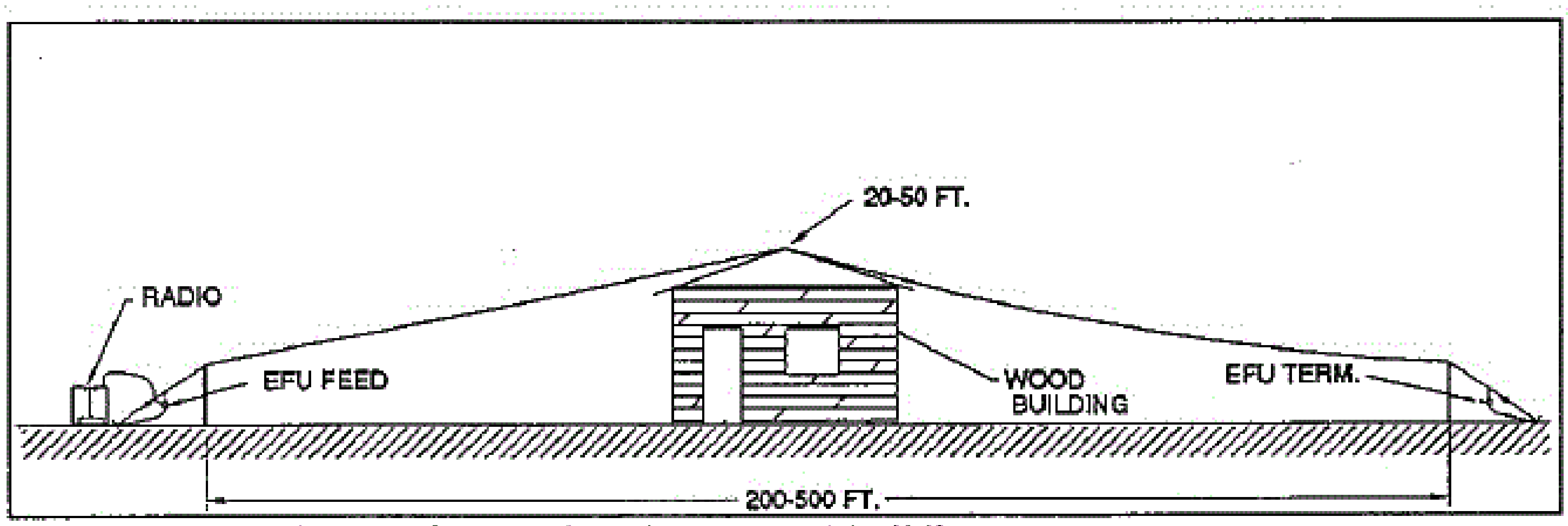

Figure F-6 Vertical half-rhombic using a wood building as a center support.

F 3.0 Sloping-vee deployment

The sloping-vee deployment requires the use of an EFU for both the feed and two termination positions (a total of 3 EFUs). Due to the tension presented by the long wire deployments of the sloping vee it is necessary to use an insulated wire termination point at the apex of the sloping vee. Figure F-7 details this configuration. Note that the EFU is suspended by a 0.125 inch diameter cord from the insulator tie point. Detailed option kit literature is available as part of the vertical half-rhombic kit which will support this deployment. Note that the gain and pattern characteristics of this sloping-vee are similar to those described for standard handbook sloping vees. The EFU's will support frequency ranges between 2 and 65 MHz for this application.

Additions to Beverage/vertical half-rhombic kit:

1	Element feed unit, 1/2 of ELPA 302A kit
1*	50 Ohm, 50 Watt coaxial load, BNC (female)
1*	30- to 50-ft. feed cable to reach from feedpoint at the top of the tower to the radio.

Details of typical deployment lengths vs antenna patterns and gains are provide in items 3, 12 and 13 of Reference Section 8.1.

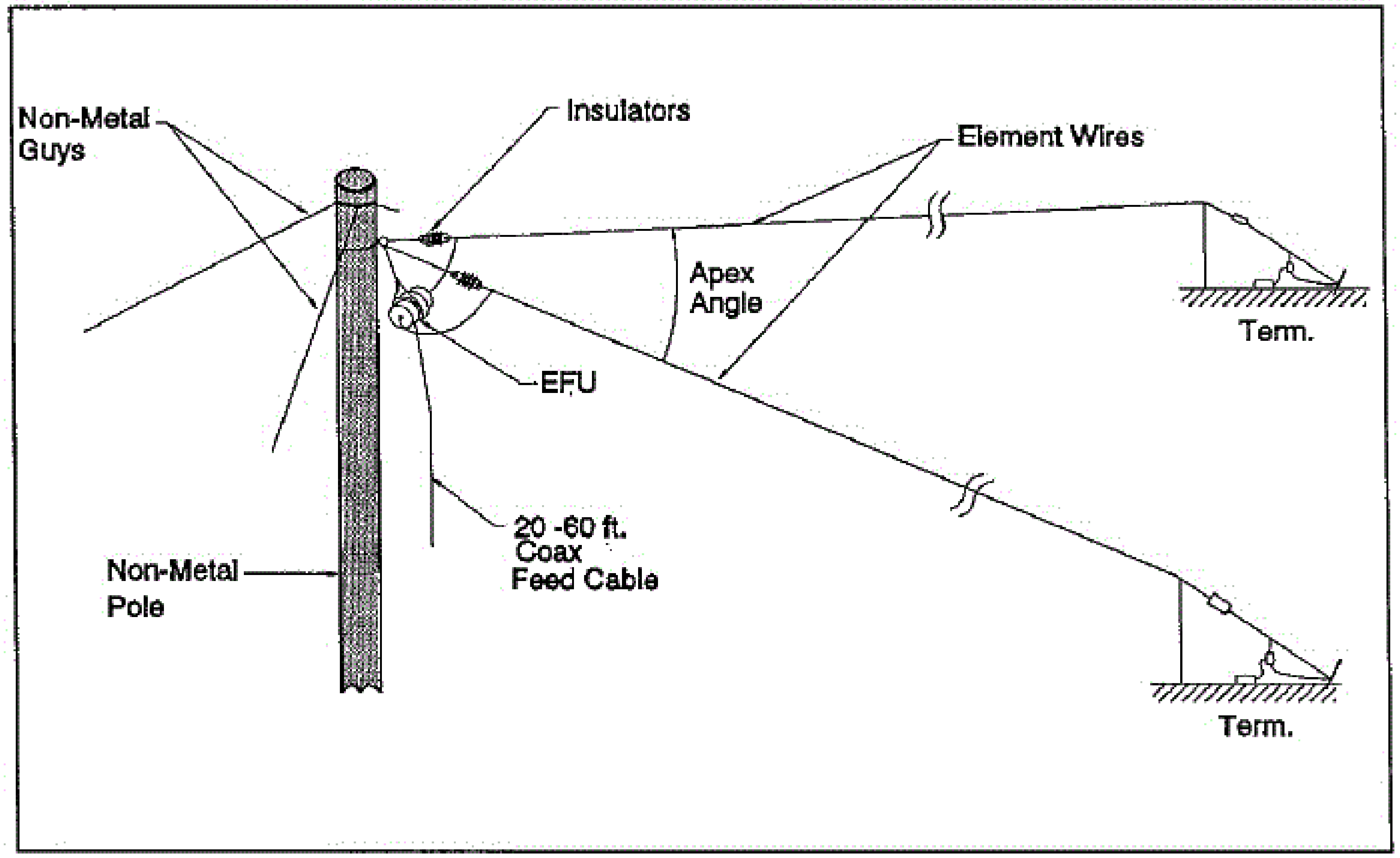

Figure F-7 Detail of sloping-vee feedpoint using an EFU.

F 4.0 ELPA 4-element and 8-element deployments

The basic layout of an ELPA 304A is provided in Figure 4-15. A 4-element beamwidth listing is provided in Table 4-6. The ELPA 308A configuration is shown in Figure F-8. The 308A can be configured from two 304As plus a splitter and cable assembly. Option kits are available.

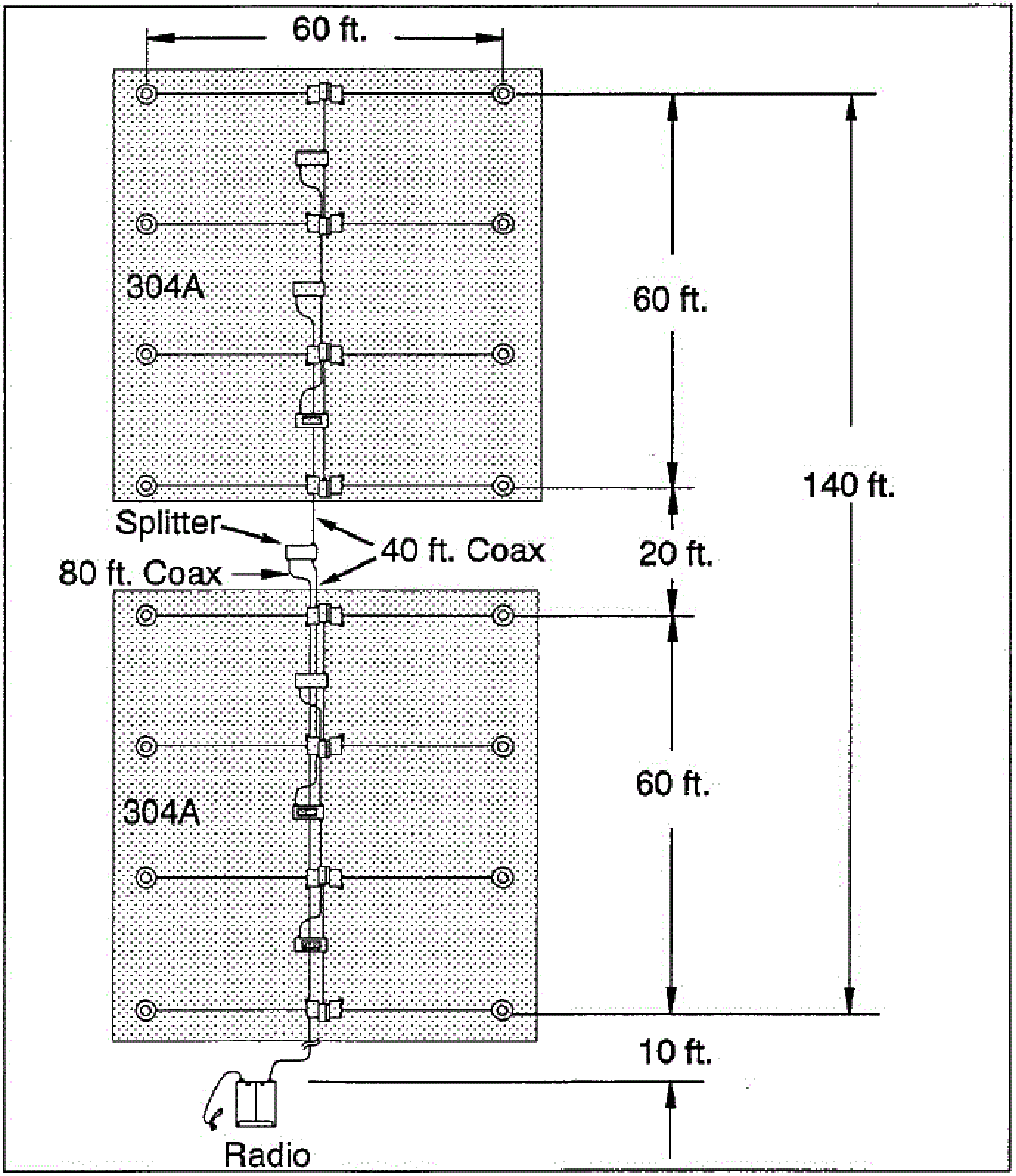

Figure F-8 Example of two 304A ELPAs forming a 308A.