

5-5a Vee Dipole Mounted over Finite Ground Planes

Tilting the poles of a dipole into a vee gives us another design parameter. Section 5-4a shows when the poles are tilted down toward a large ground (infinite in 5-4a) we broaden the beam and eliminate the *E*-plane pattern null. This concept is useful when considering an element in an array. This section considers a Vee dipole mounted over finite ground planes. We can analyze the problem using GTD with its edge diffractions, PO with additional currents excited on the finite ground planes, MoM where the additional currents on the finite ground plane that interact with the currents on the dipoles, or a volumetric method using FDTD or FEM. Since altering the currents on a dipole which can be found using MoM, FDTD or FEM have little effect on its pattern, the results below were computed using PO. A more complete analysis will change these results very little and the patterns given below can serve as a design starting guide. As the ground plane shrinks we lose control of pattern. We end with the vee dipole over a long cylinder to model it mounted over a utility pole or tower. Of course, other mounting structures modify the pattern.

3 λ Square Ground Plane

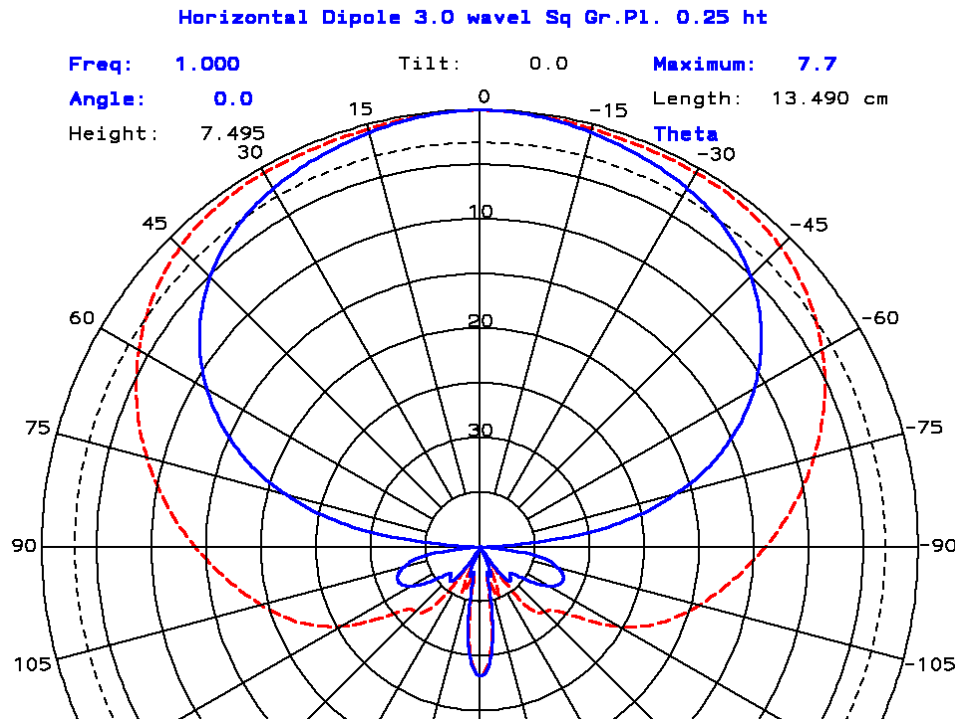


Figure 1 Horizontal Dipole 0.25λ over 3λ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

Table 1 3-dB Beamwidths of Vee Dipole Mounted over 3λ Square Ground Plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	66.4	102.5	0.225	0	68.9	106.8
0.20	5	66.6	101.0	0.225	5	68.9	105.2
0.20	10	67.3	99.6	0.225	10	69.2	103.6
0.20	15	68.5	98.2	0.225	15	70.1	102.1
0.20	20	70.3	97.0	0.225	20	71.5	100.7
0.20	25	73.1	95.8	0.225	25	73.6	99.4
0.20	30	77.1	94.7	0.225	30	76.6	98.2
0.20	35	82.4	93.7	0.225	35	80.7	97.1

Chapter 5 Dipoles, Slots, and Loops

0.20	40	88.9	92.8	0.225	40	85.7	96.1
0.20	45	95.9	91.9	0.225	45	91.2	95.2
0.20	50	102.8	91.2	0.225	50	97.0	94.4
				0.225	55	102.4	93.6
				0.225	60	107.4	93.0
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	72.1	111.9	0.275	0	76.2	117.7
0.25	5	71.8	110.0	0.275	5	75.6	115.7
0.25	10	71.9	108.3	0.275	10	75.4	113.7
0.25	15	72.4	106.6	0.275	15	75.6	111.9
0.25	20	73.5	105.0	0.275	20	76.4	110.1
0.25	25	75.2	103.6	0.275	25	77.7	108.5
0.25	30	77.6	102.3	0.275	30	79.6	107.0
0.25	35	80.8	101.0	0.275	35	82.2	105.7
0.25	40	84.7	99.9	0.275	40	85.4	104.4
0.25	45	89.2	98.9	0.275	45	89.1	103.3
0.25	50	93.9	98.0	0.275	50	93.0	102.3
0.25	55	98.5	97.2	0.275	55	96.9	101.4
0.25	60	102.8	96.6	0.275	60	100.6	100.7
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	81.3	122.7	0.325	0	87.4	126.2
0.30	5	80.4	121.5	0.325	5	86.3	125.0
0.30	10	79.9	120.0	0.325	10	85.5	123.7
0.30	15	79.9	118.0	0.325	15	85.2	122.5
0.30	20	80.3	116.0	0.325	20	85.3	121.3
0.30	25	81.2	114.2	0.325	25	85.9	120.1
0.30	30	82.8	112.6	0.325	30	87.1	118.9
0.30	35	84.9	111.0	0.325	35	88.8	117.2
0.30	40	87.5	109.6	0.325	40	90.9	115.7
0.30	45	90.5	108.4	0.325	45	93.4	114.2
0.30	50	93.8	107.3	0.325	50	96.1	113.0
0.30	55	97.1	106.3	0.325	55	98.8	111.9
0.30	60	100.2	105.4	0.325	60	101.5	110.9
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	94.5	129.8	0.375	0	102.6	133.5
0.35	5	93.2	128.6	0.375	5	101.1	132.3
0.35	10	92.2	127.4	0.375	10	99.9	131.1
0.35	15	91.6	126.2	0.375	15	99.1	129.9
0.35	20	91.4	125.0	0.375	20	98.7	128.8
0.35	25	91.7	123.9	0.375	25	98.7	127.7
0.35	30	92.5	122.8	0.375	30	99.2	126.6
0.35	35	93.8	121.7	0.375	35	100.0	125.6
0.35	40	95.5	120.6	0.375	40	101.3	124.6
0.35	45	97.5	119.6	0.375	45	102.9	123.6
0.35	50	99.8	118.7	0.375	50	104.7	122.8
0.35	55	102.1	117.8	0.375	55	106.6	122.0
0.35	60	104.3	117.0	0.375	60	108.5	121.3

Figures 2 and 3 illustrate two examples of Vee dipoles mounted over 3λ square ground plane with nearly equal beamwidths in the principal planes. These are similar to the tilted vee dipole over an infinite ground plane. Figure 4 shows the broadside dip and spread in the H -plane as the dipole is raised above 0.25λ that reduces as the dipole is tilted into the vee (Figure 5).

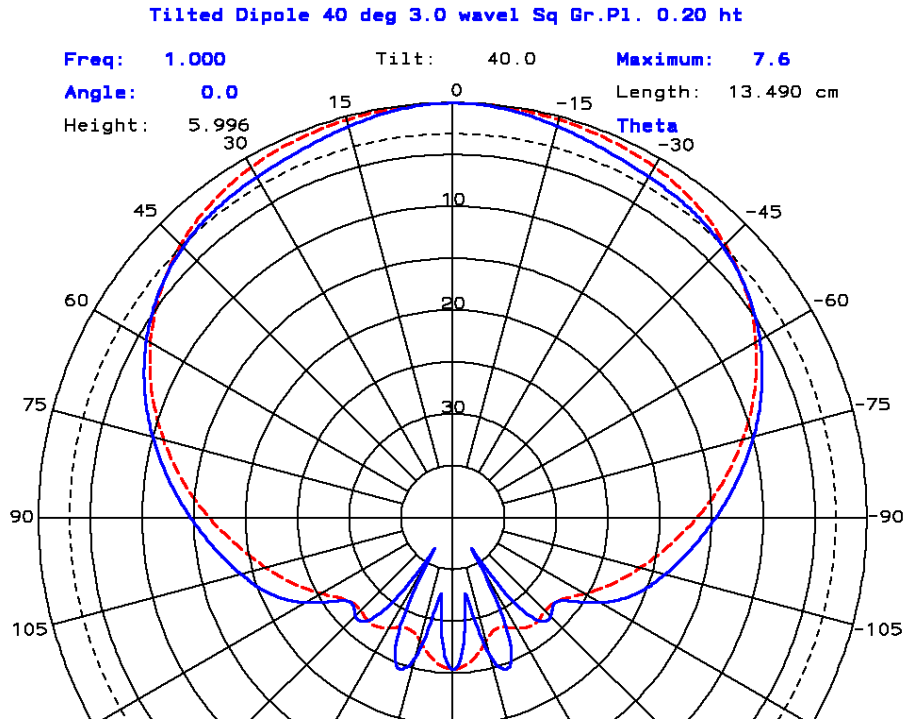


Figure 2 Vee Dipole 40° Tilt 0.20λ over 3λ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

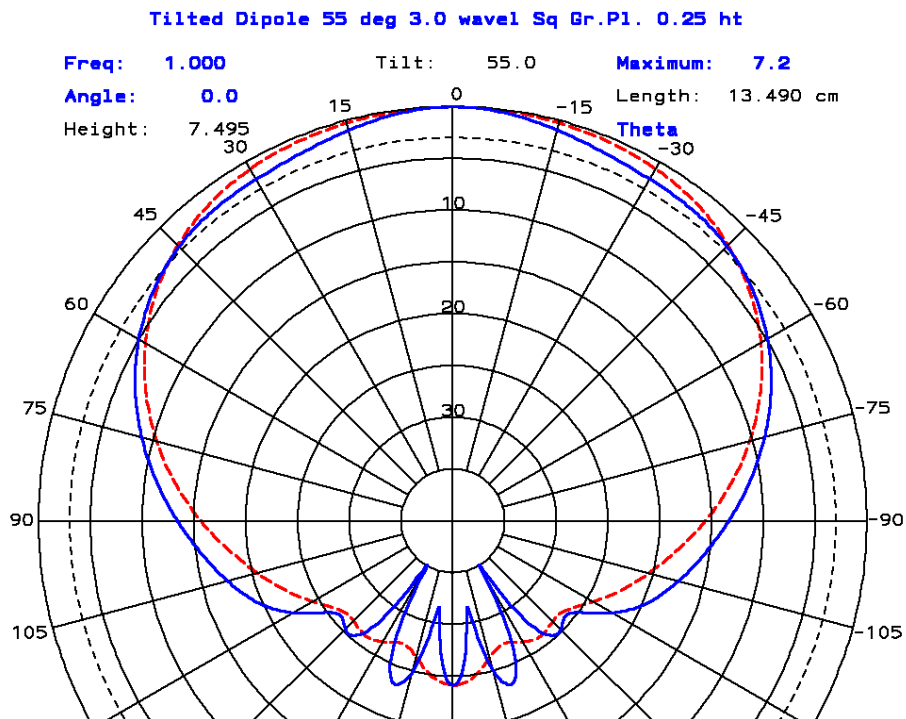


Figure 3 Vee Dipole 55° Tilt 0.25λ over 3λ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

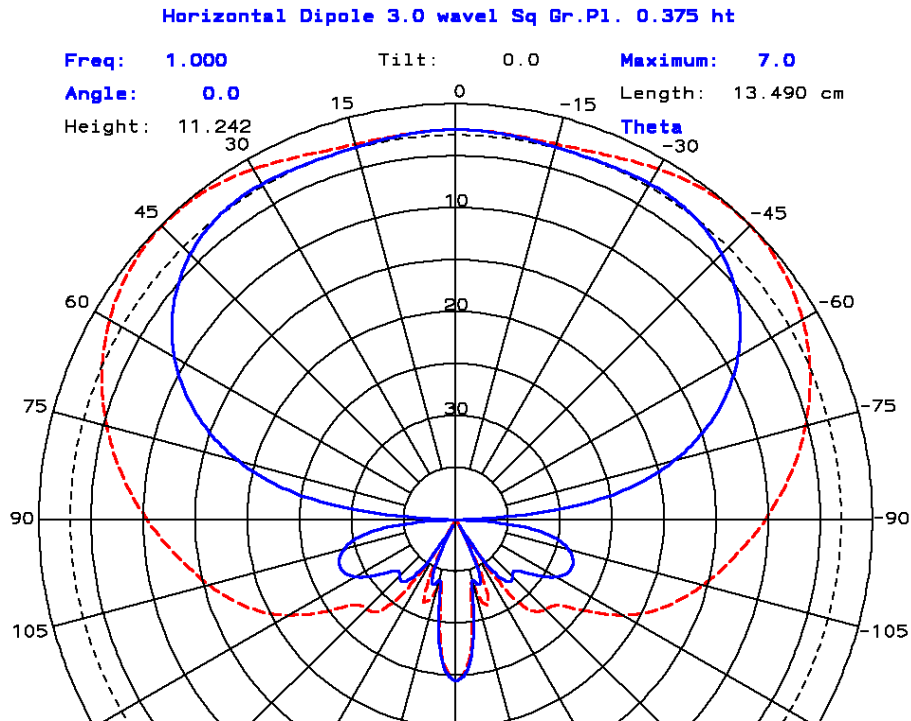


Figure 4 Horizontal Dipole 0.375λ over 3λ Square Ground Plane E -plane blue (solid) H -plane red (dashed)

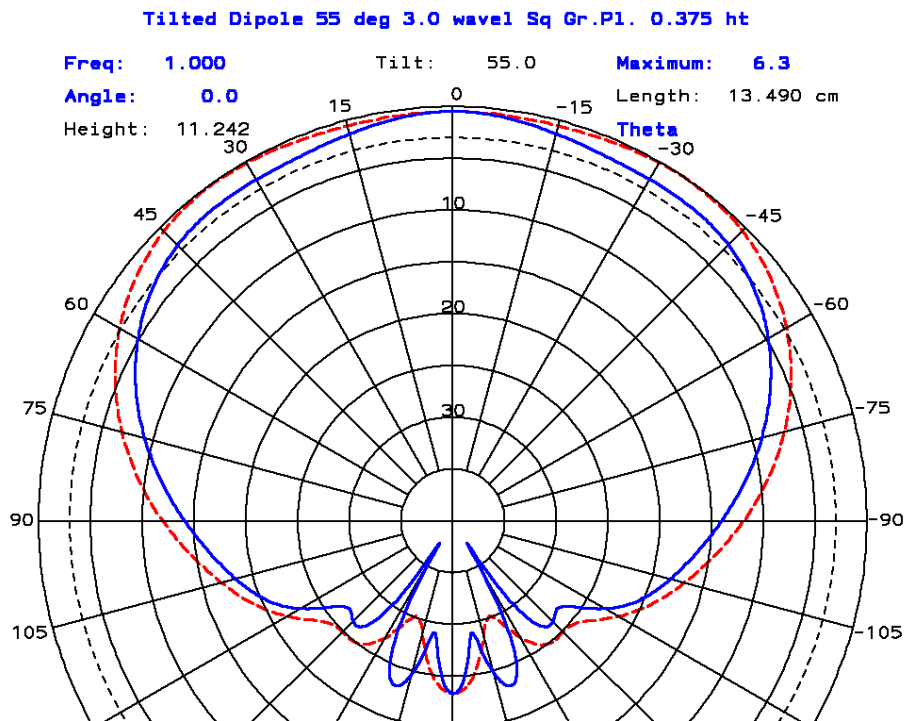


Figure 5 Vee Dipole 55° Tilt 0.375λ over 3λ Square Ground Plane E -plane blue (solid) H -plane red (dashed)

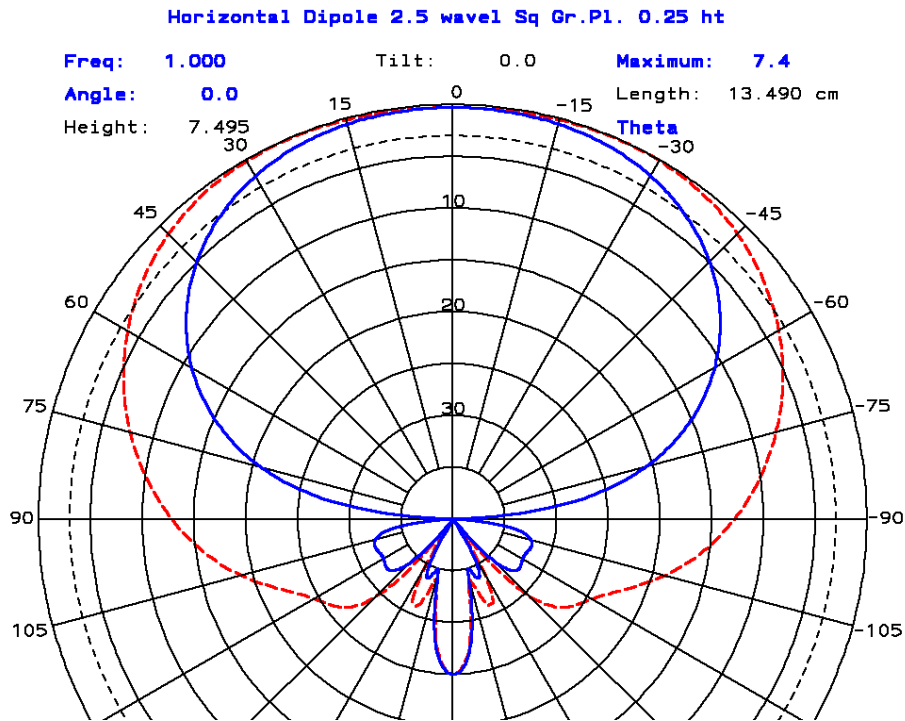
2.5 λ Square Ground Plane

Figure 6 Horizontal Dipole 0.25λ over 2.5λ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

Table 2 3-dB Beamwidths of Vee Dipole Mounted over 2.5λ Square Ground Plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	71.0	105.4	0.225	0	73.6	109.4
0.20	5	71.1	103.6	0.225	5	73.5	107.9
0.20	10	71.6	101.7	0.225	10	73.8	106.2
0.20	15	72.7	99.8	0.225	15	74.5	104.2
0.20	20	74.5	97.9	0.225	20	75.9	102.2
0.20	25	77.2	96.0	0.225	25	77.9	100.3
0.20	30	81.2	94.2	0.225	30	81.0	98.5
0.20	35	86.6	92.5	0.225	35	85.0	96.8
0.20	40	92.9	90.7	0.225	40	89.9	95.1
0.20	45	99.6	89.0	0.225	45	95.3	93.5
0.20	50	106.1	87.3	0.225	50	100.8	92.0
				0.225	55	105.9	90.5
				0.225	60	110.5	89.2
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	76.8	113.8	0.275	0	80.9	118.4
0.25	5	76.5	112.3	0.275	5	80.3	117.0
0.25	10	76.5	110.8	0.275	10	80.1	115.6
0.25	15	77.0	109.2	0.275	15	80.3	114.2
0.25	20	78.0	107.3	0.275	20	81.1	112.7
0.25	25	79.7	105.3	0.275	25	82.4	111.0
0.25	30	82.0	103.4	0.275	30	84.3	109.0
0.25	35	85.2	101.6	0.275	35	86.8	107.1
0.25	40	89.1	99.9	0.275	40	90.0	105.4

Chapter 5 Dipoles, Slots, and Loops

0.25	45	93.5	98.3	0.275	45	93.6	103.7
0.25	50	98.0	96.8	0.275	50	97.3	102.2
0.25	55	102.4	95.4	0.275	55	101.0	100.8
0.25	60	106.4	94.2	0.275	60	104.5	99.6
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	85.9	123.2	0.325	0	92.0	128.0
0.30	5	85.1	121.8	0.325	5	91.0	126.7
0.30	10	84.7	120.5	0.325	10	90.3	125.4
0.30	15	84.6	119.1	0.325	15	90.0	124.1
0.30	20	85.1	117.8	0.325	20	90.2	122.9
0.30	25	86.1	116.5	0.325	25	90.9	121.6
0.30	30	87.6	115.1	0.325	30	92.1	120.5
0.30	35	89.7	113.5	0.325	35	93.7	119.3
0.30	40	92.3	111.6	0.325	40	96.8	118.2
0.30	45	95.2	109.9	0.325	45	98.2	116.9
0.30	50	98.4	108.3	0.325	50	100.8	115.3
0.30	55	101.5	106.9	0.325	55	103.4	113.8
0.30	60	104.4	105.6	0.325	60	106.0	112.4
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	97.6	132.8	0.375	0	102.9	60.3
0.35	5	98.1	131.5	0.375	5	103.6	136.3
0.35	10	97.2	130.3	0.375	10	104.5	135.1
0.35	15	96.7	129.0	0.375	15	104.5	133.9
0.35	20	96.6	127.9	0.375	20	104.1	132.8
0.35	25	96.9	126.7	0.375	25	104.1	131.7
0.35	30	97.7	125.6	0.375	30	104.6	130.7
0.35	35	99.0	124.6	0.375	35	105.4	129.7
0.35	40	100.6	123.6	0.375	40	106.8	128.8
0.35	45	102.6	122.7	0.375	45	108.1	128.0
0.35	50	104.7	121.9	0.375	50	109.8	127.2
0.35	55	106.8	121.1	0.375	55	111.5	126.6
0.35	60	108.9	120.1	0.375	60	113.2	126.0

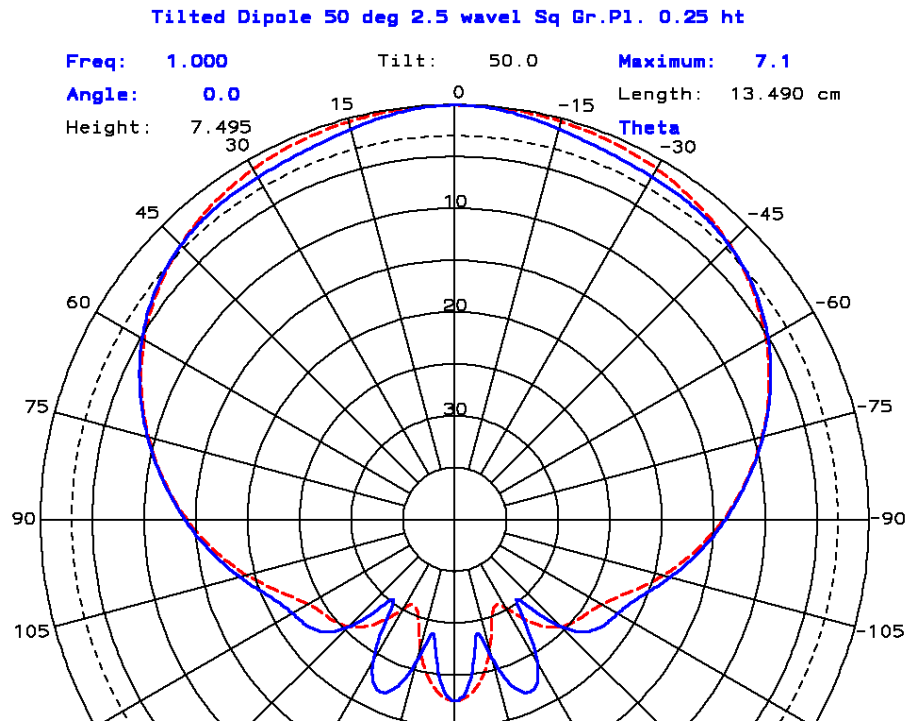


Figure 7 Vee Dipole 50° Tilt 0.25λ over 2.5λ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

2.0 λ Square Ground Plane

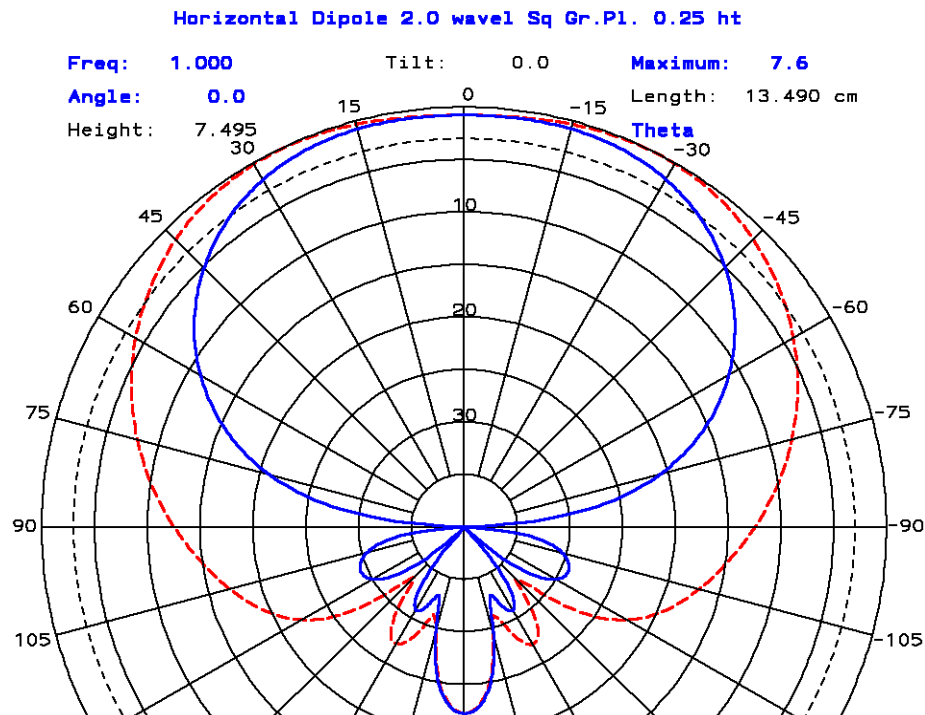


Figure 8 Horizontal Dipole 0.25λ over 2.0λ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

Table 3 3-dB Beamwidths of Vee Dipole Mounted over 2.0λ Square Ground Plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	74.0	103.7	0.225	0	76.8	106.9
0.20	5	75.6	103.2	0.225	5	78.0	106.3
0.20	10	77.7	102.7	0.225	10	79.6	105.7
0.20	15	80.4	102.4	0.225	15	81.8	105.2
0.20	20	83.6	102.1	0.225	20	84.3	104.8
0.20	25	87.3	101.9	0.225	25	87.2	104.5
0.20	30	91.3	101.8	0.225	30	90.5	104.3
0.20	35	95.4	101.9	0.225	35	93.9	104.2
0.20	40	99.6	102.0	0.225	40	97.4	104.2
0.20	45	103.8	102.2	0.225	45	100.9	104.2
0.20	50	107.8	102.4	0.225	50	104.2	104.3
				0.225	55	107.4	104.5
				0.225	60	110.4	104.7
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	80.1	110.5	0.275	0	83.6	114.4
0.25	5	80.9	109.7	0.275	5	84.1	113.6
0.25	10	82.1	109.0	0.275	10	85.0	112.8
0.25	15	83.7	108.4	0.275	15	86.2	112.1
0.25	20	85.7	107.9	0.275	20	87.7	111.4
0.25	25	88.1	107.5	0.275	25	89.6	110.9
0.25	30	90.7	107.2	0.275	30	91.8	110.5
0.25	35	93.5	107.0	0.275	35	94.1	110.2
0.25	40	96.5	106.8	0.275	40	96.6	109.9
0.25	45	99.4	106.8	0.275	45	99.1	109.7
0.25	50	102.3	106.8	0.275	50	101.5	109.6
0.25	55	105.0	106.8	0.275	55	103.9	109.6
0.25	60	107.6	106.9	0.275	60	106.1	109.6
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	87.3	118.8	0.325	0	91.2	123.4
0.30	5	87.6	117.8	0.325	5	91.3	122.4
0.30	10	88.2	116.9	0.325	10	91.7	121.4
0.30	15	89.1	116.1	0.325	15	92.3	120.5
0.30	20	90.2	115.4	0.325	20	93.2	119.6
0.30	25	91.7	114.7	0.325	25	94.4	118.9
0.30	30	93.5	114.2	0.325	30	95.8	118.3
0.30	35	95.4	113.8	0.325	35	97.4	117.8
0.30	40	97.5	113.4	0.325	40	99.1	117.3
0.30	45	99.6	113.1	0.325	45	100.9	116.9
0.30	50	101.7	112.9	0.325	50	102.8	116.7
0.30	55	103.8	112.8	0.325	55	104.5	116.4
0.30	60	105.7	112.7	0.325	60	106.2	116.3
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	95.2	61.6	0.375	0	99.4	54.5
0.35	5	95.2	127.3	0.375	5	99.3	55.7
0.35	10	95.4	126.2	0.375	10	99.4	57.1
0.35	15	95.9	125.2	0.375	15	99.8	59.0
0.35	20	96.6	124.3	0.375	20	100.3	62.8
0.35	25	97.5	123.5	0.375	25	101.0	128.4
0.35	30	98.6	122.8	0.375	30	101.9	127.6
0.35	35	99.9	122.1	0.375	35	103.0	126.9
0.35	40	101.4	121.6	0.375	40	104.3	126.3

Chapter 5 Dipoles, Slots, and Loops

0.35	45	102.9	121.1	0.375	45	105.6	125.7
0.35	50	104.5	120.8	0.375	50	106.9	125.3
0.35	55	106.0	120.5	0.375	55	108.3	124.9
0.35	60	107.5	120.3	0.375	60	109.6	124.6

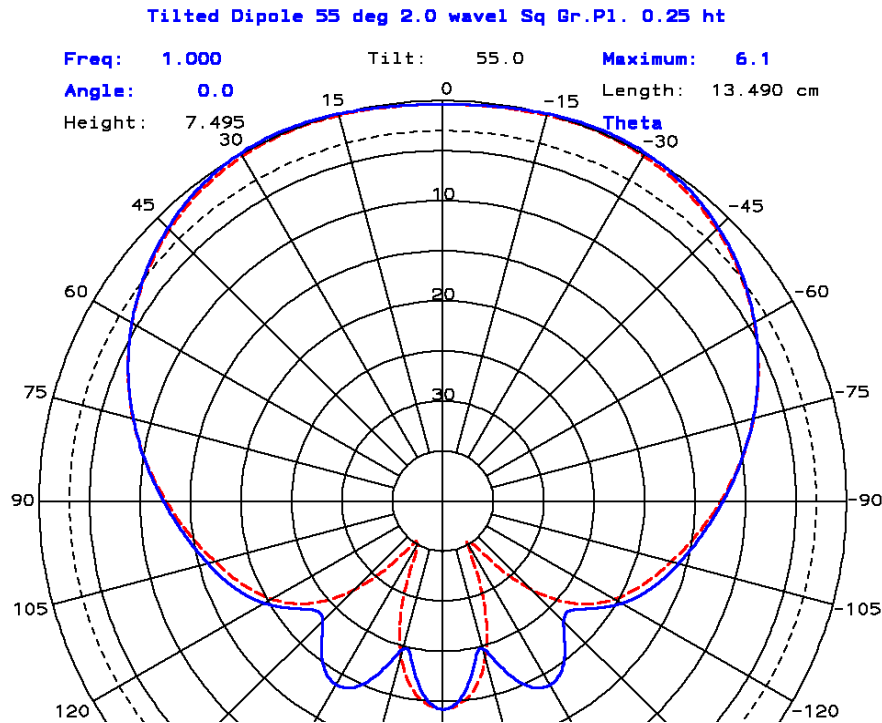


Figure 9 Vee Dipole 55° Tilt 0.25 λ over 2.0 λ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

1.5 λ Square Ground Plane

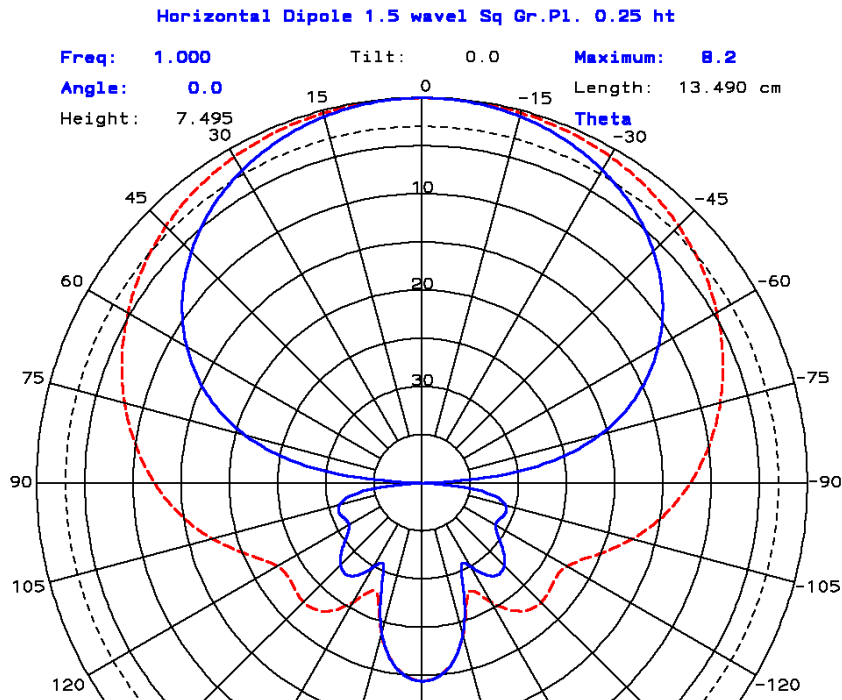


Figure 10 Horizontal Dipole 0.25λ over 1.5λ Square Ground Plane E -plane blue (solid) H -plane red (dashed)

Table 4 3-dB Beamwidths of Vee Dipole Mounted over 1.5λ Square Ground Plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	61.0	89.6	0.225	0	62.8	94.3
0.20	5	62.9	89.4	0.225	5	64.5	93.8
0.20	10	65.3	89.3	0.225	10	66.5	93.4
0.20	15	68.2	89.4	0.225	15	69.0	93.2
0.20	20	71.7	89.7	0.225	20	71.9	93.2
0.20	25	75.8	90.1	0.225	25	75.4	93.3
0.20	30	80.6	90.6	0.225	30	79.3	93.6
0.20	35	85.9	91.3	0.225	35	83.7	94.0
0.20	40	91.7	92.1	0.225	40	88.5	94.5
0.20	45	97.7	93.0	0.225	45	93.4	95.1
0.20	50	103.1	94.0	0.225	50	98.4	95.7
				0.225	55	102.7	96.5
				0.225	60	106.4	97.2
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	65.2	100.3	0.275	0	62.8	94.3
0.25	5	66.6	99.4	0.275	5	64.5	93.8
0.25	10	68.3	98.7	0.275	10	66.5	93.4
0.25	15	70.4	98.2	0.275	15	69.0	93.2
0.25	20	72.9	97.8	0.275	20	71.9	93.2
0.25	25	75.9	97.6	0.275	25	75.4	93.3
0.25	30	79.3	97.6	0.275	30	79.3	93.6
0.25	35	83.0	97.7	0.275	35	83.7	94.0
0.25	40	87.0	97.9	0.275	40	88.5	94.5

Chapter 5 Dipoles, Slots, and Loops

0.25	45	91.2	98.3	0.275	45	93.4	95.1
0.25	50	95.4	98.7	0.275	50	98.4	95.7
0.25	55	99.5	99.2	0.275	55	102.7	96.5
0.25	60	102.9	99.6	0.275	60	106.4	97.2
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	72.4	116.8	0.325	0	77.8	126.6
0.30	5	73.1	115.1	0.325	5	78.1	124.9
0.30	10	74.2	113.5	0.325	10	78.8	123.2
0.30	15	75.6	112.2	0.325	15	79.8	121.6
0.30	20	77.5	111.1	0.325	20	81.3	120.1
0.30	25	79.7	110.2	0.325	25	83.1	118.8
0.30	30	82.2	109.5	0.325	30	85.3	117.7
0.30	35	85.0	109.0	0.325	35	87.7	116.8
0.30	40	88.0	108.6	0.325	40	90.4	116.1
0.30	45	91.2	108.4	0.325	45	93.1	115.6
0.30	50	94.4	108.3	0.325	50	96.0	115.2
0.30	55	97.6	108.3	0.325	55	98.7	115.0
0.30	60	100.3	108.4	0.325	60	101.1	114.9
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	84.9	134.5	0.375	0	93.8	141.4
0.35	5	84.6	132.9	0.375	5	93.0	140.0
0.35	10	84.8	131.4	0.375	10	92.6	138.6
0.35	15	85.4	130.0	0.375	15	92.7	137.3
0.35	20	86.5	128.7	0.375	20	93.2	136.0
0.35	25	87.9	127.5	0.375	25	94.2	134.8
0.35	30	89.6	126.4	0.375	30	95.5	133.7
0.35	35	91.7	125.4	0.375	35	97.1	132.8
0.35	40	94.0	124.6	0.375	40	98.9	131.9
0.35	45	96.4	123.9	0.375	45	100.7	131.2
0.35	50	98.8	123.4	0.375	50	102.5	130.6
0.35	55	101.0	122.9	0.375	55	104.2	130.1
0.35	60	102.9	122.6	0.375	60	105.8	129.7

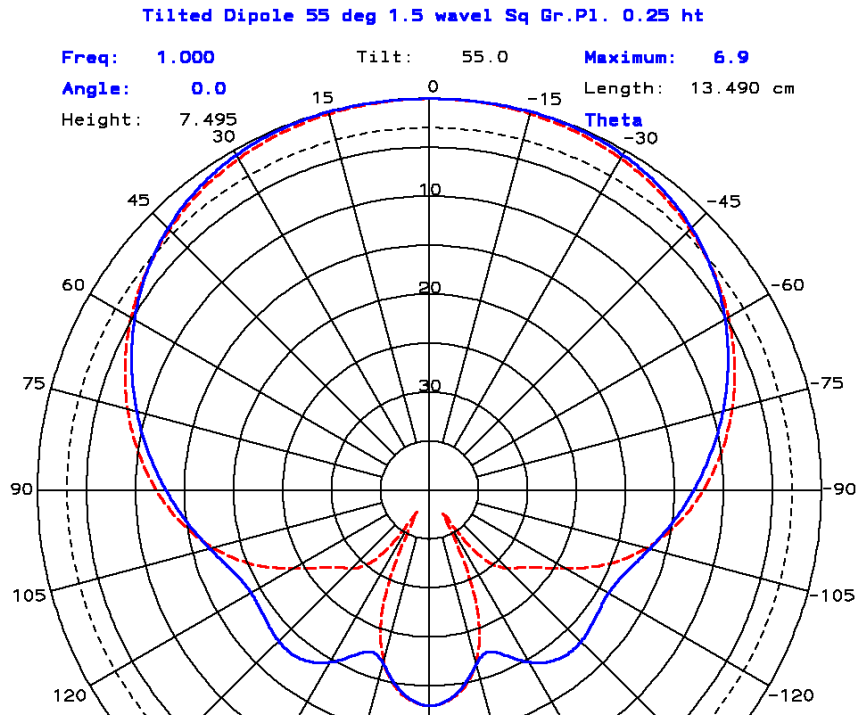


Figure 11 Vee Dipole 55° Tilt 0.25 λ over 1.5 λ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

1.0 λ Square Ground Plane

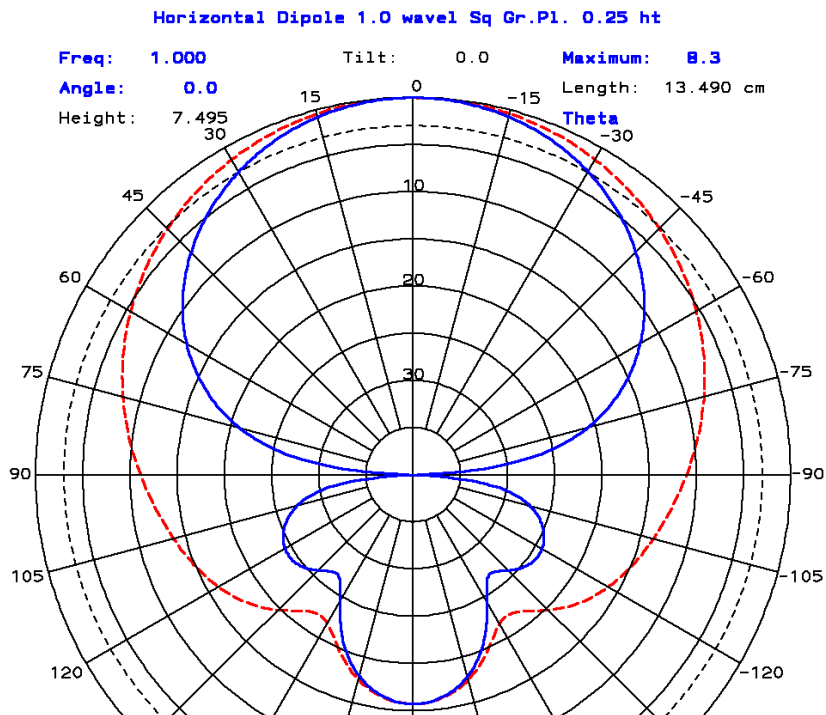


Figure 12 Horizontal Dipole 0.25 λ over 1.0 λ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

Table 5 3-dB Beamwidths of Vee Dipole Mounted over 1.0λ Square Ground Plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	58.8	82.3	0.225	0	59.7	85.0
0.20	5	59.4	81.8	0.225	5	60.2	84.3
0.20	10	60.2	81.3	0.225	10	60.8	83.6
0.20	15	61.2	80.8	0.225	15	61.6	83.1
0.20	20	62.3	80.5	0.225	20	62.5	82.6
0.20	25	63.6	80.2	0.225	25	63.6	82.1
0.20	30	65.2	79.9	0.225	30	64.8	81.7
0.20	35	66.9	79.6	0.225	35	66.3	81.4
0.20	40	68.9	79.4	0.225	40	67.8	81.1
0.20	45	71.0	79.3	0.225	45	69.5	80.8
0.20	50	73.2	79.2	0.225	50	71.3	80.6
				0.225	55	73.1	80.5
				0.225	60	74.9	80.3
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	60.9	88.6	0.275	0	62.4	93.2
0.25	5	61.2	87.6	0.275	5	62.6	91.9
0.25	10	61.7	86.7	0.275	10	62.8	90.7
0.25	15	62.3	85.9	0.275	15	63.3	89.7
0.25	20	63.0	85.2	0.275	20	63.8	88.7
0.25	25	63.9	84.6	0.275	25	64.6	87.9
0.25	30	65.9	84.1	0.275	30	63.4	87.2
0.25	35	66.1	83.6	0.275	35	66.4	86.5
0.25	40	67.4	83.2	0.275	40	67.5	86.0
0.25	45	68.8	82.9	0.275	45	68.7	85.5
0.25	50	70.3	82.6	0.275	50	69.9	85.1
0.25	55	71.8	82.3	0.275	55	71.2	84.8
0.25	60	73.2	82.1	0.275	60	72.4	84.5
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	64.4	99.4	0.325	0	66.9	107.8
0.30	5	64.3	97.7	0.325	5	66.6	105.4
0.30	10	64.4	96.1	0.325	10	66.4	103.2
0.30	15	64.6	94.6	0.325	15	66.5	101.3
0.30	20	65.0	93.4	0.325	20	66.7	99.5
0.30	25	65.6	92.2	0.325	25	67.1	98.0
0.30	30	66.3	91.2	0.325	30	67.6	96.6
0.30	35	67.1	90.3	0.325	35	68.3	95.4
0.30	40	68.0	89.6	0.325	40	69.0	94.3
0.30	45	69.1	88.9	0.325	45	69.9	93.4
0.30	50	70.1	88.4	0.325	50	70.8	92.6
0.30	55	71.2	87.9	0.325	55	71.8	92.0
0.30	60	72.3	87.5	0.325	60	72.7	91.4
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	70.2	119.0	0.375	0	74.9	133.5
0.35	5	69.6	115.9	0.375	5	73.8	129.5
0.35	10	69.2	112.9	0.375	10	72.9	125.7
0.35	15	68.9	110.3	0.375	15	72.4	122.2
0.35	20	68.9	107.9	0.375	20	72.0	119.0
0.35	25	69.1	105.7	0.375	25	72.0	116.1
0.35	30	69.5	103.8	0.375	30	72.1	113.6
0.35	35	70.0	102.1	0.375	35	72.4	111.3
0.35	40	70.6	100.7	0.375	40	72.8	109.3

Chapter 5 Dipoles, Slots, and Loops

0.35	45	71.3	99.4	0.375	45	73.4	107.5
0.35	50	72.1	98.3	0.375	50	74.0	106.0
0.35	55	72.9	97.4	0.375	55	74.8	104.8
0.35	60	73.8	96.7	0.375	60	75.5	103.7

Table 5 illustrates that when the ground plane shrinks to 1λ it can no longer significantly broaden the beam in the E -plane when the vee dipole tilt increases. However, Figure 13 shows a pattern with similar beams in the principal planes.

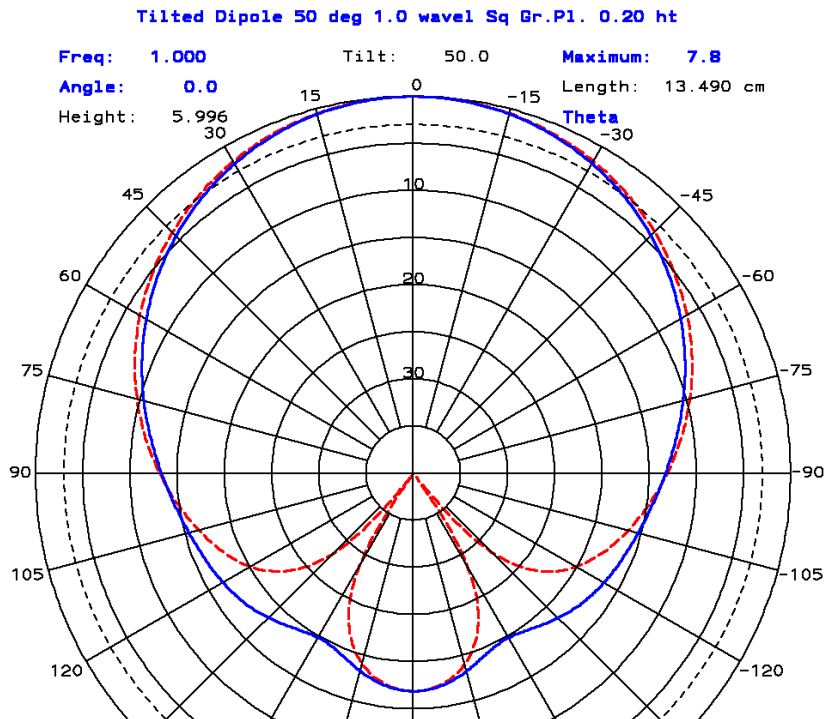


Figure 13 Vee Dipole 50° Tilt 0.20λ over 1λ Square Ground Plane E -plane blue (solid) H -plane red (dashed)

0.5 λ Square Ground Plane

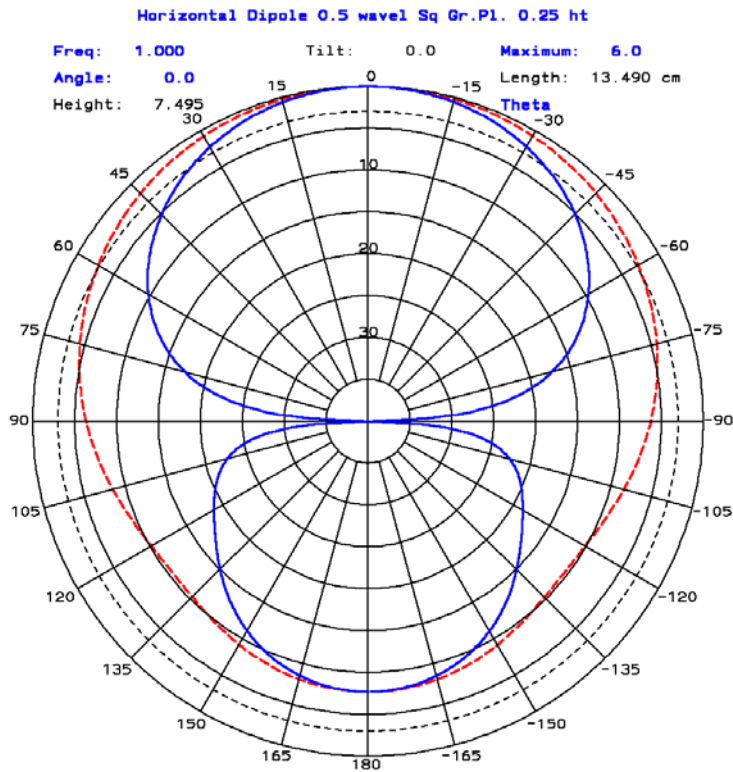


Figure 14 Horizontal Dipole 0.25λ over $\lambda/2$ Square Ground Plane *E*-plane blue (solid) *H*-plane red (dashed)

Table 6 3-dB Beamwidths of Vee Dipole Mounted over $\lambda/2$ Square Ground Plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	67.7	115.2	0.225	0	68.8	119.7
0.20	5	68.3	113.8	0.225	5	69.2	118.0
0.20	10	69.1	112.3	0.225	10	69.8	116.4
0.20	15	70.2	110.9	0.225	15	70.6	114.8
0.20	20	71.5	109.6	0.225	20	71.7	113.3
0.20	25	73.0	108.3	0.225	25	72.9	111.9
0.20	30	74.8	107.0	0.225	30	74.4	110.6
0.20	35	76.8	105.9	0.225	35	76.0	109.3
0.20	40	79.1	104.8	0.225	40	77.9	108.1
0.20	45	81.6	103.9	0.225	45	79.8	107.1
0.20	50	84.2	103.1	0.225	50	81.9	106.2
				0.225	55	84.0	105.4
				0.225	60	86.2	104.8

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	70.2	125.4	0.275	0	68.8	119.7
0.25	5	70.4	123.4	0.275	5	69.2	118.0
0.25	10	70.8	121.5	0.275	10	69.8	116.4
0.25	15	71.4	119.7	0.275	15	70.6	114.8
0.25	20	72.2	118.0	0.275	20	71.7	113.3
0.25	25	73.3	116.3	0.275	25	72.9	111.9
0.25	30	74.5	114.8	0.275	30	74.4	110.6

Chapter 5 Dipoles, Slots, and Loops

0.25	35	75.8	113.4	0.275	35	76.0	109.3
0.25	40	77.4	112.1	0.275	40	77.9	108.1
0.25	45	79.0	110.9	0.275	45	79.4	107.1
0.25	50	80.7	109.8	0.275	50	81.9	106.2
0.25	55	82.4	109.0	0.275	55	84.0	105.4
0.25	60	84.1	108.2	0.275	60	86.2	104.8
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	73.8	141.2	0.325	0	76.2	151.8
0.30	5	73.6	138.4	0.325	5	75.8	148.5
0.30	10	73.6	135.7	0.325	10	75.6	145.4
0.30	15	73.9	133.2	0.325	15	75.7	142.4
0.30	20	74.3	130.8	0.325	20	76.0	139.5
0.30	25	75.0	128.6	0.325	25	76.4	136.9
0.30	30	75.8	126.5	0.325	30	77.1	134.4
0.30	35	76.8	124.6	0.325	35	77.9	132.2
0.30	40	77.9	122.8	0.325	40	78.8	130.1
0.30	45	79.1	121.2	0.325	45	79.9	128.2
0.30	50	80.3	119.8	0.325	50	81.0	126.5
0.30	55	81.6	118.6	0.325	55	82.1	125.0
0.30	60	82.8	117.5	0.325	60	83.2	123.7
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	79.2	164.1	0.375	0	82.9	176.6
0.35	5	78.5	160.4	0.375	5	82.0	173.2
0.35	10	78.1	156.8	0.375	10	81.3	169.6
0.35	15	78.0	153.3	0.375	15	80.9	165.9
0.35	20	78.1	150.0	0.375	20	80.8	162.2
0.35	25	78.4	146.9	0.375	25	80.9	158.7
0.35	30	78.8	144.0	0.375	30	81.2	155.4
0.35	35	79.5	141.4	0.375	35	81.7	152.3
0.35	40	80.3	138.9	0.375	40	82.3	149.5
0.35	45	81.2	136.7	0.375	45	83.1	146.9
0.35	50	82.2	134.7	0.375	50	83.9	144.5
0.35	55	83.2	132.9	0.375	55	84.8	142.5
0.35	60	84.1	131.4	0.375	60	85.7	140.7

The dipole tilt has little effect on the E -plane beamwidth but the narrow width in the H -plane does not block the pattern and wide beams are formed.

Dual Resonant Loop Ground Plane

Figure 5-53 illustrates the geometry of a dual resonant loop ground plane consisting of 1λ and 2λ loops where the total width of the ground plane is $\lambda/2$. It is interesting to compare this with the $\lambda/2$ square ground plane.

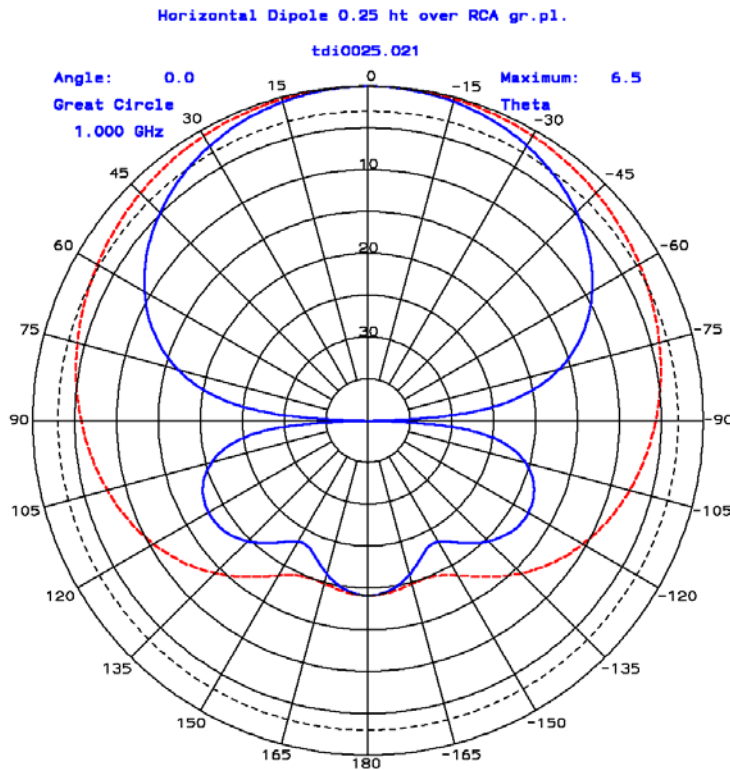


Figure 15 Horizontal Dipole 0.25λ over $\lambda/2$ wide Dual Resonant Loop *E*-plane blue (solid) *H*-plane red (dashed)

The F/B, Front/Back, of the $\lambda/2$ square ground plane is only about 8 dB while the dual resonant loop behind the dipole produces about 19 dB F/B when the dipole is spaced $\lambda/4$. Figure 16 demonstrates that the F/B increases to 25 dB for a dipole spaced 0.20λ . Tilting the vee dipole to 45° , Figure 17, reduces the F/B from 25 dB to 15 dB and illustrates that the F/B is sensitive to the vee dipole tilt, although F/B is improved compared to the square ground plane. Table 7 gives the beamwidth variation for 0.20λ and 0.25λ heights versus tilt and demonstrates that tilt has little effect on the beamwidth for a small resonant loop ground similar to the solid ground plane.

Chapter 5 Dipoles, Slots, and Loops

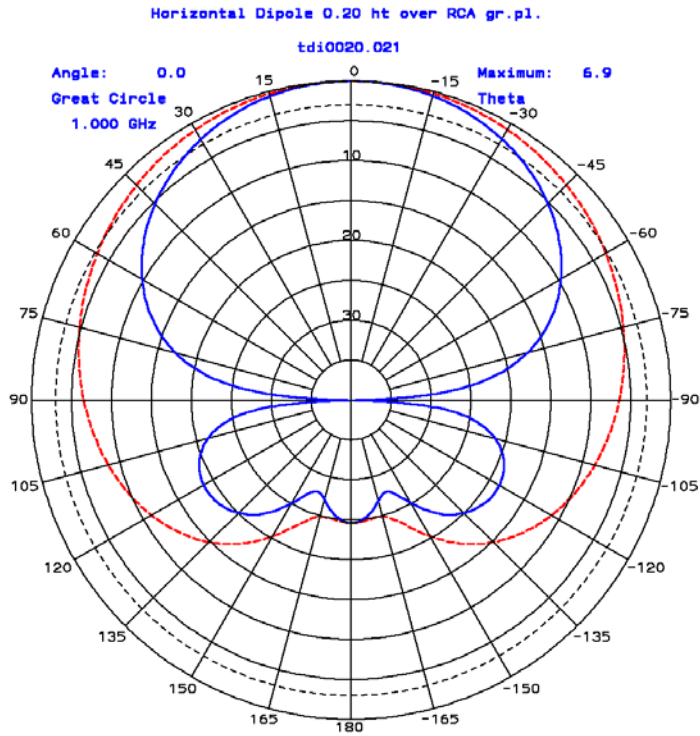


Figure 16 Horizontal Dipole 0.20λ over $\lambda/2$ wide Dual Resonant Loop E -plane blue (solid) H -plane red (dashed)

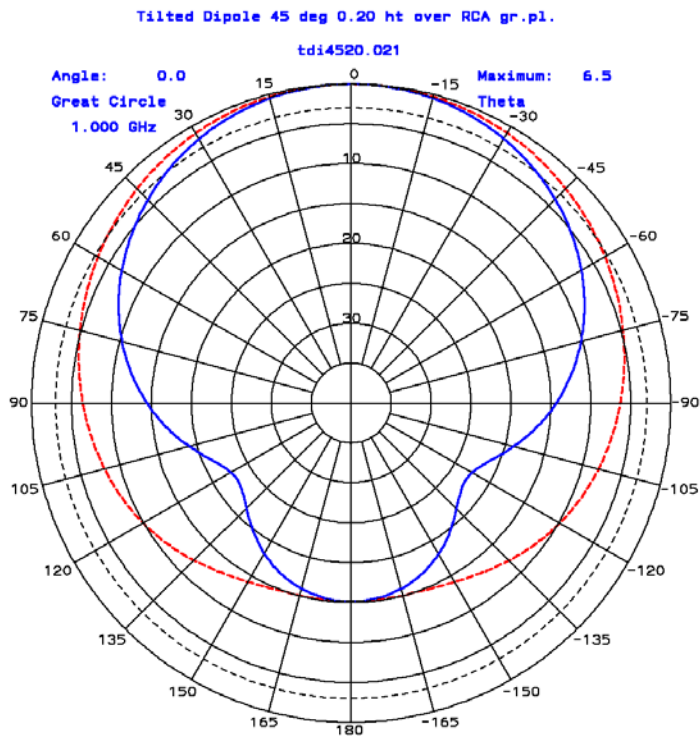


Figure 17 Vee Dipole 45° Tilt 0.20λ over $\lambda/2$ wide Dual Resonant Loop E -plane blue (solid) H -plane red (dashed)

Table 7 3-dB Beamwidths of Vee Dipole Mounted over $\lambda/2$ wide Dual Resonant Loop Plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	69.2	115.6	0.25	0	72.0	128.5
0.20	5	69.7	115.0	0.25	5	72.1	127.3
0.20	10	70.4	114.5	0.25	10	72.5	126.1
0.20	15	71.2	114.0	0.25	15	73.0	125.1
0.20	20	72.2	113.7	0.25	20	74.4	123.5
0.20	25	74.6	113.4	0.25	25	74.4	123.5
0.20	30	76.0	113.2	0.25	30	75.4	122.9
0.20	35	76.0	113.1	0.25	35	76.4	122.4
0.20	40	77.3	113.0	0.25	40	77.4	122.0
0.20	45	78.6	113.1	0.25	45	78.6	121.8
0.20	50	79.5	113.2	0.25	50	79.6	121.6
				0.25	55	80.6	121.6
				0.25	60	81.5	121.7

Vee Dipole Mounted over Wedge Ground Plane

We may broaden the *E*-plane beamwidth of a vee dipole by mounting it over a ground plane split in the middle and tilted down away from the dipole in the *E*-plane. The tilted currents in the ground plane fill-in the null and spread the pattern. Figure 18 of a horizontal dipole spaced $\lambda/4$ above the ridge of a wedge with 1λ sides tilted down 15° with an *H*-plane width of 2λ illustrate the wide *E*-plane beam without a null.

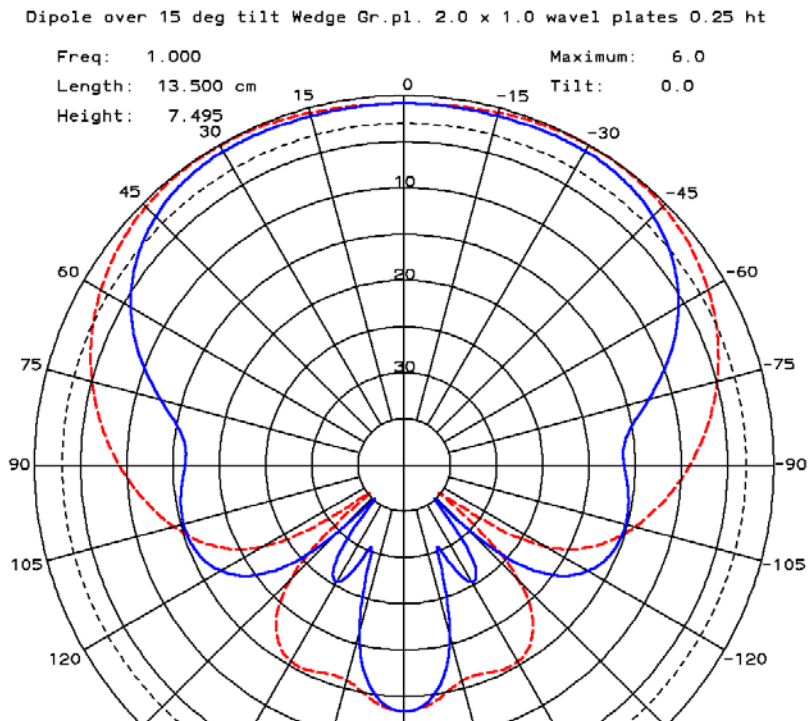


Figure 18 Horizontal Dipole 0.25λ over Wedge Ground Plane 15° 1λ sides 2λ *H*-plane width *E*-plane blue (solid) *H*-plane red (dashed)

Tilting the vee dipole to 45° over the 15° wedge produces almost equal beams in the principal planes, as shown in Figure 19.

Chapter 5 Dipoles, Slots, and Loops

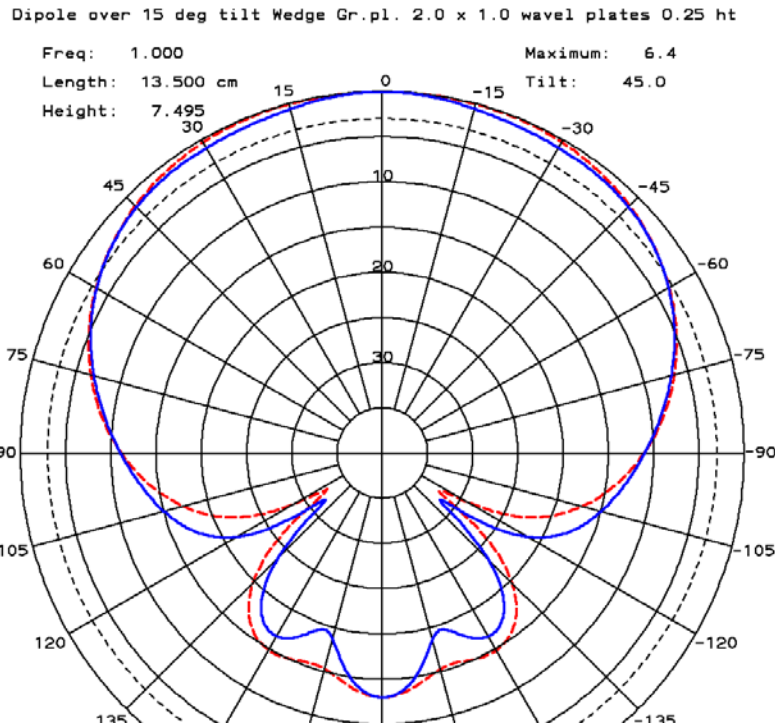


Figure 19 Vee Dipole 45° Tilt 0.25 λ over Wedge Ground Plane 15° 1 λ sides 2 λ H-plane width E-plane blue (solid) H-plane red (dashed)

Table 8 3-dB Beamwidths of Vee Dipole Mounted over Wedge Ground Plane with Ridge along H-plane with 1 λ E-plane sides tilted down 15° and 2 λ H-plane width for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	96.9	122.6	0.225	0	102.0	126.8
0.20	5	96.4	120.8	0.225	5	101.2	125.0
0.20	10	96.3	119.0	0.225	10	100.9	123.2
0.20	15	96.7	117.3	0.225	15	100.9	121.4
0.20	20	97.7	115.5	0.225	20	101.5	119.6
0.20	25	99.3	113.6	0.225	25	102.6	117.8
0.20	30	101.6	111.7	0.225	30	104.4	116.0
0.20	35	104.7	109.8	0.225	35	106.7	114.2
0.20	40	108.6	107.9	0.225	40	109.6	112.3
0.20	45	113.0	106.1	0.225	45	113.1	110.5
0.20	50	118.0	104.4	0.225	50	117.0	108.7
0.20	55	123.2	102.8	0.225	55	121.1	107.2
0.20	60	128.4	101.4	0.225	60	125.2	105.7

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	107.3	131.6	0.275	0	111.8	136.6
0.25	5	106.9	129.7	0.275	5	112.3	134.8
0.25	10	106.3	127.9	0.275	10	112.5	133.0
0.25	15	106.1	126.1	0.275	15	112.0	131.2
0.25	20	106.3	124.3	0.275	20	112.0	129.5
0.25	25	107.0	122.6	0.275	25	112.4	127.7
0.25	30	108.2	120.8	0.275	30	113.2	126.0
0.25	35	110.0	119.1	0.275	35	114.6	124.4
0.25	40	112.3	117.4	0.275	40	116.3	122.7
0.25	45	115.0	115.7	0.275	45	118.5	121.2

Chapter 5 Dipoles, Slots, and Loops

0.25	50	118.1	114.0	0.275	50	120.9	119.6
0.25	55	121.4	112.3	0.275	55	123.5	118.2
0.25	60	124.6	110.8	0.275	60	126.1	116.8
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	116.2	141.9	0.325	0	120.4	147.2
0.30	5	116.7	140.2	0.325	5	121.0	145.6
0.30	10	117.6	138.4	0.325	10	121.8	143.9
0.30	15	118.6	136.6	0.325	15	122.9	142.2
0.30	20	118.6	134.9	0.325	20	124.2	140.5
0.30	25	118.8	133.2	0.325	25	125.7	138.9
0.30	30	119.3	131.6	0.325	30	126.3	137.3
0.30	35	120.2	129.9	0.325	35	127.0	135.7
0.30	40	121.6	128.4	0.325	40	128.0	134.3
0.30	45	123.2	126.9	0.325	45	129.3	132.8
0.30	50	125.2	125.5	0.325	50	130.8	131.5
0.30	55	127.3	124.2	0.325	55	132.4	130.3
0.30	60	129.4	122.9	0.325	60	134.2	129.2
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	124.4	64.2	0.375	0	41.2	58.2
0.35	5	125.1	68.4	0.375	5	44.2	60.0
0.35	10	125.9	149.3	0.375	10	129.8	62.3
0.35	15	127.0	147.7	0.375	15	130.9	65.3
0.35	20	128.2	146.1	0.375	20	132.2	70.5
0.35	25	129.7	144.6	0.375	25	133.6	150.2
0.35	30	131.4	143.1	0.375	30	135.2	148.8
0.35	35	133.2	141.6	0.375	35	136.9	147.4
0.35	40	135.0	140.2	0.375	40	138.7	146.1
0.35	45	136.5	138.9	0.375	45	140.5	144.9
0.35	50	137.7	137.7	0.375	50	142.2	143.2
0.35	55	139.0	136.5	0.375	55	143.8	142.7
0.35	60	140.4	135.5	0.375	60	145.3	141.8

Wedge Ground Plane 20° Tilt 1λ E-plane sides 2λ H-plane Width

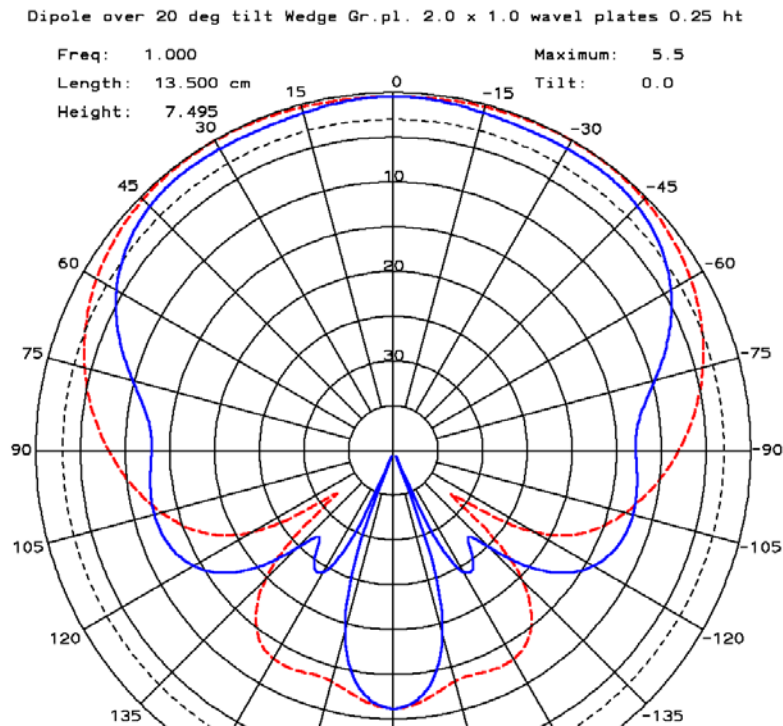


Figure 20 Horizontal Dipole 0.25λ over Wedge Ground Plane 20° 1λ sides 2λ H-plane width E-plane blue (solid) H-plane red (dashed)

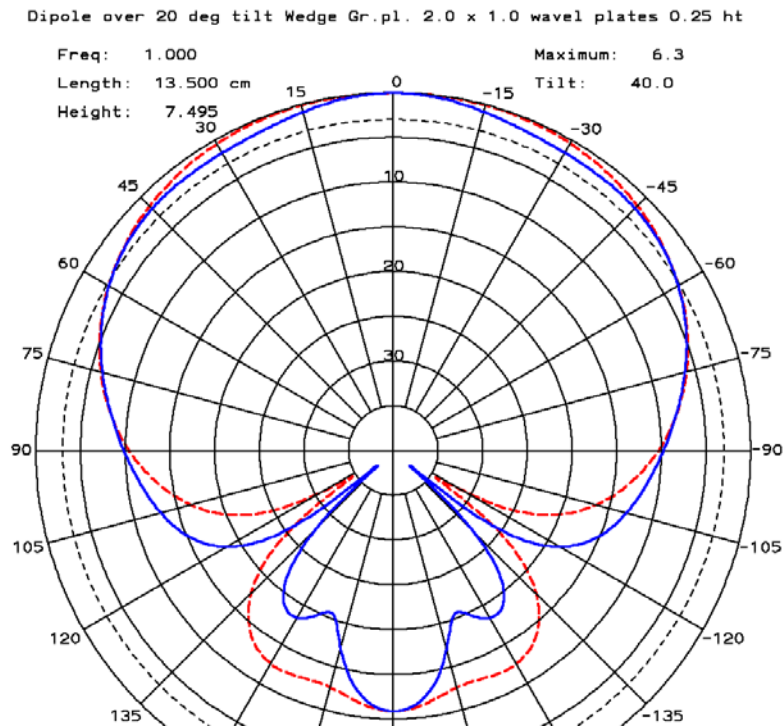


Figure 21 Vee Dipole 40° Tilt 0.25λ over Wedge Ground Plane 20° 1λ sides 2λ H-plane width E-plane blue (solid) H-plane red (dashed)

Table 9 3-dB Beamwidths of Vee Dipole Mounted over Wedge Ground Plane with Ridge along H -plane with 1λ E -plane sides tilted down 20° and 2λ H -plane width for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	102.2	127.6	0.225	0	108.0	132.8
0.20	5	101.3	125.0	0.225	5	107.0	130.4
0.20	10	100.9	122.4	0.225	10	106.4	127.8
0.20	15	100.9	119.6	0.225	15	106.2	125.2
0.20	20	101.5	116.9	0.225	20	106.4	122.5
0.20	25	102.8	114.3	0.225	25	107.3	119.7
0.20	30	104.8	111.8	0.225	30	108.7	117.0
0.20	35	107.7	109.4	0.225	35	110.9	114.5
0.20	40	111.5	107.1	0.225	40	113.7	112.1
0.20	45	115.9	104.9	0.225	45	117.1	109.8
0.20	50	121.0	102.9	0.225	50	121.0	107.6
0.20	55	126.2	101.0	0.225	55	125.1	105.8
0.20	60	131.5	99.2	0.225	60	129.3	104.1
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	114.4	138.2	0.275	0	121.4	143.7
0.25	5	113.4	135.9	0.275	5	120.4	141.6
0.25	10	112.7	133.6	0.275	10	119.6	139.4
0.25	15	112.3	131.1	0.275	15	119.1	137.1
0.25	20	112.3	128.6	0.275	20	119.0	134.8
0.25	25	112.8	126.0	0.275	25	119.2	132.4
0.25	30	113.8	123.4	0.275	30	119.9	130.0
0.25	35	115.4	120.8	0.275	35	121.1	127.6
0.25	40	117.6	118.2	0.275	40	122.8	125.2
0.25	45	120.2	115.8	0.275	45	124.8	122.8
0.25	50	123.2	113.6	0.275	50	127.1	120.6
0.25	55	126.4	111.6	0.275	55	129.7	118.4
0.25	60	129.7	109.8	0.275	60	132.3	116.5
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	127.1	149.2	0.325	0	130.8	154.5
0.30	5	127.9	147.2	0.325	5	131.8	152.7
0.30	10	127.1	145.2	0.325	10	132.9	150.9
0.30	15	126.6	143.2	0.325	15	134.3	149.0
0.30	20	126.4	141.0	0.325	20	134.4	147.1
0.30	25	126.5	138.8	0.325	25	134.4	145.1
0.30	30	126.9	136.7	0.325	30	134.8	143.1
0.30	35	127.8	134.4	0.325	35	135.4	141.2
0.30	40	129.1	132.3	0.325	40	136.4	139.2
0.30	45	130.6	130.1	0.325	45	137.6	137.3
0.30	50	132.5	128.0	0.325	50	139.1	135.4
0.30	55	134.5	126.1	0.325	55	140.7	133.6
0.30	60	136.6	124.2	0.325	60	142.3	132.0
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	45.5	159.6	0.375	0	37.7	63.8
0.35	5	135.3	158.0	0.375	5	39.5	66.6
0.35	10	136.5	156.3	0.375	10	41.8	70.4
0.35	15	137.9	154.6	0.375	15	45.0	159.9
0.35	20	139.5	152.9	0.375	20	143.0	158.3
0.35	25	141.2	151.1	0.375	25	144.7	156.8
0.35	30	143.2	149.2	0.375	30	146.6	155.2
0.35	35	144.0	147.6	0.375	35	148.6	153.6

Chapter 5 Dipoles, Slots, and Loops

0.35	40	144.8	145.9	0.375	40	150.6	152.1
0.35	45	145.8	144.2	0.375	45	152.5	150.6
0.35	50	147.0	142.5	0.375	50	154.4	149.2
0.35	55	148.2	141.0	0.375	55	156.0	147.9
0.35	60	149.6	139.5	0.375	60	157.5	146.6

Wedge Ground Plane 30° Tilt 1λ E-plane sides 2λ H-plane Width

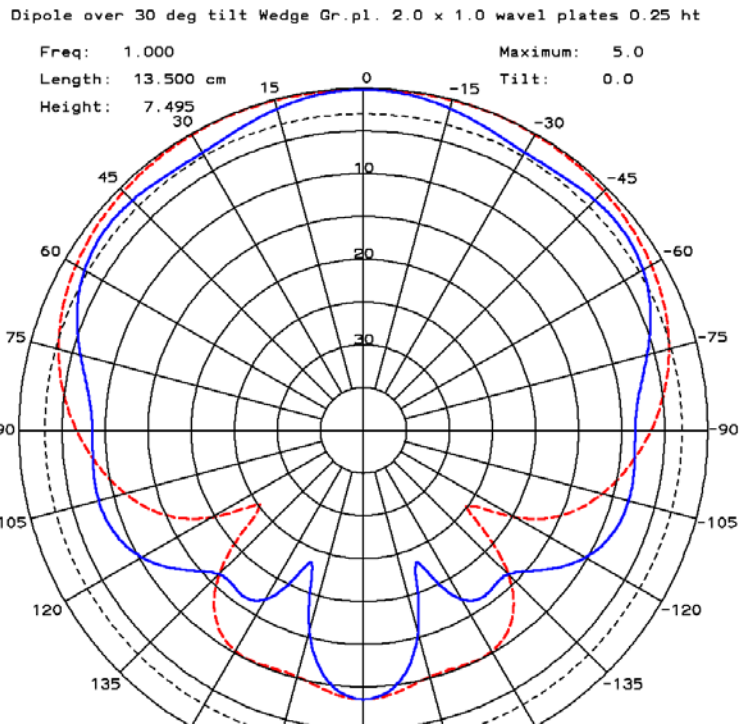


Figure 22 Horizontal Dipole 0.25λ over Wedge Ground Plane 30° 1λ sides 2λ H-plane width E-plane blue (solid) H-plane red (dashed)

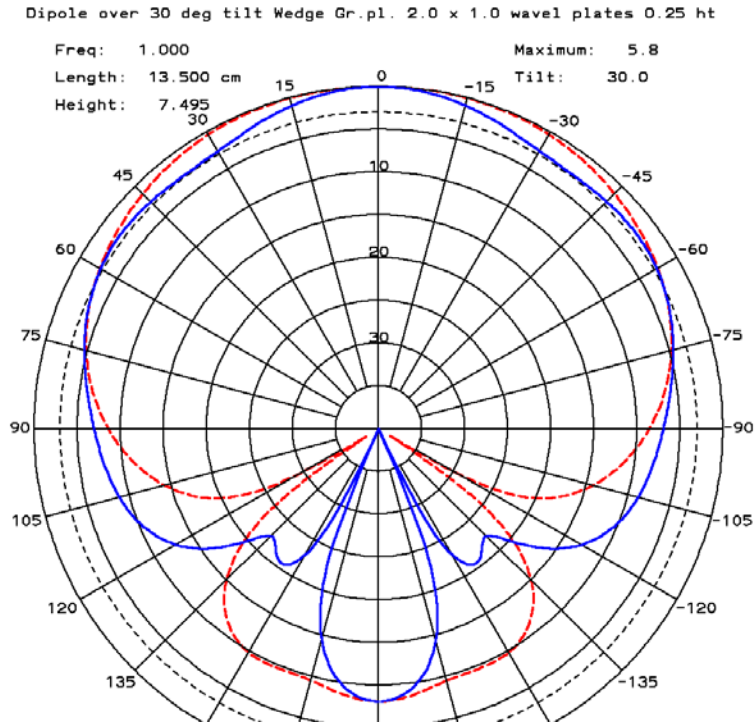


Figure 23 Vee Dipole 30° Tilt 0.25λ over Wedge Ground Plane 30° 1λ sides 2λ H-plane width E-plane blue (solid) H-plane red (dashed)

Table 10 3-dB Beamwidths of Vee Dipole Mounted over Wedge Ground Plane with Ridge along H -plane with 1λ E -plane sides tilted down 30° and 2λ H -plane width for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	109.2	130.8	0.225	0	118.6	138.8
0.20	5	107.3	127.6	0.225	5	117.3	135.6
0.20	10	105.6	124.4	0.225	10	116.2	132.3
0.20	15	104.3	121.2	0.225	15	115.5	128.9
0.20	20	103.9	118.0	0.225	20	115.5	125.6
0.20	25	104.8	114.9	0.225	25	116.4	122.3
0.20	30	107.6	112.0	0.225	30	118.2	119.1
0.20	35	112.4	109.2	0.225	35	121.2	116.1
0.20	40	118.6	106.6	0.225	40	125.2	113.2
0.20	45	125.3	104.2	0.225	45	129.8	110.6
0.20	50	132.2	102.0	0.225	50	134.8	108.3
0.20	55	138.9	100.1	0.225	55	139.9	106.2
0.20	60	145.3	98.5	0.225	60	144.8	104.3
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	127.6	146.6	0.275	0	136.5	154.0
0.25	5	126.6	143.5	0.275	5	135.8	151.1
0.25	10	125.9	140.4	0.275	10	135.3	148.1
0.25	15	125.6	137.1	0.275	15	135.2	145.1
0.25	20	125.7	133.9	0.275	20	135.4	142.0
0.25	25	126.4	130.6	0.275	25	136.1	138.9
0.25	30	127.8	127.4	0.275	30	137.3	135.8
0.25	35	130.0	124.3	0.275	35	139.0	132.8
0.25	40	132.8	121.3	0.275	40	141.2	129.8
0.25	45	136.2	118.4	0.275	45	143.8	127.0
0.25	50	139.9	115.8	0.275	50	146.7	124.3
0.25	55	143.7	113.5	0.275	55	149.7	121.9
0.25	60	147.5	111.4	0.275	60	152.6	119.8
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	145.3	160.7	0.325	0	151.1	166.5
0.30	5	145.0	158.1	0.325	5	153.1	164.4
0.30	10	144.8	155.4	0.325	10	154.7	162.1
0.30	15	144.9	152.7	0.325	15	155.1	159.7
0.30	20	145.3	149.8	0.325	20	155.8	157.1
0.30	25	146.1	146.9	0.325	25	156.8	154.5
0.30	30	147.2	144.0	0.325	30	158.0	151.8
0.30	35	148.7	141.1	0.325	35	159.4	149.2
0.30	40	150.6	138.3	0.325	40	161.1	146.6
0.30	45	152.7	135.6	0.325	45	163.0	144.0
0.30	50	155.0	133.0	0.325	50	164.9	141.6
0.30	55	157.4	130.6	0.325	55	166.8	139.3
0.30	60	159.7	128.4	0.325	60	168.7	137.2
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	37.5	171.6	0.375	0	34.8	74.4
0.35	5	39.6	169.8	0.375	5	36.5	76.4
0.35	10	42.3	167.9	0.375	10	38.4	79.2
0.35	15	46.4	165.9	0.375	15	40.5	171.3
0.35	20	164.4	163.7	0.375	20	42.9	169.5
0.35	25	167.8	161.4	0.375	25	45.4	167.6

Chapter 5 Dipoles, Slots, and Loops

0.35	30	170.7	159.1	0.375	30	48.0	165.6
0.35	35	172.2	156.8	0.375	35	50.5	163.6
0.35	40	173.8	154.4	0.375	40	52.9	161.6
0.35	45	175.3	152.1	0.375	45	55.1	159.5
0.35	50	176.9	149.8	0.375	50	58.2	157.6
0.35	55	178.4	147.8	0.375	55	187.6	155.7
0.35	60	179.8	145.8	0.375	60	188.8	154.0

Wedge Ground Plane 15° Tilt $\lambda/2$ E-plane sides 1λ H-plane Width

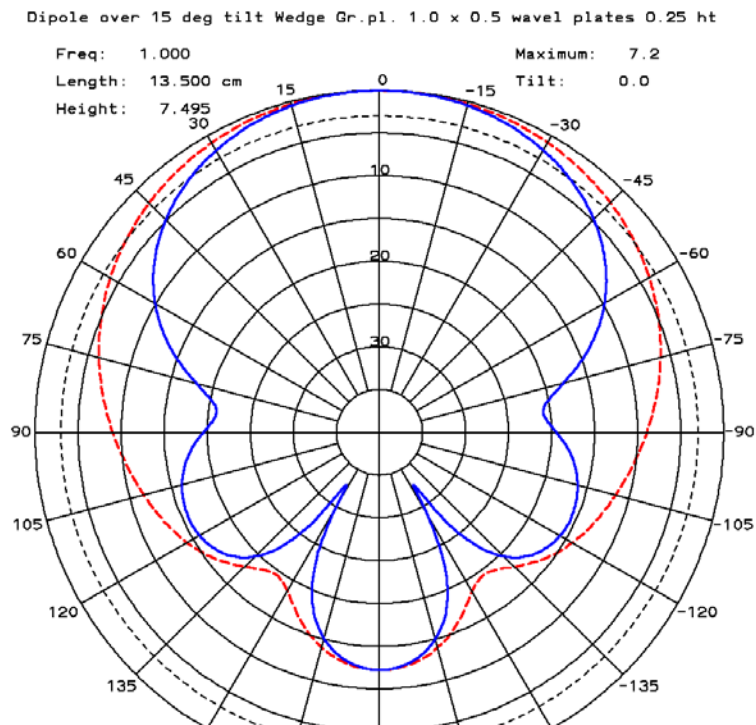


Figure 24 Horizontal Dipole 0.25λ over Wedge Ground Plane 15° $\lambda/2$ sides λ H-plane width E-plane blue (solid) H-plane red (dashed)

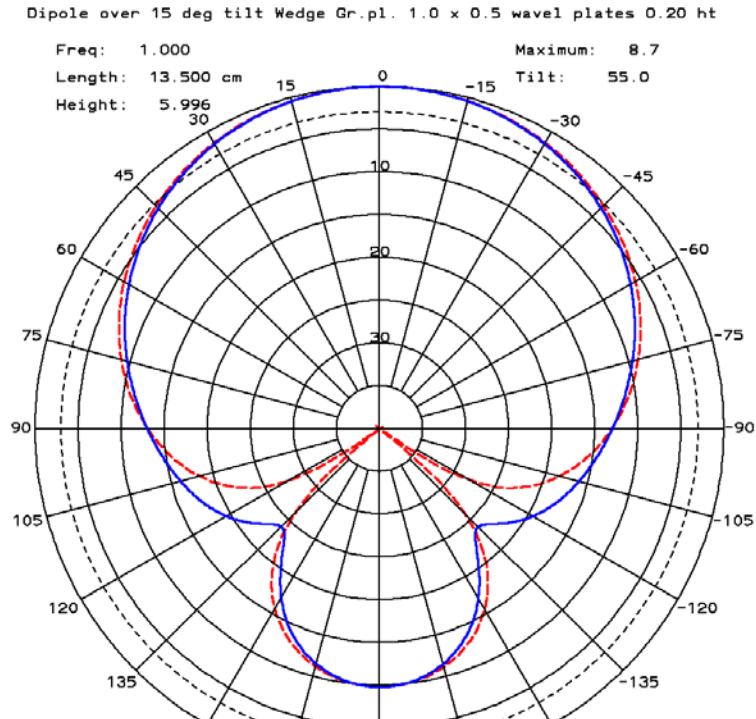


Figure 25 Vee Dipole 55° Tilt 0.20λ over Wedge Ground Plane 15° $\lambda/2$ sides λ H-plane width E-plane blue (solid) H-plane red (dashed)

Table 11 3-dB Beamwidths of Vee Dipole Mounted over Wedge Ground Plane with Ridge along H -plane with $\lambda/2$ E -plane sides tilted down 15° and λ H -plane width for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	66.0	94.4	0.225	0	69.3	100.0
0.20	5	66.1	93.2	0.225	5	69.2	98.3
0.20	10	66.4	92.0	0.225	10	69.4	96.8
0.20	15	67.0	91.0	0.225	15	69.7	95.5
0.20	20	67.9	90.2	0.225	20	70.4	94.3
0.20	25	69.0	89.4	0.225	25	71.2	93.3
0.20	30	70.4	88.7	0.225	30	72.4	92.4
0.20	35	72.1	88.2	0.225	35	73.8	91.6
0.20	40	74.2	87.7	0.225	40	75.5	91.0
0.20	45	76.6	87.3	0.225	45	77.5	90.4
0.20	50	79.3	87.0	0.225	50	79.7	90.0
0.20	55	82.4	86.8	0.225	55	82.2	89.6
0.20	60	85.9	86.6	0.225	60	84.8	89.4
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	73.5	107.3	0.275	0	78.7	116.9
0.25	5	73.1	105.1	0.275	5	77.9	114.1
0.25	10	73.0	103.1	0.275	10	77.5	111.4
0.25	15	73.1	101.3	0.275	15	77.3	109.0
0.25	20	73.5	99.8	0.275	20	77.4	106.9
0.25	25	74.1	98.4	0.275	25	77.8	105.0
0.25	30	75.1	97.1	0.275	30	78.5	103.4
0.25	35	76.2	96.1	0.275	35	79.5	102.0
0.25	40	77.7	95.2	0.275	40	80.6	100.7
0.25	45	79.3	94.4	0.275	45	82.0	99.7
0.25	50	81.2	93.8	0.275	50	83.6	98.8
0.25	55	83.2	93.3	0.275	55	85.4	98.1
0.25	60	85.3	92.9	0.275	60	87.2	97.5
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	85.2	129.3	0.325	0	93.5	144.4
0.30	5	84.1	125.7	0.325	5	91.8	140.1
0.30	10	83.2	122.3	0.325	10	90.5	135.9
0.30	15	82.7	119.2	0.325	15	89.6	132.1
0.30	20	82.5	116.4	0.325	20	89.0	128.5
0.30	25	82.6	113.9	0.325	25	88.8	125.3
0.30	30	83.0	111.7	0.325	30	88.9	122.4
0.30	35	83.7	109.7	0.325	35	89.3	119.9
0.30	40	84.7	108.0	0.325	40	90.0	117.6
0.30	45	85.8	106.6	0.325	45	90.9	115.7
0.30	50	87.2	105.4	0.325	50	92.0	114.0
0.30	55	88.6	104.4	0.325	55	93.2	112.6
0.30	60	90.2	103.5	0.325	60	94.6	111.5
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	102.9	157.1	0.375	0	110.9	167.2
0.35	5	101.2	154.0	0.375	5	109.8	164.6
0.35	10	99.6	150.7	0.375	10	108.8	161.9
0.35	15	98.2	147.2	0.375	15	107.8	159.2
0.35	20	97.2	143.5	0.375	20	107.0	156.4
0.35	25	96.6	139.5	0.375	25	106.3	153.5
0.35	30	96.4	136.0	0.375	30	105.8	150.6
0.35	35	96.4	132.7	0.375	35	105.5	147.7

Chapter 5 Dipoles, Slots, and Loops

0.35	40	96.8	129.9	0.375	40	105.6	144.8
0.35	45	97.5	127.4	0.375	45	106.0	141.8
0.35	50	98.4	125.2	0.375	50	106.6	139.0
0.35	55	99.4	123.4	0.375	55	107.4	136.7
0.35	60	100.5	121.8	0.375	60	108.3	134.7

Wedge Ground Plane 20° Tilt $\lambda/2$ E -plane sides 1λ H -plane Width

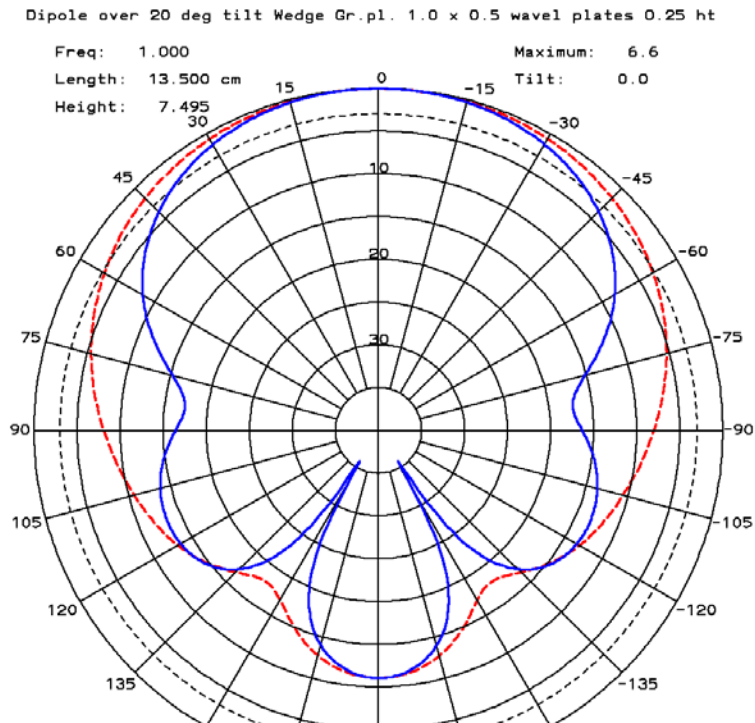


Figure 26 Horizontal Dipole 0.25λ over Wedge Ground Plane 20° $\lambda/2$ sides λ H -plane width E -plane blue (solid) H -plane red (dashed)

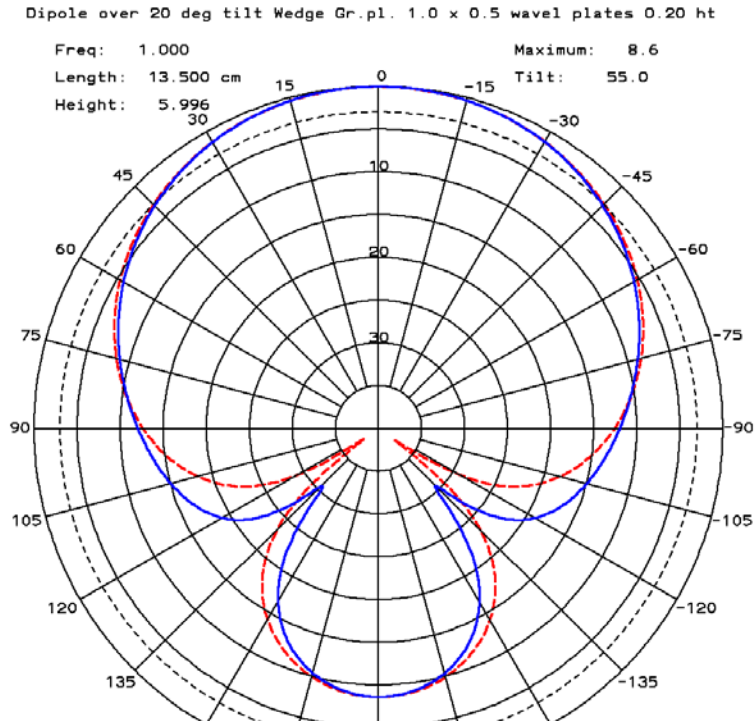


Figure 27 Vee Dipole 55° Tilt 0.20λ over Wedge Ground Plane 20° $\lambda/2$ sides λ H -plane width E -plane blue (solid) H -plane red (dashed)

Table 12 3-dB Beamwidths of Vee Dipole Mounted over Wedge Ground Plane with Ridge along H -plane with $\lambda/2$ E -plane sides tilted down 20° and λ H -plane width for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	71.6	101.2	0.225	0	76.2	108.2
0.20	5	71.5	99.5	0.225	5	75.8	106.1
0.20	10	71.6	98.0	0.225	10	75.7	104.1
0.20	15	72.1	96.7	0.225	15	75.9	102.3
0.20	20	72.9	95.5	0.225	20	76.4	100.8
0.20	25	73.9	94.5	0.225	25	77.2	99.4
0.20	30	75.3	93.6	0.225	30	78.3	98.2
0.20	35	77.0	92.8	0.225	35	79.8	97.1
0.20	40	79.2	92.2	0.225	40	81.5	96.2
0.20	45	81.7	91.6	0.225	45	83.6	95.5
0.20	50	84.6	91.2	0.225	50	86.0	94.9
0.20	55	87.9	90.9	0.225	55	88.6	94.4
0.20	60	91.6	90.6	0.225	60	91.4	94.0

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	81.8	117.4	0.275	0	88.6	129.0
0.25	5	81.1	114.6	0.275	5	87.5	125.5
0.25	10	80.7	112.0	0.275	10	86.8	122.2
0.25	15	80.6	109.7	0.275	15	86.4	119.2
0.25	20	80.8	107.6	0.275	20	86.3	116.5
0.25	25	81.4	105.8	0.275	25	86.5	114.1
0.25	30	82.2	104.2	0.275	30	87.1	112.0
0.25	35	83.4	102.8	0.275	35	88.0	110.1
0.25	40	84.8	101.6	0.275	40	89.2	108.5
0.25	45	86.6	100.5	0.275	45	90.6	107.1
0.25	50	88.5	99.7	0.275	50	92.3	105.9
0.25	55	90.7	99.0	0.275	55	94.1	104.9
0.25	60	93.0	98.4	0.275	60	96.0	104.1

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	96.8	143.2	0.325	0	105.3	155.7
0.30	5	95.4	139.1	0.325	5	104.2	152.5
0.30	10	94.3	135.1	0.325	10	103.1	149.2
0.30	15	93.5	131.4	0.325	15	102.1	145.7
0.30	20	93.1	127.9	0.325	20	101.4	142.0
0.30	25	93.0	124.8	0.325	25	101.0	138.2
0.30	30	93.3	122.1	0.325	30	100.9	134.7
0.30	35	93.9	119.6	0.325	35	101.2	131.7
0.30	40	94.8	117.5	0.325	40	101.8	128.9
0.30	45	95.9	115.6	0.325	45	102.7	126.5
0.30	50	97.3	114.0	0.325	50	103.8	124.5
0.30	55	98.9	112.7	0.325	55	105.1	122.7
0.30	60	100.5	111.6	0.325	60	106.5	121.2

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	112.6	165.8	0.375	0	118.9	174.7
0.35	5	111.8	163.2	0.375	5	118.4	172.3
0.35	10	111.1	160.4	0.375	10	118.1	169.9
0.35	15	110.5	157.5	0.375	15	117.8	167.4
0.35	20	110.1	154.7	0.375	20	117.7	164.9
0.35	25	109.9	151.7	0.375	25	117.8	162.4
0.35	30	109.9	148.8	0.375	30	118.0	159.9

Chapter 5 Dipoles, Slots, and Loops

0.35	35	110.1	145.8	0.375	35	118.4	157.5
0.35	40	110.5	142.9	0.375	40	119.0	155.2
0.35	45	111.2	140.0	0.375	45	119.7	152.9
0.35	50	112.0	137.4	0.375	50	120.6	150.8
0.35	55	113.1	135.2	0.375	55	121.5	148.8
0.35	60	114.2	133.3	0.375	60	122.5	147.0

Wedge Ground Plane 30° Tilt $\lambda/2$ E -plane sides 1λ H -plane Width

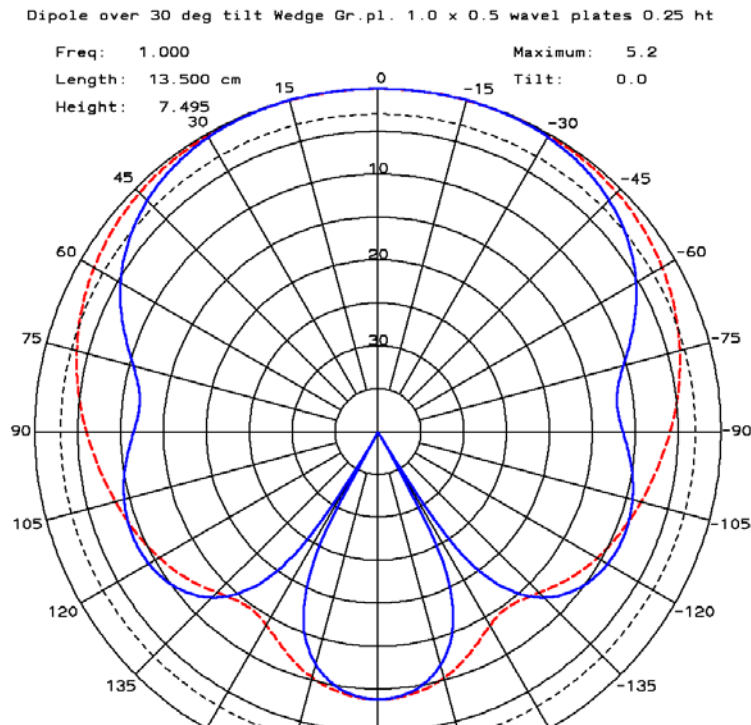


Figure 28 Horizontal Dipole 0.25λ over Wedge Ground Plane 30° $\lambda/2$ sides λ H -plane width E -plane blue (solid) H -plane red (dashed)

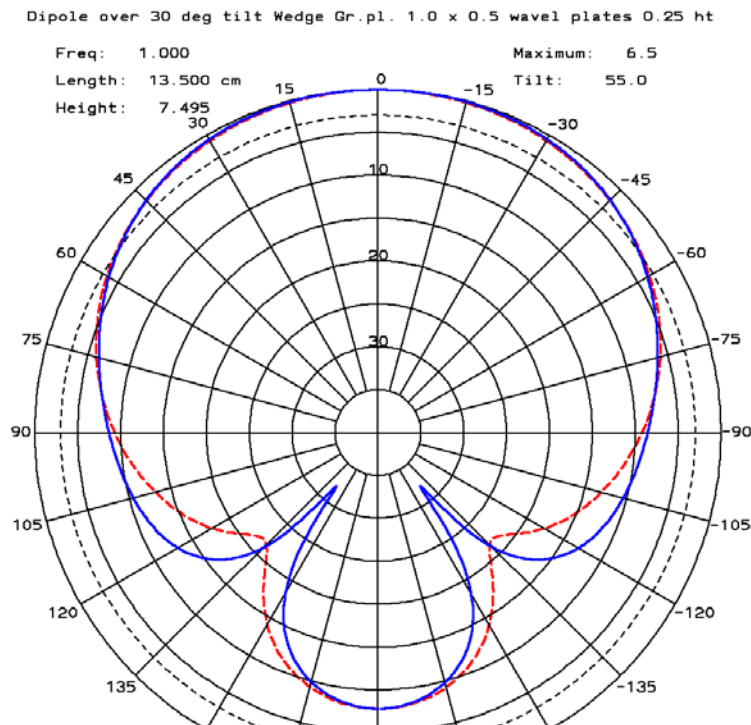


Figure 29 Vee Dipole 55° Tilt 0.25λ over Wedge Ground Plane 30° $\lambda/2$ sides λ H -plane width E -plane blue (solid) H -plane red (dashed)

Table 13 3-dB Beamwidths of Vee Dipole Mounted over Wedge Ground Plane with Ridge along H -plane with $\lambda/2$ E -plane sides tilted down 30° and λ H -plane width for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	87.4	119.3	0.225	0	94.3	129.5
0.20	5	86.9	116.7	0.225	5	93.6	126.2
0.20	10	86.8	114.2	0.225	10	93.2	123.2
0.20	15	87.0	112.0	0.225	15	93.2	120.4
0.20	20	87.6	110.0	0.225	20	93.5	117.8
0.20	25	88.6	108.2	0.225	25	94.2	115.5
0.20	30	90.0	106.6	0.225	30	95.3	113.5
0.20	35	91.9	105.2	0.225	35	96.8	111.7
0.20	40	94.2	104.0	0.225	40	98.7	110.1
0.20	45	96.9	102.9	0.225	45	100.9	108.8
0.20	50	100.2	102.0	0.225	50	103.6	107.6
0.20	55	103.9	101.3	0.225	55	106.5	106.6
0.20	60	108.0	100.7	0.225	60	109.6	105.7
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	102.1	141.7	0.275	0	109.3	153.4
0.25	5	101.2	137.9	0.275	5	108.7	150.1
0.25	10	100.6	134.2	0.275	10	108.3	146.8
0.25	15	100.3	130.8	0.275	15	108.1	143.3
0.25	20	100.4	127.7	0.275	20	108.1	139.7
0.25	25	100.8	124.8	0.275	25	108.4	136.2
0.25	30	101.6	122.2	0.275	30	109.0	133.1
0.25	35	102.8	120.0	0.275	35	110.0	130.2
0.25	40	104.3	117.9	0.275	40	111.2	127.7
0.25	45	106.2	116.2	0.275	45	112.8	125.5
0.25	50	108.4	114.7	0.275	50	114.6	123.6
0.25	55	110.7	113.4	0.275	55	116.5	121.9
0.25	60	113.3	112.2	0.275	60	118.6	120.5
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	115.7	163.4	0.325	0	121.6	172.3
0.30	5	115.4	160.6	0.325	5	121.5	169.7
0.30	10	115.2	157.7	0.325	10	121.6	167.1
0.30	15	115.3	154.7	0.325	15	121.8	164.5
0.30	20	115.5	151.7	0.325	20	122.2	161.8
0.30	25	115.9	148.6	0.325	25	122.8	159.1
0.30	30	116.6	145.6	0.325	30	123.6	156.5
0.30	35	117.5	142.6	0.325	35	124.6	153.9
0.30	40	118.6	139.6	0.325	40	125.7	151.4
0.30	45	120.0	136.9	0.325	45	127.0	149.0
0.30	50	121.5	135.0	0.325	50	128.4	146.7
0.30	55	123.1	132.4	0.325	55	129.8	144.6
0.30	60	124.8	130.6	0.325	60	131.2	142.7
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	127.1	180.5	0.375	0	55.0	73.9
0.35	5	127.2	178.1	0.375	5	60.4	76.1
0.35	10	127.4	175.7	0.375	10	132.9	79.3
0.35	15	127.8	173.2	0.375	15	133.5	85.8
0.35	20	128.4	170.8	0.375	20	134.3	178.9
0.35	25	129.2	168.3	0.375	25	135.3	176.6
0.35	30	130.2	165.9	0.375	30	136.4	174.4
0.35	35	131.2	163.6	0.375	35	137.7	172.2

Chapter 5 Dipoles, Slots, and Loops

0.35	40	132.5	161.3	0.375	40	139.1	170.1
0.35	45	133.8	159.2	0.375	45	140.5	168.2
0.35	50	135.1	157.2	0.375	50	141.9	166.3
0.35	55	136.5	155.3	0.375	55	143.2	164.6
0.35	60	137.8	153.6	0.375	60	144.6	163.0

Wedge Ground Plane 15° Tilt $\lambda/4$ E-plane sides $\lambda/2$ H-plane Width

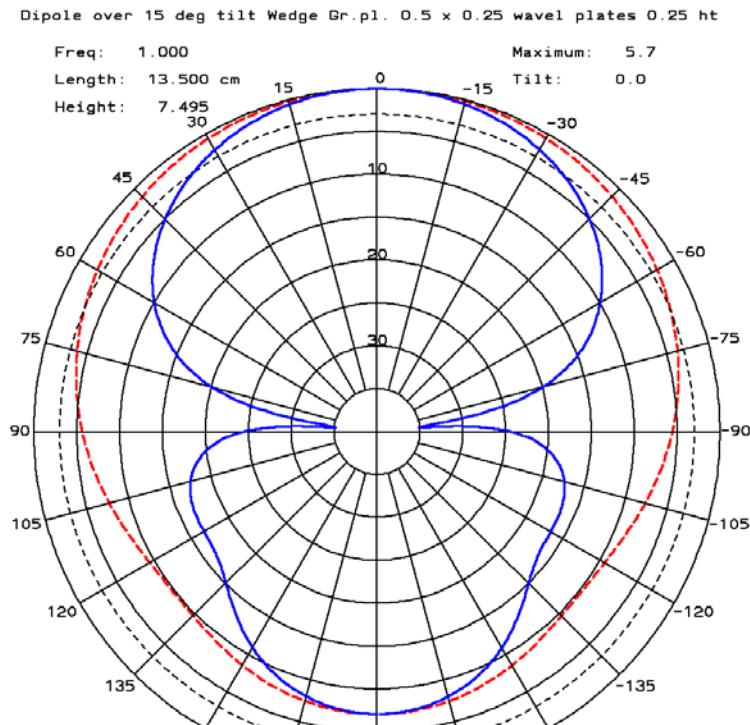


Figure 30 Horizontal Dipole 0.25λ over Wedge Ground Plane 15° $\lambda/4$ sides $\lambda/2$ H-plane width E-plane blue (solid) H-plane red (dashed)

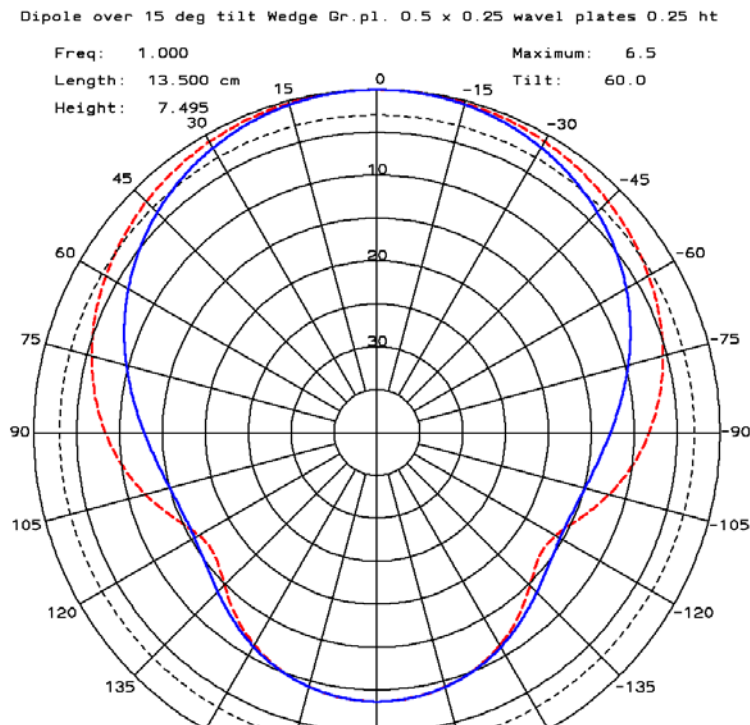


Figure 31 Vee Dipole 55° Tilt 0.25λ over Wedge Ground Plane 30° $\lambda/4$ sides $\lambda/2$ H-plane width E-plane blue (solid) H-plane red (dashed)

Table 14 3-dB Beamwidths of Vee Dipole Mounted over Wedge Ground Plane with Ridge along H -plane with $\lambda/4$ E -plane sides tilted down 15° and $\lambda/2$ H -plane width for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	67.5	122.2	0.225	0	69.4	128.2
0.20	5	67.7	120.3	0.225	5	69.5	126.1
0.20	10	68.1	118.5	0.225	10	69.7	124.0
0.20	15	68.7	116.8	0.225	15	70.2	122.0
0.20	20	69.5	115.1	0.225	20	70.8	120.1
0.20	25	70.5	113.5	0.225	25	71.6	118.3
0.20	30	71.6	111.9	0.225	30	72.6	116.5
0.20	35	73.0	110.3	0.225	35	73.7	114.8
0.20	40	74.5	108.8	0.225	40	75.0	113.2
0.20	45	76.2	107.4	0.225	45	76.4	111.7
0.20	50	78.1	106.1	0.225	50	78.0	110.3
0.20	55	80.1	104.9	0.225	55	79.6	109.0
0.20	60	82.2	103.8	0.225	60	81.2	107.9

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	71.6	135.8	0.275	0	74.2	145.0
0.25	5	71.5	133.2	0.275	5	73.9	142.0
0.25	10	71.6	130.8	0.275	10	73.8	139.1
0.25	15	71.9	128.4	0.275	15	74.0	136.4
0.25	20	72.4	126.2	0.275	20	74.3	133.8
0.25	25	73.0	124.1	0.275	25	74.8	131.3
0.25	30	73.9	122.1	0.275	30	75.5	129.0
0.25	35	74.8	120.3	0.275	35	76.3	126.9
0.25	40	75.9	118.5	0.275	40	77.3	124.8
0.25	45	77.2	116.8	0.275	45	78.3	123.0
0.25	50	78.4	115.3	0.275	50	79.4	121.3
0.25	55	79.8	113.9	0.275	55	80.6	119.7
0.25	60	81.2	112.7	0.275	60	81.8	118.3

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	85.2	129.3	0.325	0	93.5	144.4
0.30	5	84.1	125.7	0.325	5	91.8	140.1
0.30	10	83.2	122.3	0.325	10	90.5	135.9
0.30	15	82.7	119.2	0.325	15	89.6	132.1
0.30	20	82.5	116.4	0.325	20	89.0	128.5
0.30	25	82.6	113.9	0.325	25	88.8	125.3
0.30	30	83.0	111.7	0.325	30	88.9	122.4
0.30	35	83.7	109.7	0.325	35	89.3	119.9
0.30	40	84.7	108.0	0.325	40	90.0	117.6
0.30	45	85.8	106.6	0.325	45	90.9	115.7
0.30	50	87.2	105.4	0.325	50	92.0	114.0
0.30	55	88.6	104.4	0.325	55	93.2	112.6
0.30	60	90.2	103.5	0.325	60	94.6	111.5

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	77.3	156.0	0.375	0	91.1	190.2
0.35	5	76.8	152.5	0.375	5	89.7	187.4
0.35	10	76.5	149.2	0.375	10	88.6	184.5
0.35	15	76.4	146.0	0.375	15	87.8	181.4
0.35	20	76.6	142.9	0.375	20	87.4	178.3
0.35	25	77.0	140.1	0.375	25	87.2	175.1
0.35	30	77.5	137.4	0.375	30	87.2	171.9
0.35	35	78.2	134.9	0.375	35	87.5	168.6

Chapter 5 Dipoles, Slots, and Loops

0.35	40	79.0	132.6	0.375	40	87.9	165.4
0.35	45	80.0	130.4	0.375	45	88.5	162.2
0.35	50	81.0	128.5	0.375	50	89.2	159.3
0.35	55	82.0	126.7	0.375	55	90.0	156.8
0.35	60	83.0	125.1	0.375	60	90.8	154.5

Wedge Ground Plane 20° Tilt $\lambda/4$ E-plane sides $\lambda/2$ H-plane Width

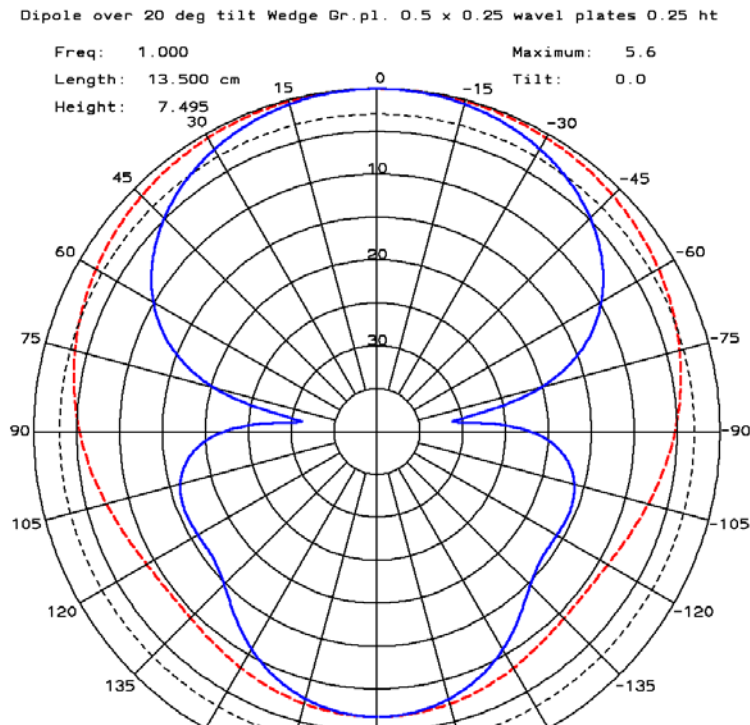


Figure 32 Horizontal Dipole 0.25λ over Wedge Ground Plane 20° $\lambda/4$ sides $\lambda/2$ H-plane width E-plane blue (solid) H-plane red (dashed)

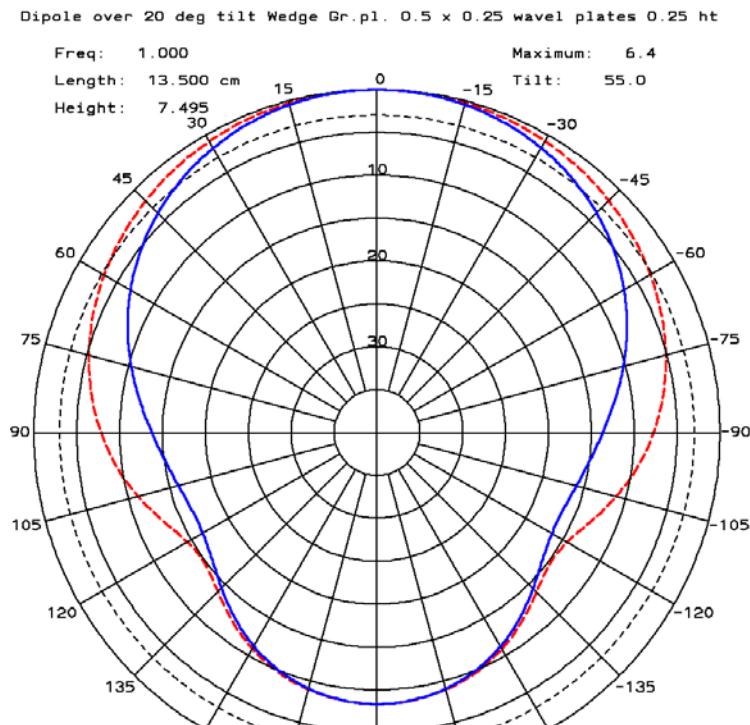


Figure 33 Vee Dipole 55° Tilt 0.25λ over Wedge Ground Plane 20° $\lambda/4$ sides $\lambda/2$ H-plane width E-plane blue (solid) H-plane red (dashed)

Table 15 3-dB Beamwidths of Vee Dipole Mounted over Wedge Ground Plane with Ridge along H -plane with $\lambda/4$ E -plane sides tilted down 20° and $\lambda/2$ H -plane width for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	68.1	125.6	0.225	0	70.3	132.2
0.20	5	68.2	123.6	0.225	5	70.3	129.8
0.20	10	68.6	121.6	0.225	10	70.4	127.6
0.20	15	69.0	119.7	0.225	15	70.8	125.4
0.20	20	69.7	117.8	0.225	20	71.3	123.3
0.20	25	70.6	116.0	0.225	25	72.1	121.3
0.20	30	71.7	114.3	0.225	30	73.0	119.4
0.20	35	72.9	112.6	0.225	35	74.0	117.5
0.20	40	74.3	110.9	0.225	40	75.2	115.8
0.20	45	75.8	109.3	0.225	45	76.5	114.1
0.20	50	77.5	107.8	0.225	50	77.9	112.5
0.20	55	79.3	106.4	0.225	55	79.4	111.0
0.20	60	81.2	105.1	0.225	60	80.9	109.6
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	72.8	140.4	0.275	0	75.8	150.3
0.25	5	72.6	137.6	0.275	5	75.4	147.1
0.25	10	72.6	135.0	0.275	10	75.2	144.0
0.25	15	72.8	132.4	0.275	15	75.2	141.0
0.25	20	73.2	130.0	0.275	20	75.5	138.2
0.25	25	73.8	127.7	0.275	25	75.9	135.5
0.25	30	74.6	125.5	0.275	30	76.5	133.0
0.25	35	75.5	123.5	0.275	35	77.3	130.7
0.25	40	76.5	121.5	0.275	40	78.2	128.4
0.25	45	77.6	119.7	0.275	45	79.2	126.4
0.25	50	78.8	118.0	0.275	50	80.3	124.5
0.25	55	80.1	116.4	0.275	55	81.4	122.7
0.25	60	81.4	114.9	0.275	60	82.5	121.1
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	96.8	143.2	0.325	0	105.3	155.7
0.30	5	95.4	139.1	0.325	5	104.2	152.5
0.30	10	94.3	135.1	0.325	10	103.1	149.2
0.30	15	93.5	131.4	0.325	15	102.1	145.7
0.30	20	93.1	127.9	0.325	20	101.4	142.0
0.30	25	93.0	124.8	0.325	25	101.0	138.2
0.30	30	93.3	122.1	0.325	30	100.9	134.7
0.30	35	93.9	119.6	0.325	35	101.2	131.7
0.30	40	94.8	117.5	0.325	40	101.8	128.9
0.30	45	95.9	115.6	0.325	45	102.7	126.5
0.30	50	97.3	114.0	0.325	50	103.8	124.5
0.30	55	98.9	112.7	0.325	55	105.1	122.7
0.30	60	100.5	111.6	0.325	60	106.5	121.2
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	88.5	185.5	0.375	0	94.5	194.4
0.35	5	87.3	182.4	0.375	5	93.0	191.8
0.35	10	86.4	179.2	0.375	10	91.9	189.0
0.35	15	85.8	175.8	0.375	15	91.0	186.2
0.35	20	85.5	172.3	0.375	20	90.5	183.2
0.35	25	85.5	168.7	0.375	25	90.2	180.2
0.35	30	85.6	165.1	0.375	30	90.2	177.2
0.35	35	86.0	161.6	0.375	35	90.5	174.1

Chapter 5 Dipoles, Slots, and Loops

0.35	40	86.6	158.4	0.375	40	90.9	171.0
0.35	45	87.2	155.4	0.375	45	91.5	168.0
0.35	50	88.0	152.6	0.375	50	92.2	165.1
0.35	55	88.8	150.1	0.375	55	92.9	162.3
0.35	60	89.7	147.9	0.375	60	93.7	159.9

Vee Dipole over 3.0λ diameter 6λ long Cylinder with E -plane along Cylinder Axis

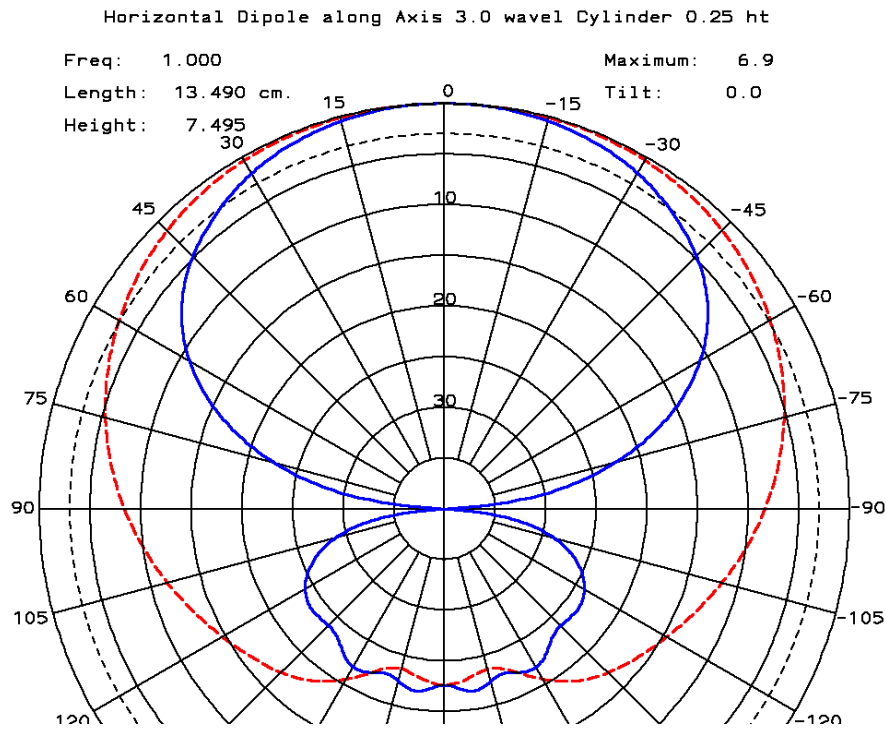


Figure 34 Horizontal Dipole 0.25λ over 3.0λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

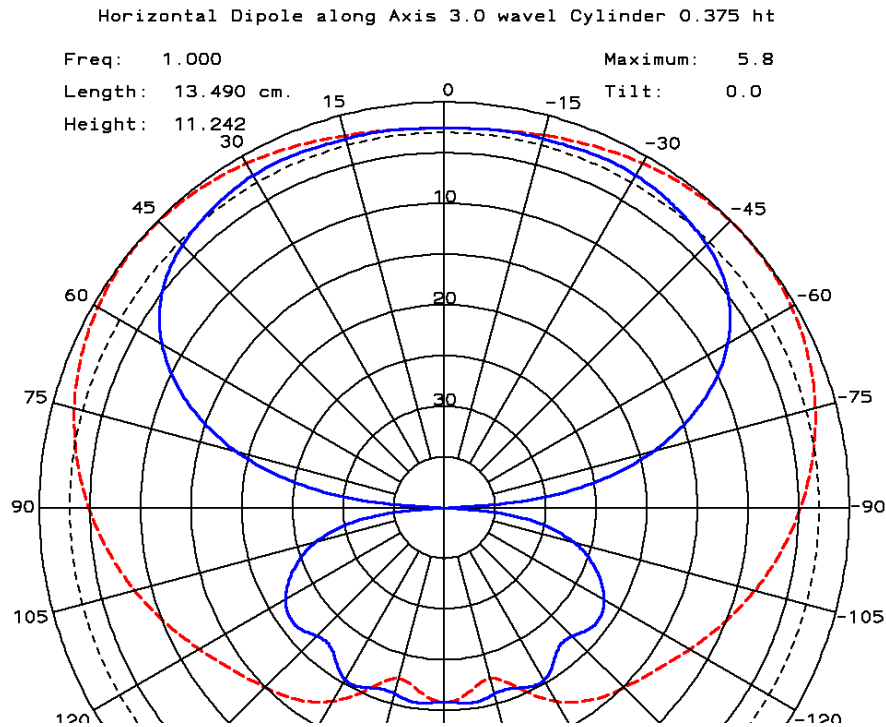


Figure 35 Horizontal Dipole 0.375λ over 3.0λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

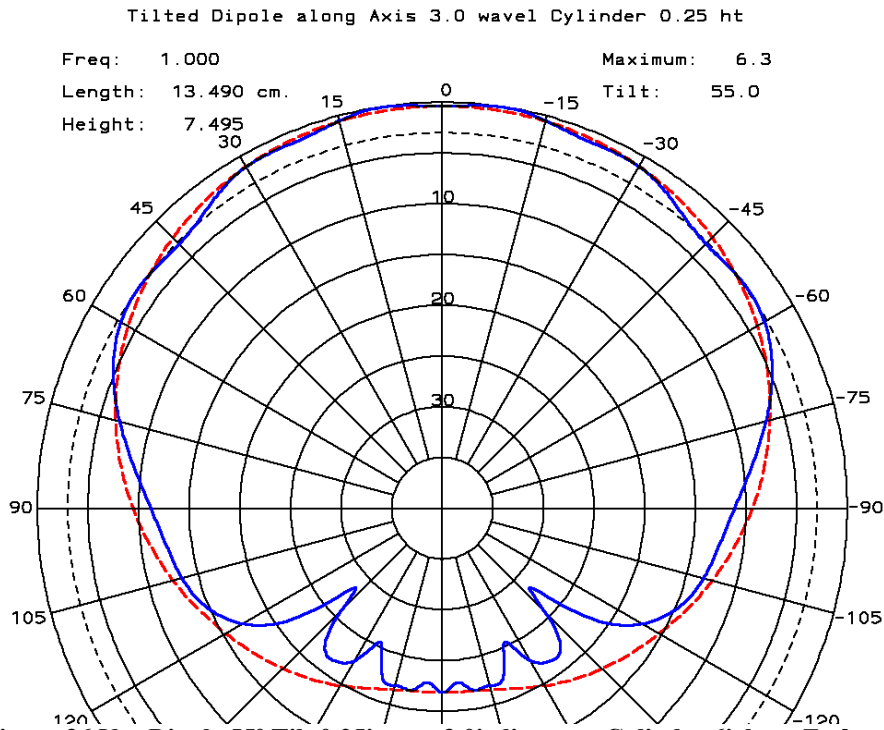


Figure 36 Vee Dipole 55° Tilt 0.25 λ over 3.0 λ diameter Cylinder 6 λ long *E*-plane blue (solid) *H*-plane red (dashed)

Table 16 3-dB Beamwidths of Vee Dipole Mounted over 3.0 λ diameter Cylinder 6 λ long with Axis along *E*-plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	67.7	106.0	0.225	0	70.6	113.4
0.20	5	68.2	104.5	0.225	5	70.7	111.6
0.20	10	69.0	103.2	0.225	10	71.1	109.9
0.20	15	70.3	102.2	0.225	15	71.6	108.4
0.20	20	71.6	101.4	0.225	20	72.4	107.2
0.20	25	73.2	100.8	0.225	25	73.6	106.2
0.20	30	75.3	100.4	0.225	30	74.9	105.4
0.20	35	77.7	100.1	0.225	35	76.6	104.8
0.20	40	81.0	100.0	0.225	40	78.6	104.4
0.20	45	86.7	99.9	0.225	45	81.2	104.1
0.20	50	121.9	100.0	0.225	50	85.4	103.9
				0.225	55	122.0	103.8
				0.225	60	127.7	103.7

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	74.1	122.3	0.275	0	78.6	131.8
0.25	5	73.7	120.0	0.275	5	79.3	129.6
0.25	10	75.6	117.9	0.275	10	76.8	127.4
0.25	15	73.7	116.1	0.275	15	76.4	125.4
0.25	20	74.0	114.5	0.275	20	76.3	123.2
0.25	25	74.6	113.1	0.275	25	76.4	121.5
0.25	30	75.5	111.9	0.275	30	76.8	119.9
0.25	35	76.6	111.0	0.275	35	77.5	118.6
0.25	40	78.0	110.2	0.275	40	78.4	117.6
0.25	45	79.7	109.6	0.275	45	79.5	116.7

Chapter 5 Dipoles, Slots, and Loops

0.25	50	81.8	109.2	0.275	50	80.9	116.0
0.25	55	85.0	108.9	0.275	55	82.6	115.4
0.25	60	122.6	108.6	0.275	60	85.1	115.0
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	85.9	140.1	0.325	0	91.7	147.7
0.30	5	82.4	138.1	0.325	5	89.1	145.9
0.30	10	80.9	136.2	0.325	10	86.7	144.1
0.30	15	79.8	134.4	0.325	15	84.8	142.4
0.30	20	79.2	132.6	0.325	20	83.5	140.8
0.30	25	79.0	130.8	0.325	25	82.6	139.2
0.30	30	79.0	129.2	0.325	30	82.0	137.8
0.30	35	79.2	127.7	0.325	35	81.9	136.4
0.30	40	79.7	126.3	0.325	40	82.0	135.2
0.30	45	80.4	125.2	0.325	45	82.4	134.1
0.30	50	81.4	124.2	0.325	50	83.0	133.2
0.30	55	82.5	123.4	0.325	55	83.8	132.3
0.30	60	84.0	122.8	0.325	60	84.8	131.6
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	99.9	155.0	0.375	0	106.8	161.1
0.35	5	97.2	153.0	0.375	5	105.7	159.5
0.35	10	94.4	151.4	0.375	10	104.0	158.0
0.35	15	91.9	149.8	0.375	15	101.7	156.5
0.35	20	89.8	148.3	0.375	20	99.3	155.1
0.35	25	88.1	146.8	0.375	25	97.2	153.8
0.35	30	86.9	145.5	0.375	30	95.3	152.5
0.35	35	86.1	144.3	0.375	35	93.8	151.4
0.35	40	85.8	143.1	0.375	40	92.7	150.3
0.35	45	85.8	142.1	0.375	45	92.2	149.4
0.35	50	86.0	141.2	0.375	50	92.6	148.5
0.35	55	86.5	140.5	0.375	55	94.8	147.8
0.35	60	87.3	139.8	0.375	60	123.4	147.2

Vee Dipole over 2.5λ diameter 6λ long Cylinder with E -plane along Cylinder Axis

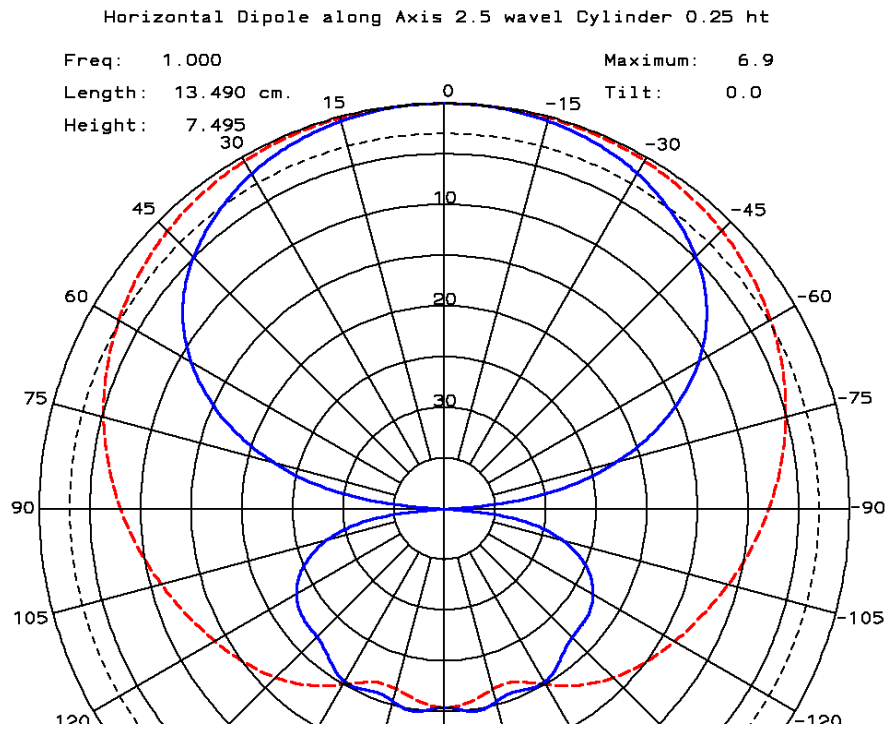


Figure 37 Horizontal Dipole 0.25λ over 2.5λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

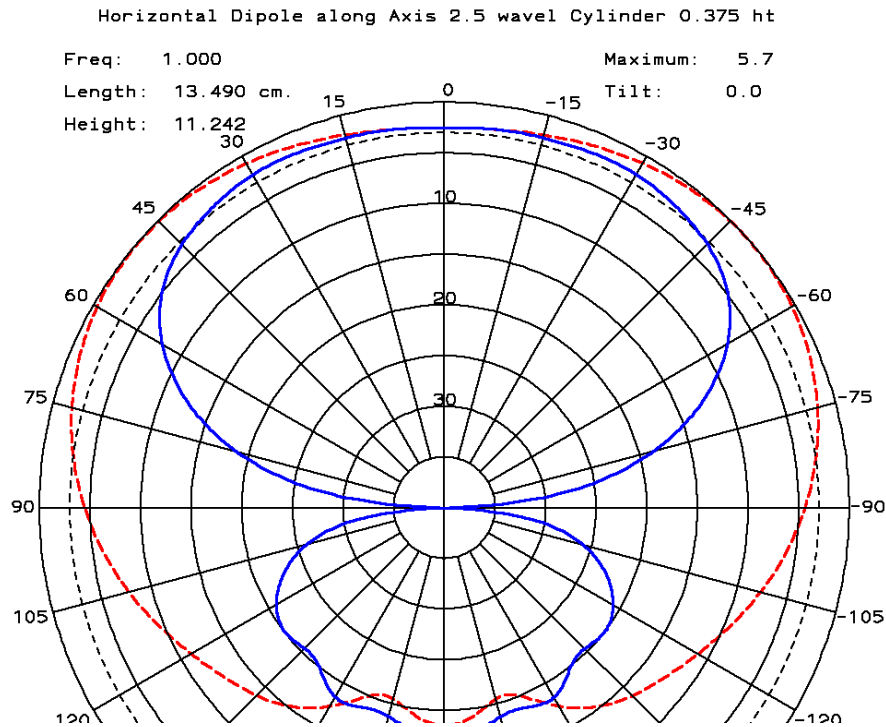


Figure 38 Horizontal Dipole 0.375λ over 2.5λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

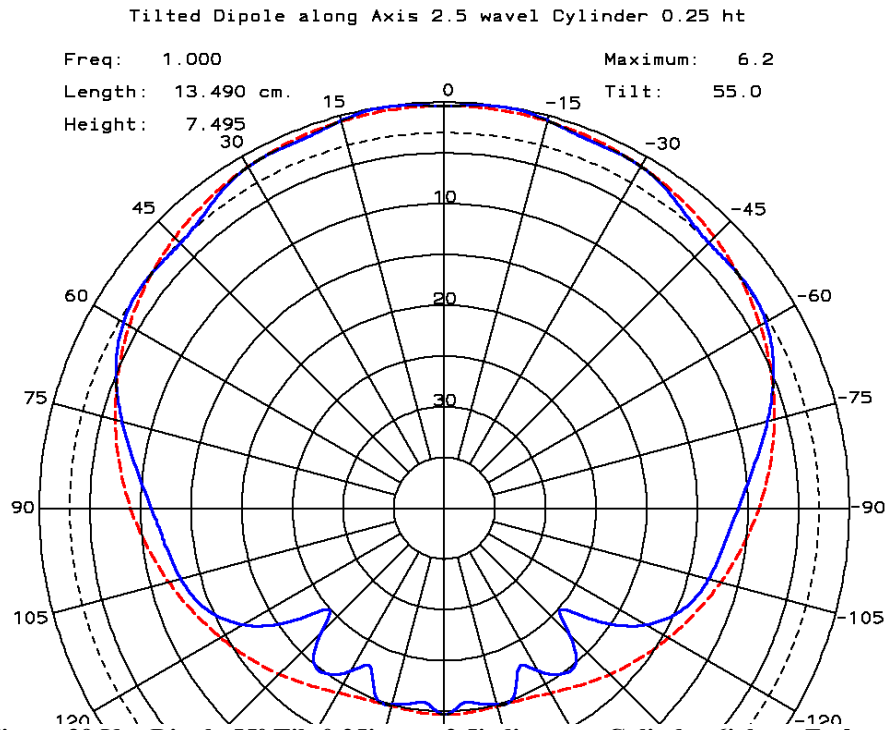


Figure 39 Vee Dipole 55° Tilt 0.25λ over 2.5λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

Table 17 3-dB Beamwidths of Vee Dipole Mounted over 2.5λ diameter Cylinder 6λ long with Axis along E -plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	67.2	106.7	0.225	0	70.0	113.8
0.20	5	67.8	105.3	0.225	5	70.2	111.8
0.20	10	69.3	104.2	0.225	10	70.3	110.2
0.20	15	69.9	103.2	0.225	15	70.4	108.9
0.20	20	71.5	102.5	0.225	20	72.3	107.7
0.20	25	73.4	102.0	0.225	25	73.5	106.8
0.20	30	75.6	101.6	0.225	30	75.1	106.1
0.20	35	78.3	101.4	0.225	35	77.0	105.5
0.20	40	82.0	101.3	0.225	40	79.4	105.2
0.20	45	92.2	101.2	0.225	45	82.6	104.9
0.20	50	120.9	101.4	0.225	50	89.3	104.8
				0.225	55	120.9	104.7
				0.225	60	126.9	104.6

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	73.6	123.0	0.275	0	78.2	133.3
0.25	5	73.2	120.6	0.275	5	79.0	130.8
0.25	10	75.2	118.4	0.275	10	73.8	128.3
0.25	15	73.4	116.5	0.275	15	76.3	126.0
0.25	20	73.8	114.9	0.275	20	75.9	123.8
0.25	25	74.5	113.5	0.275	25	75.9	122.0
0.25	30	75.5	112.4	0.275	30	76.2	120.4
0.25	35	76.9	111.4	0.275	35	76.8	119.1
0.25	40	78.5	110.7	0.275	40	77.6	118.0
0.25	45	80.5	110.2	0.275	45	78.7	117.1

Chapter 5 Dipoles, Slots, and Loops

0.25	50	83.2	109.8	0.275	50	80.1	116.4
0.25	55	88.2	109.5	0.275	55	81.8	115.9
0.25	60	121.7	109.2	0.275	60	84.1	115.5
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	85.5	142.6	0.325	0	91.3	150.8
0.30	5	82.2	140.4	0.325	5	88.6	148.8
0.30	10	80.6	138.2	0.325	10	86.4	147.0
0.30	15	79.6	136.1	0.325	15	84.6	145.1
0.30	20	79.0	134.1	0.325	20	83.3	143.3
0.30	25	78.7	132.1	0.325	25	82.5	141.5
0.30	30	78.8	130.2	0.325	30	82.0	139.9
0.30	35	79.3	128.4	0.325	35	81.9	138.4
0.30	40	79.9	127.0	0.325	40	82.2	137.0
0.30	45	80.8	125.8	0.325	45	82.8	135.7
0.30	50	82.0	124.8	0.325	50	83.6	134.6
0.30	55	83.6	124.0	0.325	55	84.7	133.6
0.30	60	85.9	123.3	0.325	60	86.4	132.7
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	99.5	158.1	0.375	0	106.3	164.8
0.35	5	96.8	156.4	0.375	5	105.3	163.2
0.35	10	94.1	154.7	0.375	10	103.8	161.6
0.35	15	91.5	153.0	0.375	15	101.6	160.1
0.35	20	89.5	151.4	0.375	20	99.2	158.6
0.35	25	88.0	149.8	0.375	25	97.1	157.2
0.35	30	86.9	148.4	0.375	30	95.5	155.9
0.35	35	86.2	147.0	0.375	35	94.4	154.6
0.35	40	85.9	145.8	0.375	40	93.8	153.5
0.35	45	86.1	144.6	0.375	45	93.9	152.5
0.35	50	86.7	143.6	0.375	50	111.6	151.6
0.35	55	87.8	142.7	0.375	55	119.2	150.8
0.35	60	89.8	142.0	0.375	60	123.7	150.1

Vee Dipole over 2.0λ diameter 6λ long Cylinder with E -plane along Cylinder Axis

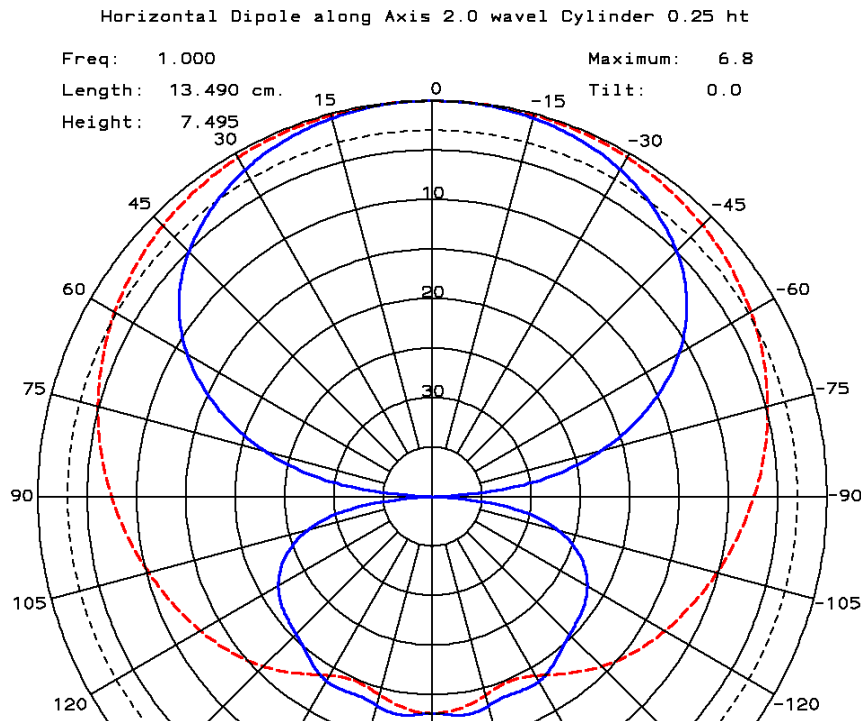


Figure 40 Horizontal Dipole 0.25λ over 2.0λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

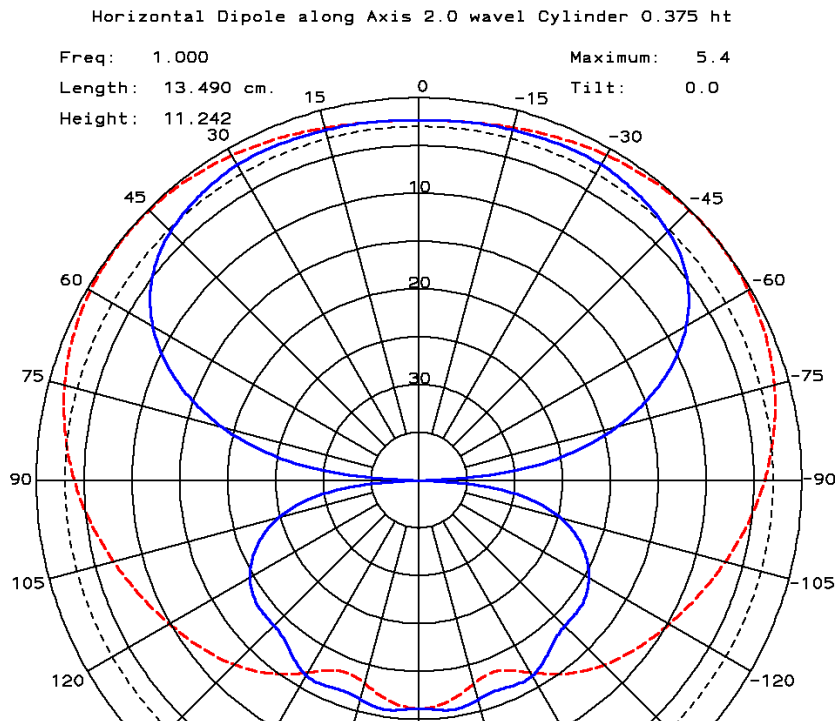


Figure 41 Horizontal Dipole 0.375λ over 2.0λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

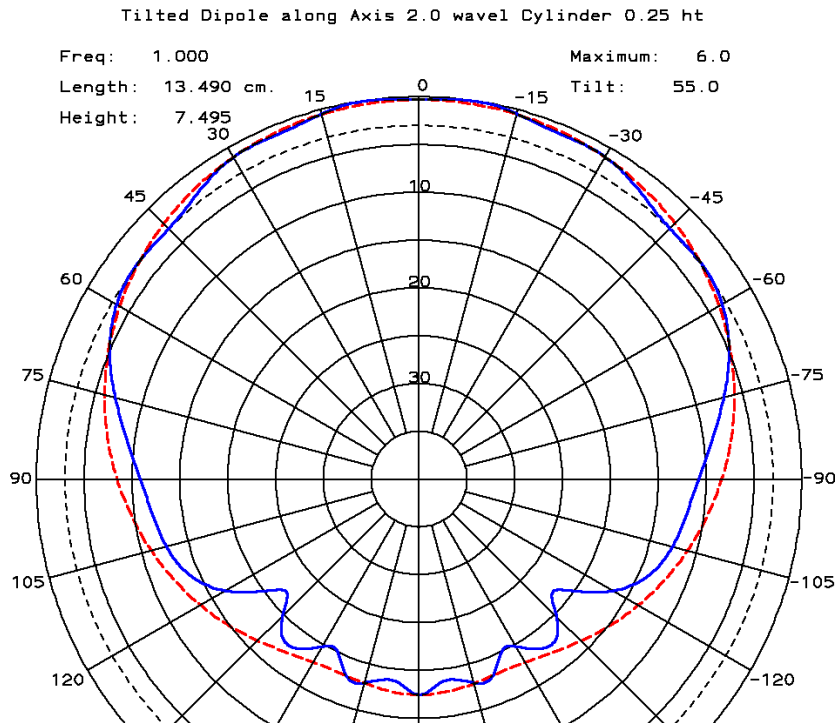


Figure 42 Vee Dipole 55° Tilt 0.25 λ over 2.0 λ diameter Cylinder 6 λ long *E*-plane along Axis *E*-plane blue (solid) *H*-plane red (dashed)

Table 18 3-dB Beamwidths of Vee Dipole Mounted over 2.0 λ diameter Cylinder 6 λ long with Axis along *E*-plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	66.5	108.5	0.225	0	69.3	115.6
0.20	5	67.2	107.3	0.225	5	69.4	113.7
0.20	10	68.4	106.3	0.225	10	70.2	112.0
0.20	15	72.3	105.5	0.225	15	71.0	110.7
0.20	20	71.4	104.9	0.225	20	72.2	109.6
0.20	25	73.5	104.5	0.225	25	73.6	108.8
0.20	30	76.0	104.2	0.225	30	75.4	108.1
0.20	35	79.1	104.0	0.225	35	77.6	107.6
0.20	40	83.4	103.9	0.225	40	80.3	107.3
0.20	45	105.9	103.9	0.225	45	84.2	107.1
0.20	50	119.6	104.1	0.225	50	108.6	107.0
				0.225	55	119.6	106.9
				0.225	60	125.7	106.8

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	72.9	124.5	0.275	0	69.3	115.6
0.25	5	72.5	122.2	0.275	5	69.4	113.7
0.25	10	74.8	120.0	0.275	10	70.2	112.0
0.25	15	72.8	118.1	0.275	15	71.0	110.7
0.25	20	73.5	116.5	0.275	20	72.2	109.6
0.25	25	74.5	115.1	0.275	25	73.6	108.8
0.25	30	75.7	114.0	0.275	30	75.4	108.1
0.25	35	77.2	113.2	0.275	35	77.6	107.6
0.25	40	79.1	112.5	0.275	40	80.3	107.3
0.25	45	81.6	111.9	0.275	45	84.2	107.1

Chapter 5 Dipoles, Slots, and Loops

0.25	50	85.2	111.6	0.275	50	108.6	107.0
0.25	55	112.2	111.3	0.275	55	119.6	106.9
0.25	60	120.3	111.1	0.275	60	125.7	106.8
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	84.7	145.7	0.325	0	90.4	154.7
0.30	5	81.5	143.2	0.325	5	87.8	152.6
0.30	10	80.1	140.7	0.325	10	85.6	150.5
0.30	15	78.7	138.2	0.325	15	84.1	148.4
0.30	20	77.4	135.9	0.325	20	83.0	146.3
0.30	25	78.6	133.5	0.325	25	82.3	144.3
0.30	30	78.8	131.5	0.325	30	82.1	142.3
0.30	35	79.4	129.8	0.325	35	82.4	140.7
0.30	40	80.4	128.3	0.325	40	82.5	139.0
0.30	45	81.6	127.1	0.325	45	83.4	137.5
0.30	50	83.2	126.1	0.325	50	84.7	136.1
0.30	55	85.5	125.2	0.325	55	86.8	135.0
0.30	60	90.8	124.6	0.325	60	90.9	134.1
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	98.6	162.5	0.375	0	105.3	169.4
0.35	5	96.0	160.7	0.375	5	104.5	167.8
0.35	10	93.3	158.8	0.375	10	103.0	166.2
0.35	15	90.8	157.1	0.375	15	100.9	164.6
0.35	20	89.0	155.3	0.375	20	98.7	163.0
0.35	25	87.7	153.6	0.375	25	96.8	161.5
0.35	30	86.9	151.9	0.375	30	95.6	160.1
0.35	35	86.5	150.4	0.375	35	95.2	158.7
0.35	40	86.6	149.0	0.375	40	95.8	157.5
0.35	45	87.1	147.7	0.375	45	100.3	156.4
0.35	50	88.2	146.5	0.375	50	112.9	155.4
0.35	55	90.8	145.5	0.375	55	118.9	154.5
0.35	60	117.8	144.6	0.375	60	123.2	153.7

Vee Dipole over 1.5λ diameter 6λ long Cylinder with E -plane along Cylinder Axis

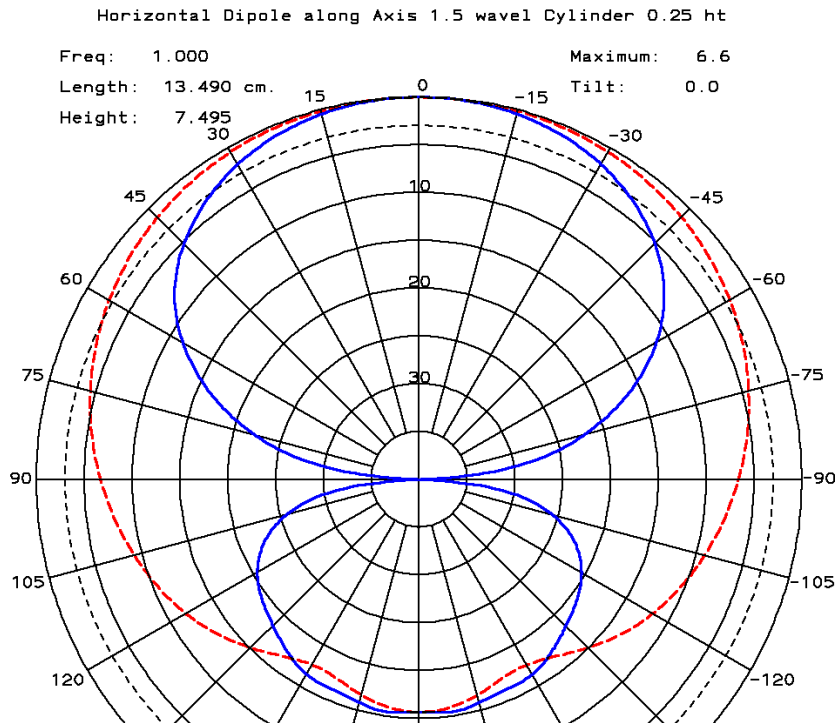


Figure 43 Horizontal Dipole 0.25λ over 1.5λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

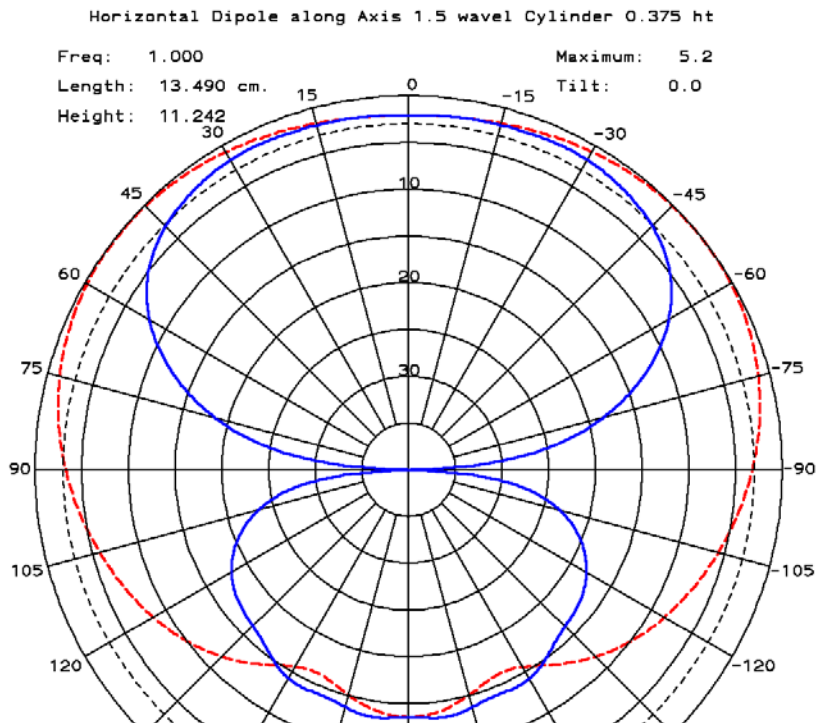


Figure 44 Horizontal Dipole 0.375λ over 1.5λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

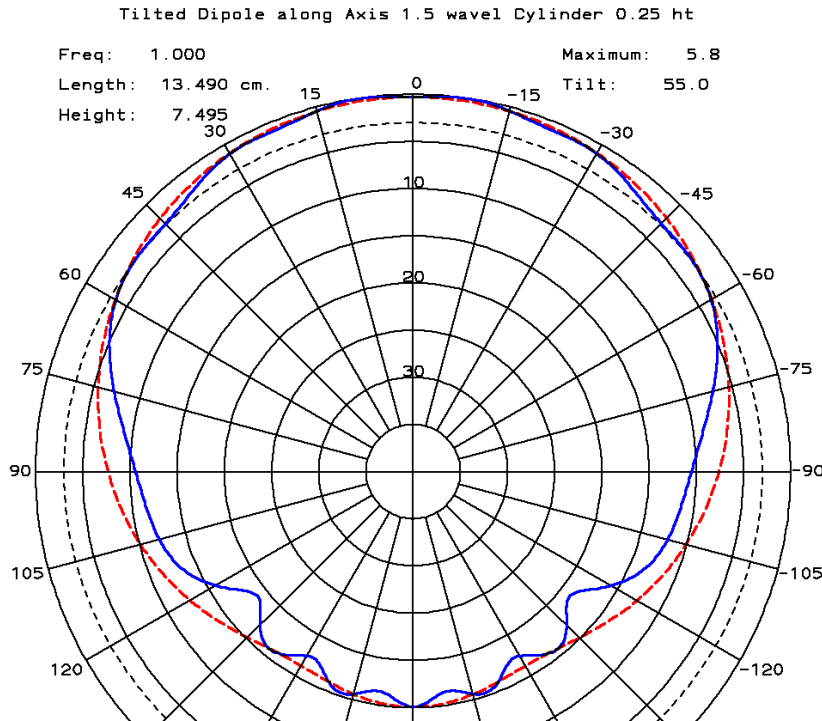


Figure 45 Vee Dipole 55° Tilt 0.25 λ over 1.5 λ diameter Cylinder 6 λ long *E*-plane along Axis *E*-plane blue (solid) *H*-plane red (dashed)

Table 19 3-dB Beamwidths of Vee Dipole Mounted over 1.5 λ diameter Cylinder 6 λ long with Axis along *E*-plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	65.7	113.5	0.225	0	68.4	120.1
0.20	5	66.5	112.2	0.225	5	68.7	118.3
0.20	10	67.9	111.1	0.225	10	69.3	116.7
0.20	15	72.3	110.4	0.225	15	73.1	115.3
0.20	20	71.6	109.8	0.225	20	72.0	114.2
0.20	25	73.8	109.4	0.225	25	73.8	113.4
0.20	30	76.6	109.1	0.225	30	75.8	112.8
0.20	35	80.1	108.9	0.225	35	78.3	112.3
0.20	40	85.2	108.8	0.225	40	81.4	112.0
0.20	45	104.2	108.8	0.225	45	86.4	111.7
0.20	50	117.8	109.0	0.225	50	106.6	111.6
				0.225	55	117.8	111.6
				0.225	60	124.0	111.4

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	71.8	128.7	0.275	0	76.1	139.3
0.25	5	71.6	126.3	0.275	5	75.4	136.4
0.25	10	71.9	124.2	0.275	10	77.1	133.7
0.25	15	74.5	122.4	0.275	15	74.9	131.3
0.25	20	73.1	120.7	0.275	20	75.1	129.2
0.25	25	74.3	119.4	0.275	25	75.8	127.4
0.25	30	75.9	118.3	0.275	30	76.8	125.8
0.25	35	77.8	117.4	0.275	35	78.2	124.5
0.25	40	80.0	116.8	0.275	40	79.9	123.4
0.25	45	83.0	116.2	0.275	45	82.2	122.5
0.25	50	87.9	115.8	0.275	50	85.1	121.8

Chapter 5 Dipoles, Slots, and Loops

0.25	55	109.9	115.6	0.275	55	91.4	121.3
0.25	60	118.5	115.3	0.275	60	113.7	120.9
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	81.7	151.0	0.325	0	89.7	161.2
0.30	5	81.8	148.1	0.325	5	86.4	158.7
0.30	10	79.2	145.2	0.325	10	84.7	156.2
0.30	15	78.6	142.3	0.325	15	83.4	153.8
0.30	20	78.3	139.7	0.325	20	82.6	151.4
0.30	25	78.4	137.4	0.325	25	82.2	149.0
0.30	30	78.8	135.3	0.325	30	82.2	146.8
0.30	35	79.6	133.6	0.325	35	82.5	145.0
0.30	40	80.9	132.0	0.325	40	83.3	142.7
0.30	45	82.6	130.8	0.325	45	84.6	141.1
0.30	50	85.0	129.7	0.325	50	86.7	139.7
0.30	55	88.7	128.9	0.325	55	90.4	138.5
0.30	60	111.0	128.3	0.325	60	111.8	137.6
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	96.8	169.7	0.375	0	103.8	177.1
0.35	5	94.2	167.7	0.375	5	102.9	175.3
0.35	10	91.7	165.7	0.375	10	101.1	173.6
0.35	15	89.8	163.6	0.375	15	99.1	171.8
0.35	20	88.5	161.5	0.375	20	97.2	170.1
0.35	25	87.6	159.5	0.375	25	96.1	168.4
0.35	30	87.1	157.6	0.375	30	95.7	166.8
0.35	35	87.2	155.8	0.375	35	96.2	165.2
0.35	40	87.7	154.2	0.375	40	98.2	163.8
0.35	45	88.9	152.6	0.375	45	104.1	162.4
0.35	50	91.5	151.2	0.375	50	111.9	161.2
0.35	55	108.5	150.0	0.375	55	117.4	160.2
0.35	60	116.1	148.9	0.375	60	121.5	159.3

Vee Dipole over 1.0λ diameter 6λ long Cylinder with E -plane along Cylinder Axis

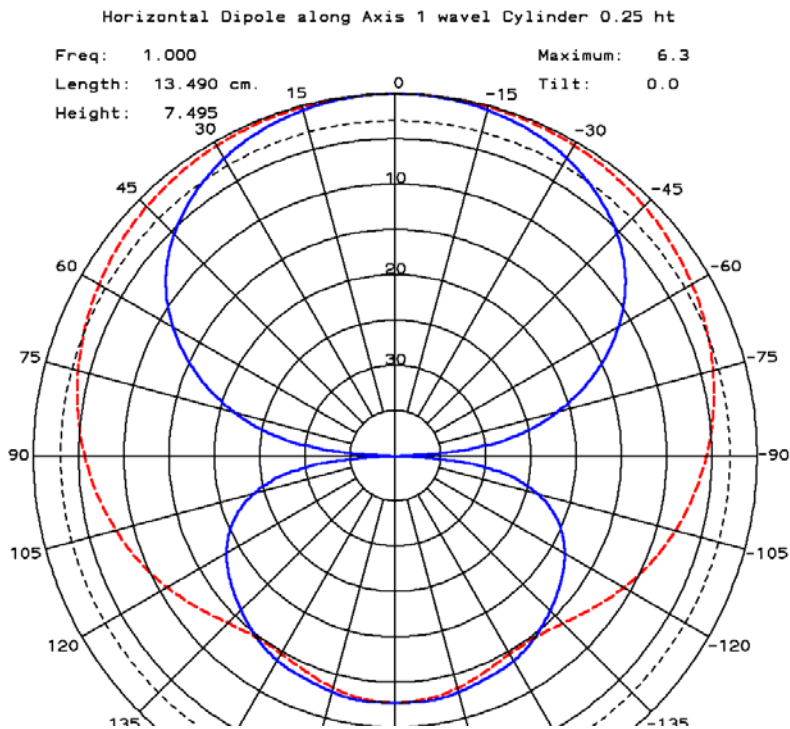


Figure 46 Horizontal Dipole 0.25λ over 1.0λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

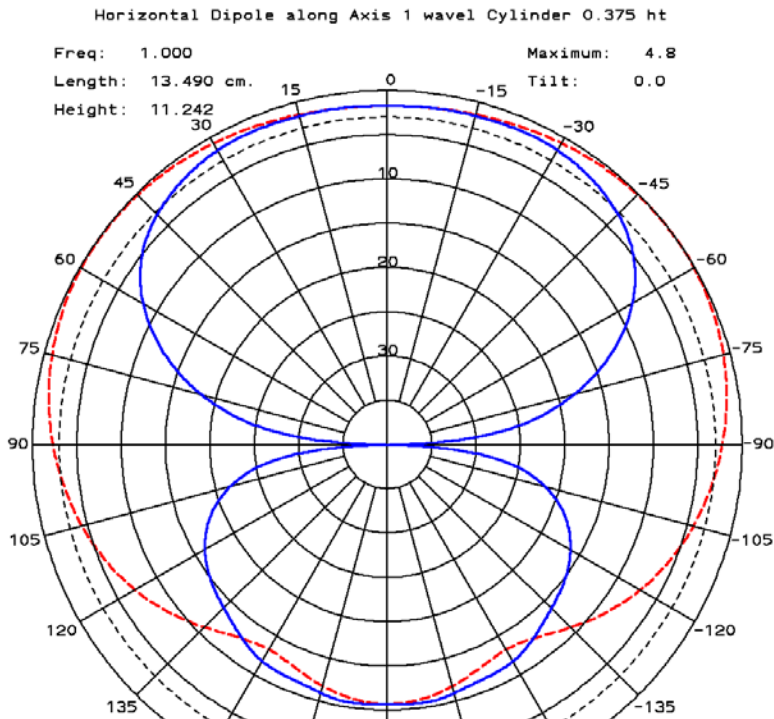


Figure 47 Horizontal Dipole 0.375λ over 1.0λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

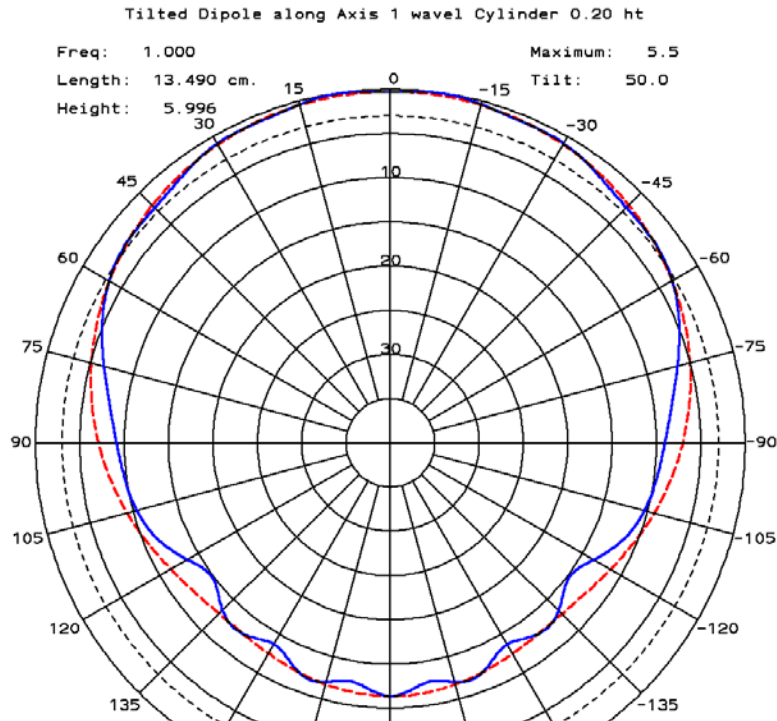


Figure 48 Vee Dipole 50° Tilt 0.20 λ over 1.0 λ diameter Cylinder 6 λ long *E*-plane along Axis *E*-plane blue (solid) *H*-plane red (dashed)

Table 20 3-dB Beamwidths of Vee Dipole Mounted over 1.0 λ diameter Cylinder 6 λ long with Axis along *E*-plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	64.8	123.1	0.225	0	67.3	129.7
0.20	5	65.9	121.7	0.225	5	67.7	127.8
0.20	10	67.4	120.5	0.225	10	68.7	126.1
0.20	15	69.5	119.5	0.225	15	70.3	124.6
0.20	20	74.2	118.7	0.225	20	74.5	123.4
0.20	25	74.2	118.2	0.225	25	74.0	122.4
0.20	30	77.4	117.8	0.225	30	76.4	121.7
0.20	35	81.2	117.6	0.225	35	79.3	121.1
0.20	40	87.1	117.3	0.225	40	83.0	120.7
0.20	45	102.3	117.2	0.225	45	88.9	120.4
0.20	50	115.6	117.5	0.225	50	103.7	120.2
				0.225	55	115.0	120.2
				0.225	60	121.8	119.9
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	70.4	138.5	0.275	0	74.4	149.5
0.25	5	70.4	135.9	0.275	5	73.9	146.3
0.25	10	70.8	133.7	0.275	10	73.8	143.5
0.25	15	73.4	131.7	0.275	15	76.2	140.9
0.25	20	72.8	130.0	0.275	20	74.5	138.7
0.25	25	74.4	128.5	0.275	25	75.5	136.7
0.25	30	76.2	127.3	0.275	30	76.9	135.0
0.25	35	78.5	126.3	0.275	35	78.7	133.6
0.25	40	81.3	125.6	0.275	40	80.8	132.4
0.25	45	85.0	125.0	0.275	45	83.6	131.4

Chapter 5 Dipoles, Slots, and Loops

0.25	50	91.4	124.5	0.275	50	87.6	130.6
0.25	55	106.5	124.2	0.275	55	96.9	130.0
0.25	60	115.3	123.9	0.275	60	110.2	129.6
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	79.6	162.2	0.325	0	87.0	173.5
0.30	5	78.5	158.9	0.325	5	84.3	170.6
0.30	10	79.6	155.5	0.325	10	82.9	167.8
0.30	15	77.4	152.3	0.325	15	82.0	165.0
0.30	20	77.4	149.5	0.325	20	81.4	162.1
0.30	25	77.8	147.0	0.325	25	81.4	159.4
0.30	30	78.6	144.8	0.325	30	81.6	156.8
0.30	35	79.9	142.9	0.325	35	82.4	154.4
0.30	40	81.6	141.2	0.325	40	83.7	152.3
0.30	45	83.8	139.9	0.325	45	85.6	150.5
0.30	50	87.0	138.7	0.325	50	88.5	149.0
0.30	55	92.5	137.8	0.325	55	94.0	147.7
0.30	60	106.5	137.1	0.325	60	106.9	146.7
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	93.7	183.2	0.375	0	101.1	191.7
0.35	5	91.6	180.7	0.375	5	100.1	189.6
0.35	10	89.8	178.2	0.375	10	98.5	187.4
0.35	15	88.4	175.8	0.375	15	97.1	185.2
0.35	20	87.3	173.4	0.375	20	96.0	183.0
0.35	25	86.7	171.0	0.375	25	95.3	181.0
0.35	30	86.6	168.8	0.375	30	95.2	179.0
0.35	35	87.0	166.7	0.375	35	95.9	177.1
0.35	40	88.0	164.7	0.375	40	97.9	175.4
0.35	45	89.9	162.9	0.375	45	102.2	173.8
0.35	50	93.8	161.2	0.375	50	108.3	172.4
0.35	55	103.5	159.7	0.375	55	113.8	171.1
0.35	60	111.8	158.4	0.375	60	118.0	170.0

Vee Dipole over 0.5λ diameter 6λ long Cylinder with E -plane along Cylinder Axis

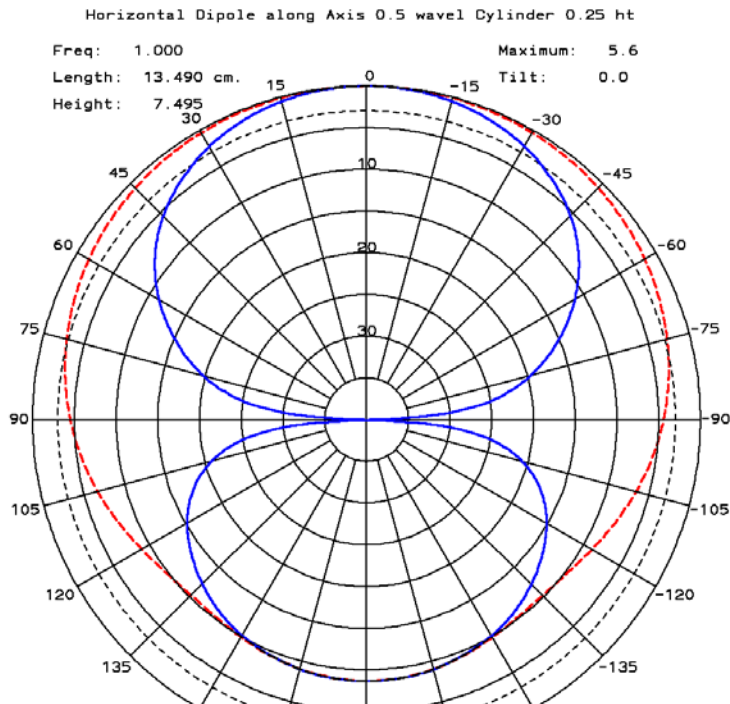


Figure 49 Horizontal Dipole 0.25λ over 0.5λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

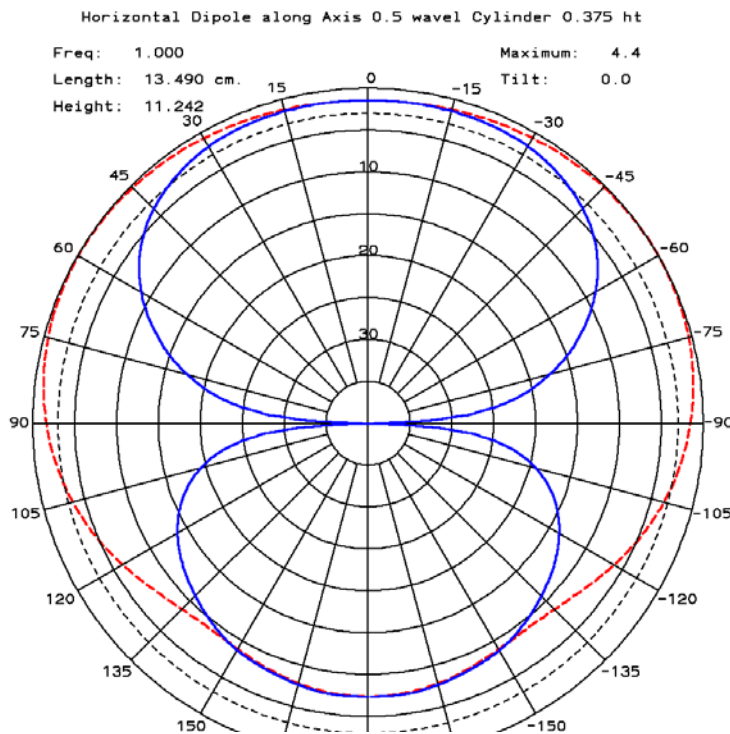


Figure 50 Horizontal Dipole 0.375λ over 0.5λ diameter Cylinder 6λ long E -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

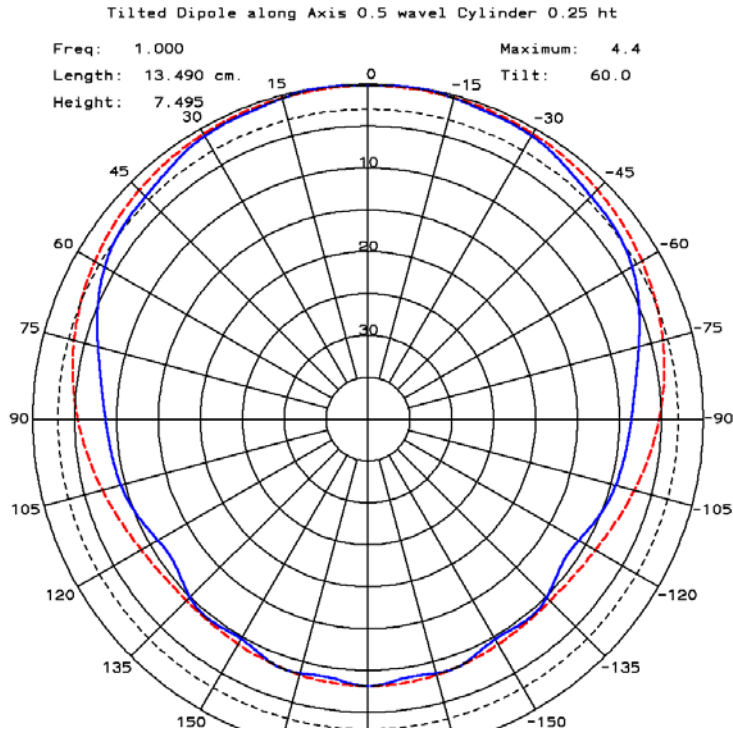


Figure 51 Vee Dipole 60° Tilt 0.25 λ over 0.5 λ diameter Cylinder 6 λ long *E*-plane along Axis *E*-plane blue (solid) *H*-plane red (dashed)

Table 21 3-dB Beamwidths of Vee Dipole Mounted over 0.5 λ diameter Cylinder 6 λ long with Axis along *E*-plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	64.7	139.3	0.225	0	66.7	146.2
0.20	5	65.9	137.7	0.225	5	67.4	144.1
0.20	10	67.4	136.4	0.225	10	68.5	142.3
0.20	15	69.4	135.3	0.225	15	70.0	140.7
0.20	20	72.1	134.5	0.225	20	72.0	139.4
0.20	25	77.6	133.9	0.225	25	77.0	138.4
0.20	30	78.4	133.6	0.225	30	77.0	137.6
0.20	35	82.6	133.5	0.225	35	80.3	137.0
0.20	40	88.9	133.6	0.225	40	84.5	136.7
0.20	45	99.5	133.8	0.225	45	90.5	136.5
0.20	50	111.2	134.1	0.225	50	100.4	136.5
				0.225	55	110.4	136.5
				0.225	60	117.7	136.7

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	69.2	155.0	0.275	0	72.4	165.7
0.25	5	69.5	152.4	0.275	5	72.3	162.6
0.25	10	70.2	150.1	0.275	10	72.6	159.8
0.25	15	71.3	148.0	0.275	15	73.3	157.2
0.25	20	72.9	146.2	0.275	20	75.5	154.9
0.25	25	77.2	144.7	0.275	25	78.2	152.9
0.25	30	76.8	143.5	0.275	30	77.4	151.2
0.25	35	79.4	142.5	0.275	35	79.5	149.8
0.25	40	82.6	141.7	0.275	40	82.1	148.6
0.25	45	86.8	141.1	0.275	45	85.3	147.6

Chapter 5 Dipoles, Slots, and Loops

0.25	50	92.9	140.7	0.275	50	89.8	146.9
0.25	55	102.1	140.5	0.275	55	96.5	146.3
0.25	60	110.3	140.3	0.275	60	104.7	145.9
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	76.5	177.5	0.325	0	81.8	187.6
0.30	5	76.0	174.4	0.325	5	80.7	185.0
0.30	10	75.8	171.3	0.325	10	80.7	182.4
0.30	15	76.2	168.2	0.325	15	81.7	179.8
0.30	20	76.9	165.5	0.325	20	80.0	177.2
0.30	25	77.6	163.0	0.325	25	80.6	174.7
0.30	30	79.0	160.8	0.325	30	81.5	172.2
0.30	35	80.6	159.0	0.325	35	82.9	170.0
0.30	40	82.8	157.4	0.325	40	84.7	168.0
0.30	45	85.5	156.0	0.325	45	87.1	166.3
0.30	50	89.1	154.9	0.325	50	90.4	164.8
0.30	55	94.2	154.0	0.325	55	95.0	163.6
0.30	60	101.4	153.4	0.325	60	101.2	162.7
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	88.3	196.1	0.375	0	95.6	203.4
0.35	5	86.8	194.0	0.375	5	94.0	201.6
0.35	10	85.6	191.8	0.375	10	92.6	199.7
0.35	15	85.0	189.6	0.375	15	91.6	197.8
0.35	20	84.6	187.4	0.375	20	91.0	196.0
0.35	25	84.8	185.2	0.375	25	90.8	194.1
0.35	30	85.4	183.2	0.375	30	91.4	192.4
0.35	35	86.5	181.2	0.375	35	92.3	190.7
0.35	40	88.2	179.4	0.375	40	94.1	189.1
0.35	45	90.6	177.7	0.375	45	96.8	187.6
0.35	50	94.0	176.2	0.375	50	100.7	186.3
0.35	55	98.8	174.8	0.375	55	105.4	185.1
0.35	60	104.4	173.7	0.375	60	109.4	184.1

Vee Dipole over Cylinder with Dipole Tilted over Cylinder

Vee Dipole over 3λ diameter 6λ long Cylinder with H -plane along Cylinder Axis

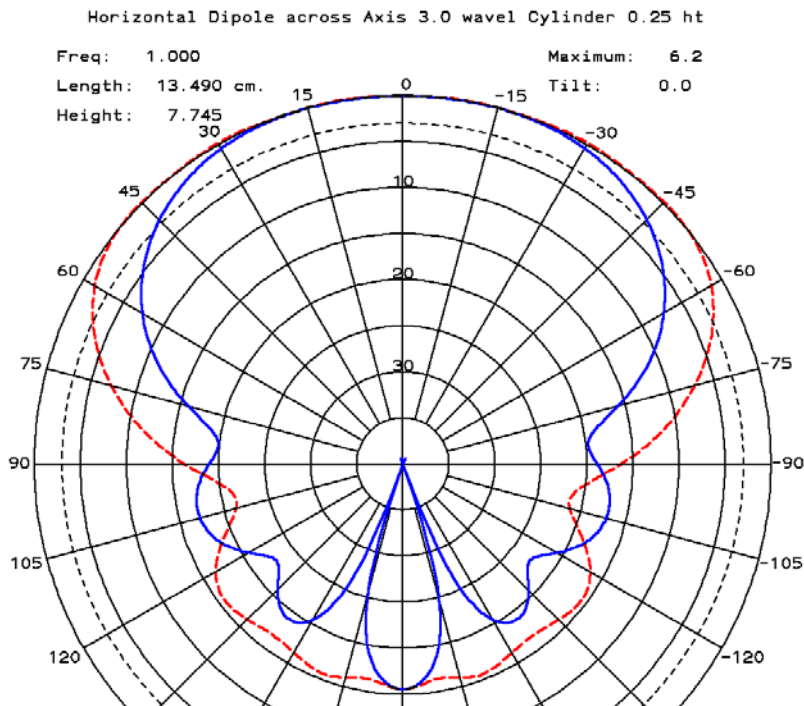


Figure 52 Horizontal Dipole 0.25λ over 3.0λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

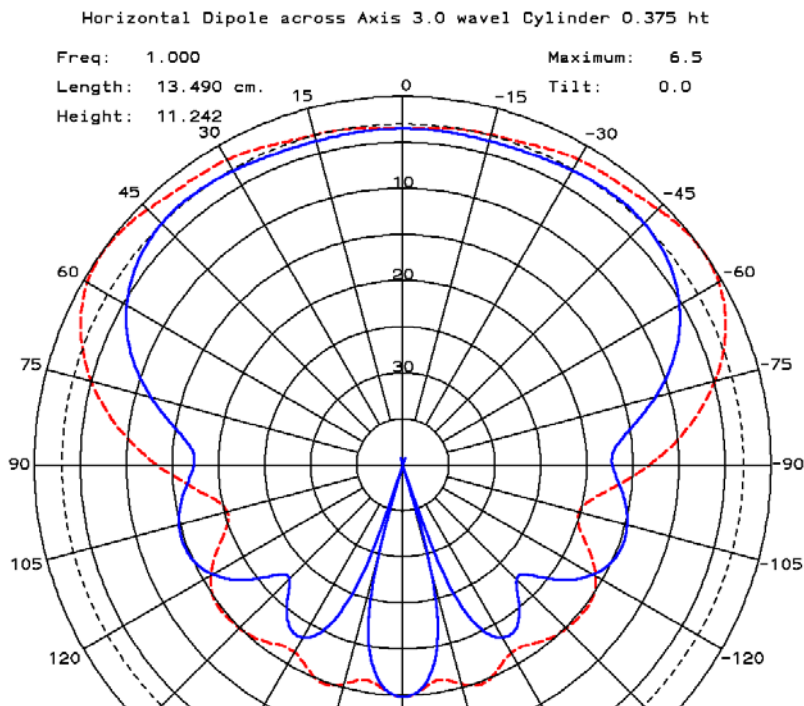


Figure 53 Horizontal Dipole 0.25λ over 3.0λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

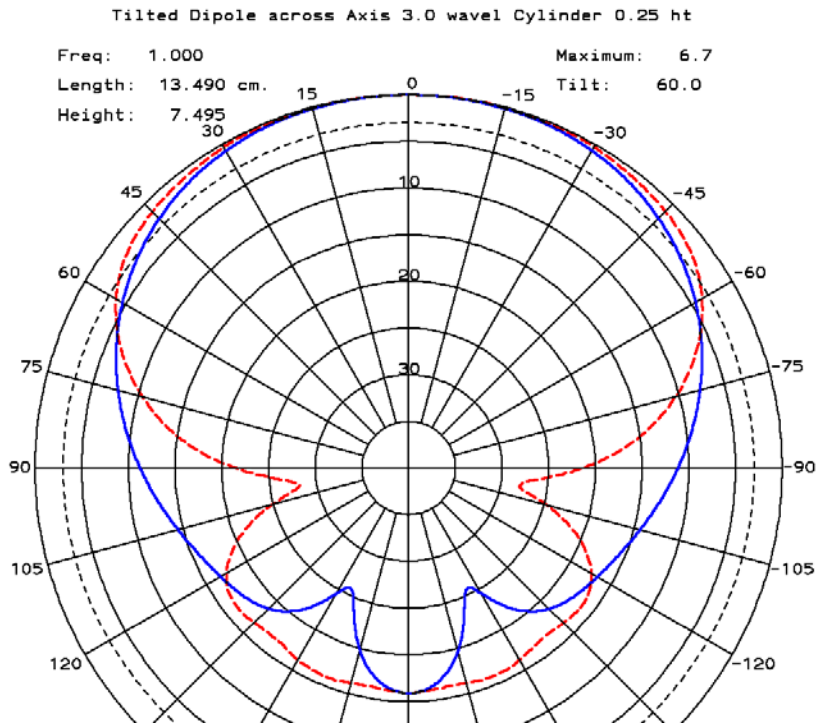


Figure 54 Vee Dipole 60° tilt 0.25 λ over 3.0 λ diameter Cylinder 6 λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Table 22 3-dB Beamwidths of Vee Dipole Mounted over 3.0 λ diameter Cylinder 6 λ long with Axis along H -plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	81.0	119.7	0.225	0	87.2	124.5
0.20	5	80.3	118.2	0.225	5	86.4	123.1
0.20	10	79.8	116.6	0.225	10	85.9	121.6
0.20	15	79.5	115.0	0.225	15	85.6	120.1
0.20	20	79.5	113.3	0.225	20	85.6	118.7
0.20	25	80.2	111.8	0.225	25	85.7	117.1
0.20	30	81.2	110.3	0.225	30	86.4	115.7
0.20	35	82.6	108.7	0.225	35	87.8	114.5
0.20	40	85.2	107.5	0.225	40	89.3	113.1
0.20	45	88.3	106.3	0.225	45	91.3	111.9
0.20	50	92.3	105.6	0.225	50	94.3	111.1
				0.225	55	97.0	110.1
				0.225	60	100.4	109.5

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	94.1	129.8	0.275	0	97.8	131.7
0.25	5	91.8	127.3	0.275	5	97.2	130.9
0.25	10	91.5	126.0	0.275	10	96.8	130.0
0.25	15	91.5	124.8	0.275	15	96.6	128.8
0.25	20	91.2	123.5	0.275	20	96.7	127.7
0.25	25	91.6	122.2	0.275	25	97.0	126.5
0.25	30	92.1	120.9	0.275	30	97.5	125.4
0.25	35	92.6	119.5	0.275	35	98.3	124.3
0.25	40	94.1	118.4	0.275	40	99.2	123.3
0.25	45	95.6	117.2	0.275	45	100.4	122.2

Chapter 5 Dipoles, Slots, and Loops

0.25	50	97.4	116.1	0.275	50	101.8	121.1
0.25	55	99.5	115.2	0.275	55	103.8	120.4
0.25	60	102.2	114.6	0.275	60	105.5	119.5
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	103.8	134.0	0.325	0	110.5	136.2
0.30	5	103.0	133.2	0.325	5	109.6	135.5
0.30	10	102.4	132.5	0.325	10	108.8	134.8
0.30	15	102.1	131.8	0.325	15	108.3	134.1
0.30	20	102.1	131.0	0.325	20	108.0	133.4
0.30	25	102.4	130.3	0.325	25	108.1	132.7
0.30	30	102.8	129.4	0.325	30	108.5	132.1
0.30	35	103.6	128.4	0.325	35	109.1	131.4
0.30	40	104.6	127.4	0.325	40	109.9	130.7
0.30	45	105.8	126.5	0.325	45	111.1	130.2
0.30	50	107.2	125.6	0.325	50	112.4	129.7
0.30	55	108.6	124.9	0.325	55	113.9	129.0
0.30	60	110.2	124.2	0.325	60	115.3	128.3
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	117.1	138.4	0.375	0	123.0	60.5
0.35	5	116.4	137.7	0.375	5	122.6	65.3
0.35	10	115.7	137.0	0.375	10	122.2	139.1
0.35	15	115.2	136.3	0.375	15	122.0	138.4
0.35	20	114.8	135.6	0.375	20	121.9	137.8
0.35	25	114.7	134.9	0.375	25	121.9	137.1
0.35	30	114.9	134.3	0.375	30	122.0	136.5
0.35	35	115.6	133.8	0.375	35	122.3	135.9
0.35	40	116.2	133.2	0.375	40	123.1	135.4
0.35	45	117.1	132.6	0.375	45	124.0	134.9
0.35	50	118.1	132.1	0.375	50	125.0	134.4
0.35	55	119.4	131.7	0.375	55	126.0	134.0
0.35	60	120.6	131.2	0.375	60	127.1	133.6

Vee Dipole over 2.5λ diameter 6λ long Cylinder with H -plane along Cylinder Axis

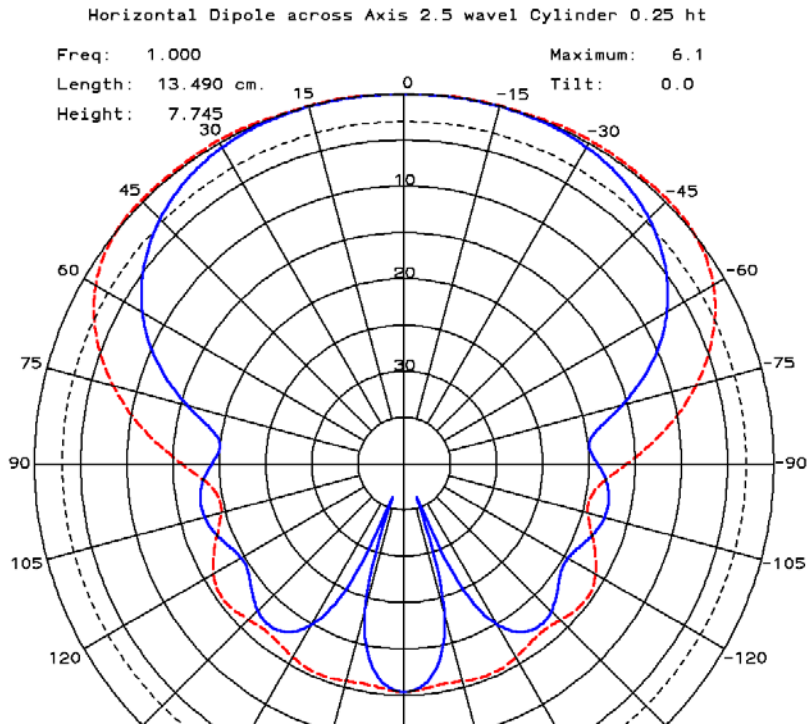


Figure 55 Horizontal Dipole 0.25λ over 2.5λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

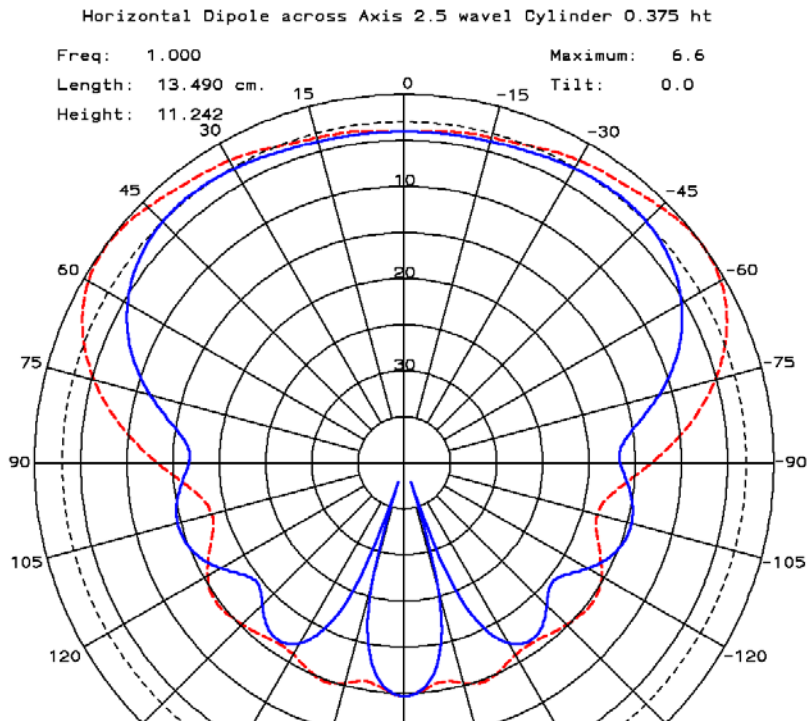


Figure 56 Horizontal Dipole 0.375λ over 2.5λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

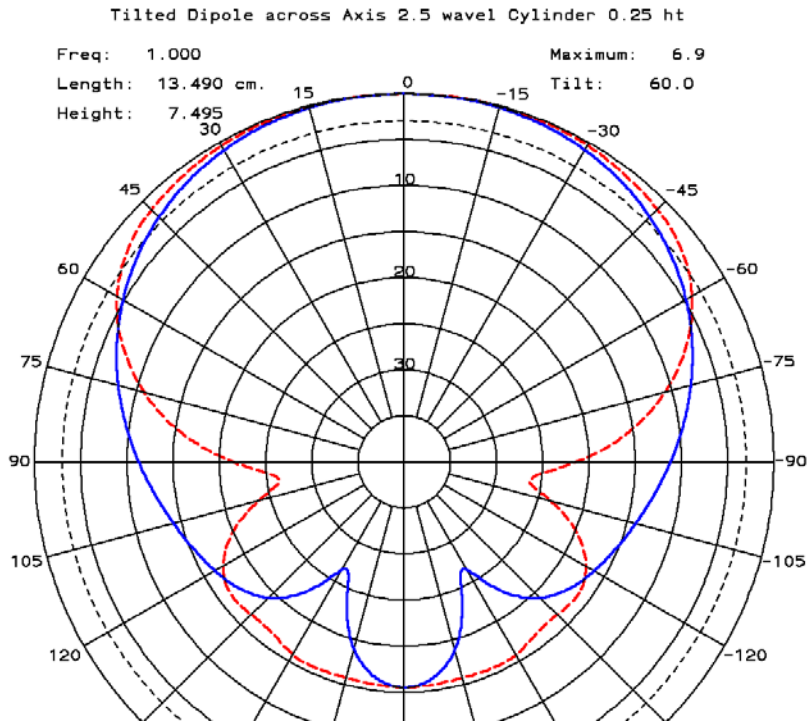


Figure 57 Vee Dipole 60° tilt 0.25 λ over 2.5 λ diameter Cylinder 6 λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Table 23 3-dB Beamwidths of Vee Dipole Mounted over 2.5 λ diameter Cylinder 6 λ long with Axis along H -plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	78.7	117.6	0.225	0	85.4	122.6
0.20	5	77.8	116.0	0.225	5	84.4	121.1
0.20	10	77.0	114.2	0.225	10	83.7	119.8
0.20	15	76.5	112.4	0.225	15	83.0	118.1
0.20	20	76.6	110.8	0.225	20	82.6	116.4
0.20	25	76.8	109.0	0.225	25	82.9	115.0
0.20	30	78.0	107.6	0.225	30	83.1	113.3
0.20	35	80.0	106.3	0.225	35	83.7	111.7
0.20	40	82.2	104.9	0.225	40	85.6	110.6
0.20	45	85.3	103.9	0.225	45	87.8	109.4
0.20	50	88.9	103.8	0.225	50	90.6	108.7
				0.225	55	93.5	107.8
				0.225	60	96.8	107.1

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	94.1	128.3	0.275	0	98.1	130.2
0.25	5	91.2	125.5	0.275	5	97.3	129.4
0.25	10	90.2	124.2	0.275	10	96.6	128.5
0.25	15	89.6	122.9	0.275	15	96.1	127.1
0.25	20	89.2	121.6	0.275	20	95.8	125.9
0.25	25	88.9	120.2	0.275	25	95.7	124.6
0.25	30	89.3	119.0	0.275	30	95.5	123.4
0.25	35	90.0	117.6	0.275	35	96.1	122.4
0.25	40	90.5	116.1	0.275	40	96.8	121.4
0.25	45	92.0	115.0	0.275	45	97.7	120.4

Chapter 5 Dipoles, Slots, and Loops

0.25	50	94.0	114.0	0.275	50	98.9	119.4
0.25	55	96.1	113.1	0.275	55	100.3	118.4
0.25	60	98.7	112.4	0.275	60	102.1	117.6
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	104.2	132.6	0.325	0	110.5	134.9
0.30	5	103.3	131.8	0.325	5	109.6	134.2
0.30	10	102.7	131.1	0.325	10	108.9	133.4
0.30	15	102.2	130.3	0.325	15	108.4	132.8
0.30	20	102.0	129.5	0.325	20	108.1	132.0
0.30	25	102.0	128.8	0.325	25	108.0	131.3
0.30	30	102.2	127.8	0.325	30	108.4	130.7
0.30	35	102.6	126.7	0.325	35	108.8	130.0
0.30	40	103.2	125.6	0.325	40	109.4	129.3
0.30	45	104.3	124.8	0.325	45	110.1	128.7
0.30	50	105.0	123.9	0.325	50	111.3	128.1
0.30	55	106.2	123.1	0.325	55	112.6	127.4
0.30	60	107.6	122.5	0.325	60	113.7	126.7
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	116.8	137.1	0.375	0	122.9	48.3
0.35	5	116.0	136.4	0.375	5	122.4	50.7
0.35	10	115.4	135.7	0.375	10	121.8	59.0
0.35	15	114.9	135.0	0.375	15	121.5	64.0
0.35	20	114.6	134.3	0.375	20	121.3	136.5
0.35	25	114.4	133.6	0.375	25	121.2	135.9
0.35	30	114.6	133.0	0.375	30	121.3	135.2
0.35	35	115.0	132.4	0.375	35	121.5	134.6
0.35	40	115.7	131.9	0.375	40	122.2	134.1
0.35	45	116.5	131.3	0.375	45	123.1	133.6
0.35	50	117.4	130.7	0.375	50	124.1	133.1
0.35	55	118.5	130.3	0.375	55	125.1	132.7
0.35	60	119.6	129.9	0.375	60	126.1	132.3

Vee Dipole over 2.0λ diameter 6λ long Cylinder with H -plane along Cylinder Axis

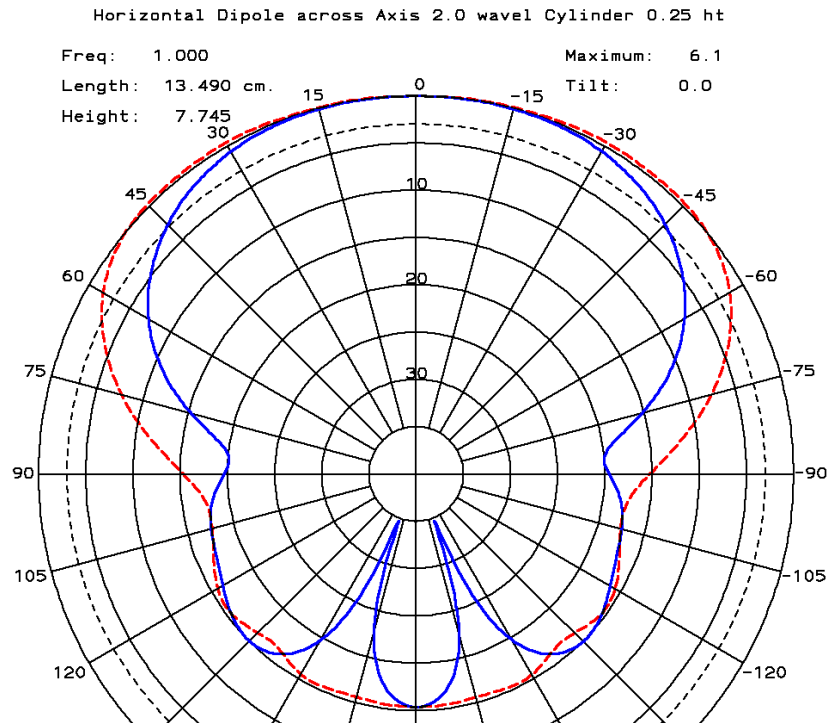


Figure 58 Horizontal Dipole 0.25λ over 2.0λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

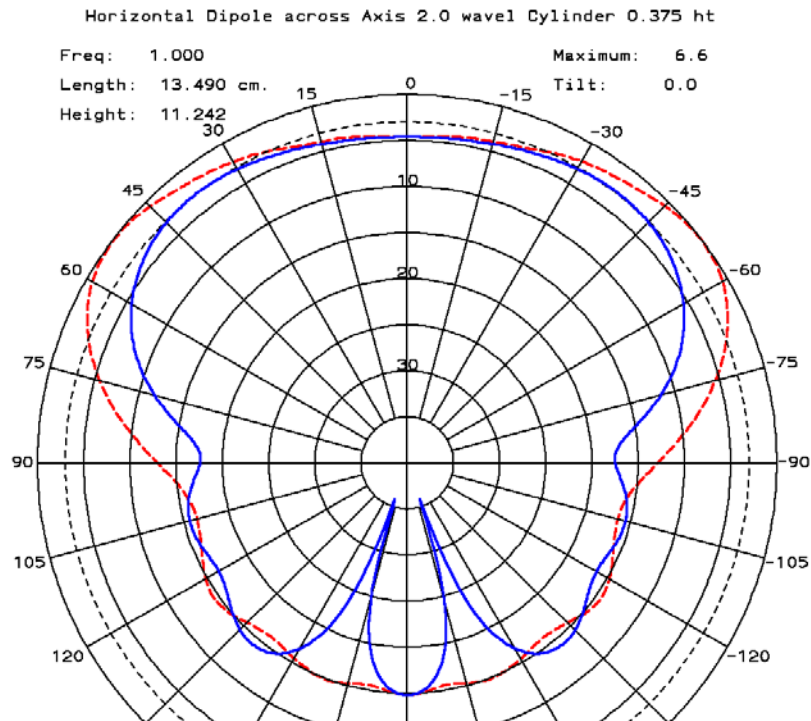


Figure 59 Horizontal Dipole 0.375λ over 2.0λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

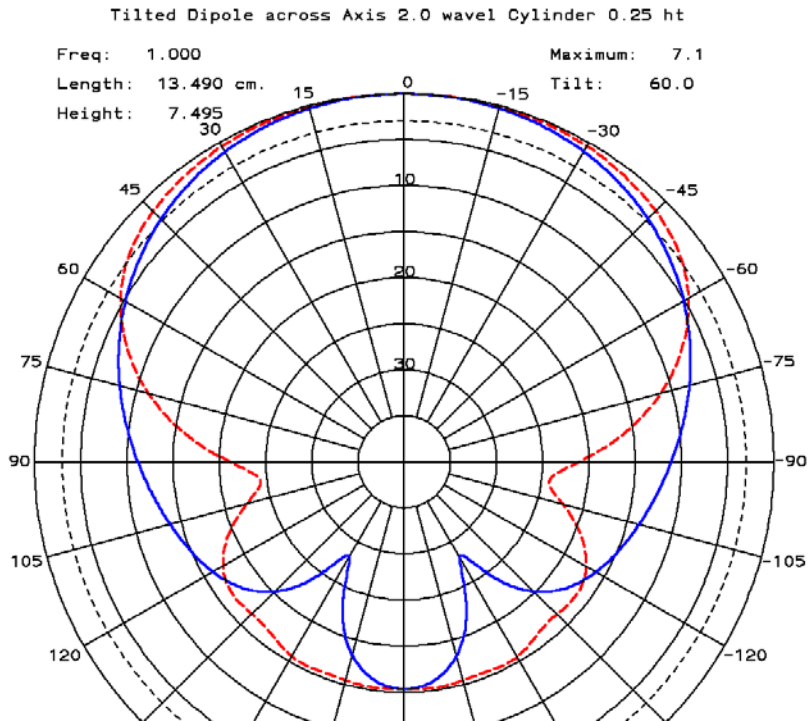


Figure 60 Vee Dipole 60° tilt 0.25 λ over 2.0 λ diameter Cylinder 6 λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Table 24 3-dB Beamwidths of Vee Dipole Mounted over 2.0 λ diameter Cylinder 6 λ long with Axis along H -plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	76.1	114.6	0.225	0	82.9	119.9
0.20	5	75.1	112.8	0.225	5	81.7	118.5
0.20	10	74.4	111.0	0.225	10	80.7	116.9
0.20	15	73.9	109.1	0.225	15	80.0	115.1
0.20	20	74.0	107.4	0.225	20	79.5	113.4
0.20	25	74.5	105.8	0.225	25	79.6	111.8
0.20	30	75.3	104.1	0.225	30	80.1	110.2
0.20	35	76.8	103.3	0.225	35	81.0	108.7
0.20	40	79.4	102.6	0.225	40	82.2	107.2
0.20	45	82.7	102.6	0.225	45	84.3	106.3
0.20	50	86.0	100.0	0.225	50	87.0	105.4
				0.225	55	89.6	104.5
				0.225	60	92.6	103.7

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	92.8	125.8	0.275	0	97.6	128.3
0.25	5	88.9	123.0	0.275	5	96.4	127.3
0.25	10	87.7	121.6	0.275	10	95.2	126.0
0.25	15	86.8	120.2	0.275	15	94.2	124.6
0.25	20	86.2	118.9	0.275	20	93.4	123.4
0.25	25	85.8	117.6	0.275	25	92.8	122.1
0.25	30	85.8	116.0	0.275	30	92.5	120.8
0.25	35	86.4	114.6	0.275	35	92.4	119.6
0.25	40	87.5	113.4	0.275	40	93.2	118.7
0.25	45	88.3	111.9	0.275	45	94.3	117.9
0.25	50	89.9	110.8	0.275	50	95.0	116.6

Chapter 5 Dipoles, Slots, and Loops

0.25	55	92.2	110.1	0.275	55	96.5	115.6
0.25	60	94.4	109.2	0.275	60	98.0	114.8
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	103.8	134.0	0.325	0	110.5	136.2
0.30	5	103.0	133.2	0.325	5	109.6	135.5
0.30	10	102.4	132.5	0.325	10	108.8	134.8
0.30	15	102.1	131.8	0.325	15	108.3	134.1
0.30	20	102.1	131.0	0.325	20	108.0	133.4
0.30	25	102.4	130.3	0.325	25	108.1	132.7
0.30	30	102.8	129.4	0.325	30	108.5	132.1
0.30	35	103.6	128.4	0.325	35	109.1	131.4
0.30	40	104.6	127.4	0.325	40	109.9	130.7
0.30	45	105.8	126.5	0.325	45	111.1	130.2
0.30	50	107.2	125.6	0.325	50	112.4	129.7
0.30	55	108.6	124.9	0.325	55	113.9	129.0
0.30	60	110.2	124.2	0.325	60	115.3	128.3
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	104.2	130.9	0.375	0	122.6	45.2
0.35	5	103.2	130.1	0.375	5	122.0	46.7
0.35	10	102.3	129.3	0.375	10	121.5	48.8
0.35	15	101.5	128.4	0.375	15	121.1	52.8
0.35	20	100.9	127.6	0.375	20	120.8	60.3
0.35	25	100.4	126.5	0.375	25	120.8	134.3
0.35	30	100.1	125.4	0.375	30	120.8	133.6
0.35	35	99.9	124.2	0.375	35	121.0	133.0
0.35	40	99.9	123.0	0.375	40	121.6	132.5
0.35	45	100.6	122.1	0.375	45	122.4	132.0
0.35	50	101.8	121.4	0.375	50	123.3	131.5
0.35	55	102.9	120.7	0.375	55	124.2	131.0
0.35	60	103.9	120.0	0.375	60	125.1	130.7

Vee Dipole over 1.5λ diameter 6λ long Cylinder with H -plane along Cylinder Axis

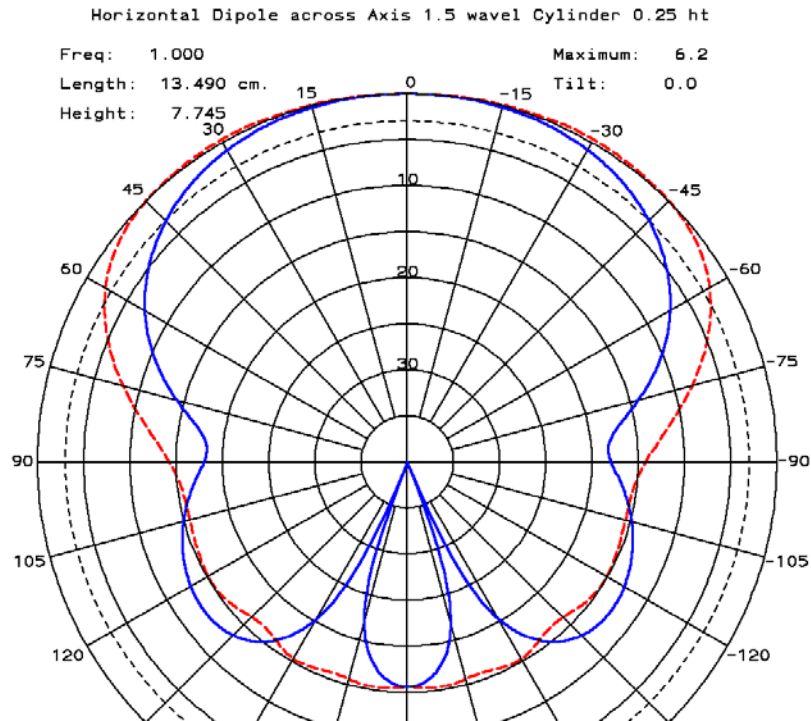


Figure 61 Horizontal Dipole 0.25λ over 1.5λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

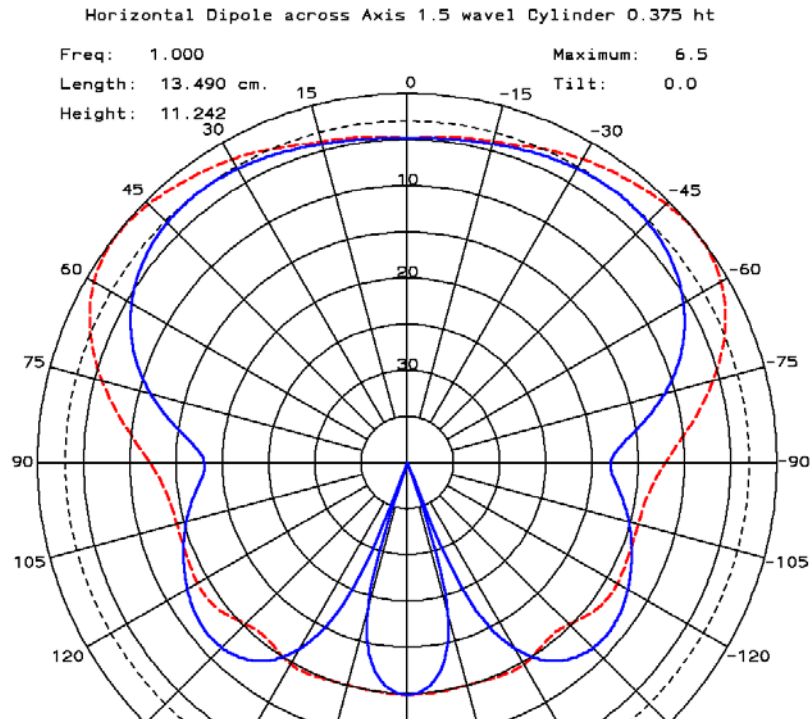


Figure 62 Horizontal Dipole 0.375λ over 1.5λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

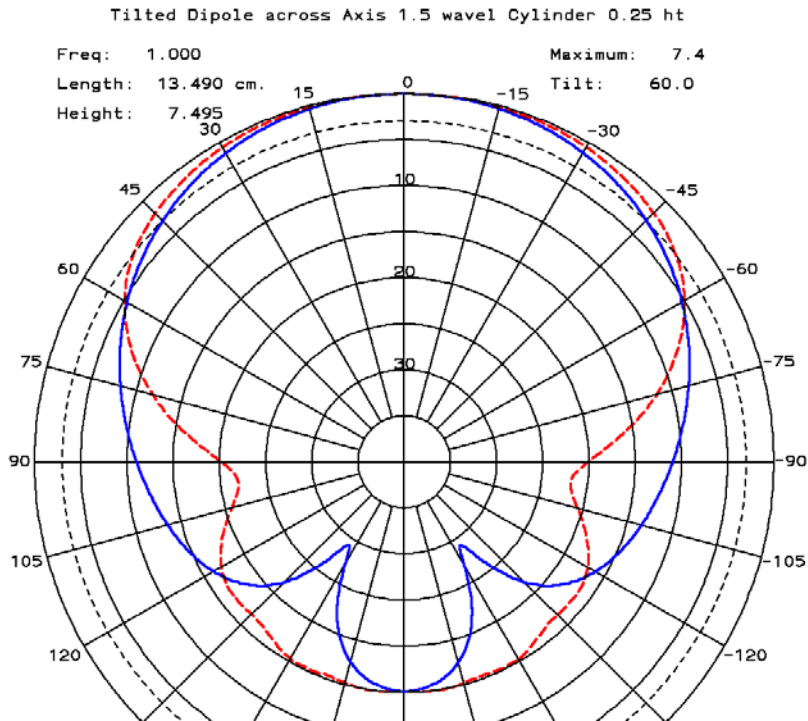


Figure 63 Vee Dipole 60° tilt 0.25 λ over 1.5 λ diameter Cylinder 6 λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Table 25 3-dB Beamwidths of Vee Dipole Mounted over 1.5 λ diameter Cylinder 6 λ long with Axis along H -plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	74.0	110.5	0.225	0	80.3	116.4
0.20	5	73.2	108.6	0.225	5	79.1	114.6
0.20	10	72.7	106.8	0.225	10	78.2	112.7
0.20	15	72.4	105.1	0.225	15	77.5	111.0
0.20	20	72.5	103.9	0.225	20	77.2	109.2
0.20	25	73.2	102.5	0.225	25	77.3	107.6
0.20	30	74.3	100.3	0.225	30	77.8	106.0
0.20	35	75.6	98.7	0.225	35	78.9	104.7
0.20	40	77.2	97.1	0.225	40	80.4	103.5
0.20	45	80.0	96.4	0.225	45	81.9	102.8
0.20	50	83.6	95.9	0.225	50	83.8	104.2
				0.225	55	86.7	100.6
				0.225	60	90.0	100.1

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	90.2	122.4	0.275	0	95.7	125.3
0.25	5	86.0	119.6	0.275	5	93.9	124.0
0.25	10	84.8	118.2	0.275	10	92.4	122.7
0.25	15	83.7	116.7	0.275	15	91.1	121.3
0.25	20	83.1	115.2	0.275	20	90.2	120.0
0.25	25	82.7	113.5	0.275	25	89.5	118.7
0.25	30	82.6	111.8	0.275	30	89.0	117.4
0.25	35	83.2	110.5	0.275	35	88.8	116.2
0.25	40	84.3	109.3	0.275	40	89.3	114.9
0.25	45	85.7	108.2	0.275	45	90.5	114.0
0.25	50	87.1	107.0	0.275	50	91.8	113.0

Chapter 5 Dipoles, Slots, and Loops

0.25	55	88.9	106.0	0.275	55	93.0	111.9
0.25	60	91.0	105.3	0.275	60	94.4	111.0
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	103.9	128.7	0.325	0	111.1	131.3
0.30	5	102.4	127.8	0.325	5	110.0	130.5
0.30	10	100.9	126.8	0.325	10	108.9	129.7
0.30	15	99.5	125.7	0.325	15	107.9	128.8
0.30	20	98.3	124.4	0.325	20	106.9	128.0
0.30	25	97.4	123.2	0.325	25	106.1	127.2
0.30	30	96.7	122.0	0.325	30	105.5	126.4
0.30	35	96.3	120.8	0.325	35	105.1	125.4
0.30	40	95.9	119.6	0.325	40	104.7	124.3
0.30	45	96.4	118.7	0.325	45	104.4	123.2
0.30	50	97.5	118.0	0.325	50	104.5	122.2
0.30	55	98.7	117.4	0.325	55	105.5	121.6
0.30	60	99.7	116.6	0.325	60	106.5	121.0
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	117.6	58.1	0.375	0	123.5	45.0
0.35	5	116.8	133.0	0.375	5	122.9	46.8
0.35	10	116.0	132.2	0.375	10	122.4	49.1
0.35	15	115.2	131.4	0.375	15	122.0	53.4
0.35	20	114.6	130.6	0.375	20	121.6	59.8
0.35	25	114.2	129.9	0.375	25	121.5	132.4
0.35	30	113.9	129.2	0.375	30	121.3	131.7
0.35	35	113.8	128.6	0.375	35	121.5	131.1
0.35	40	113.9	127.9	0.375	40	121.9	130.5
0.35	45	113.9	127.3	0.375	45	122.3	130.0
0.35	50	113.9	126.6	0.375	50	122.9	129.5
0.35	55	113.9	125.7	0.375	55	123.4	129.0
0.35	60	114.8	125.2	0.375	60	123.8	128.4

Vee Dipole over 1.0λ diameter 6λ long Cylinder with H -plane along Cylinder Axis

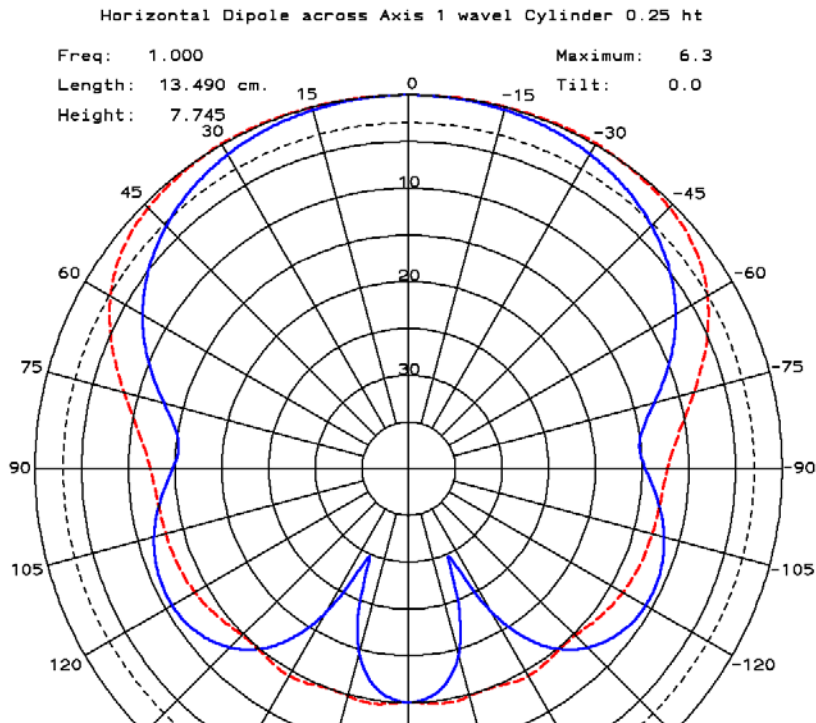


Figure 64 Horizontal Dipole 0.25λ over 1.0λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

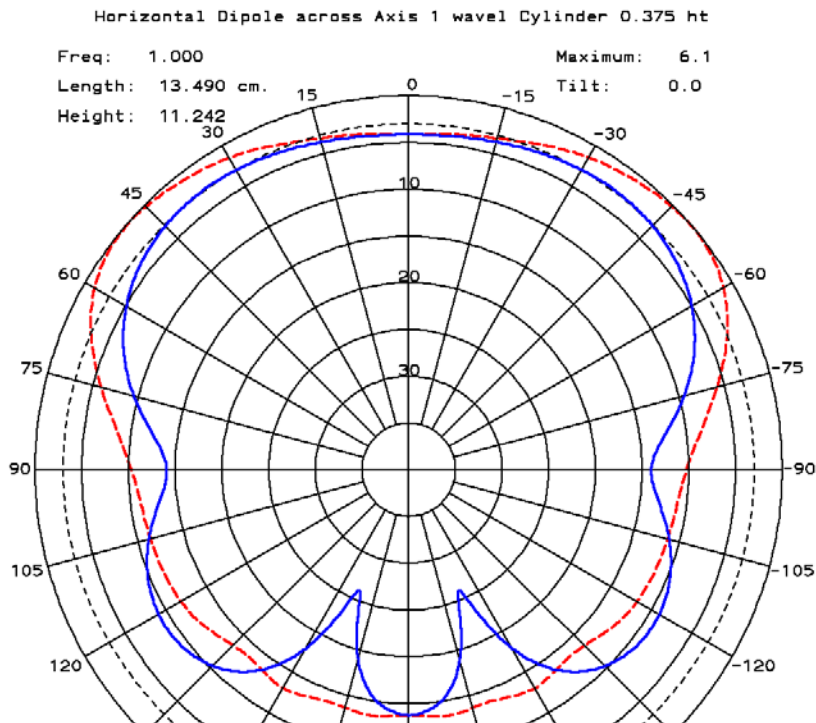


Figure 65 Horizontal Dipole 0.375λ over 1.0λ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

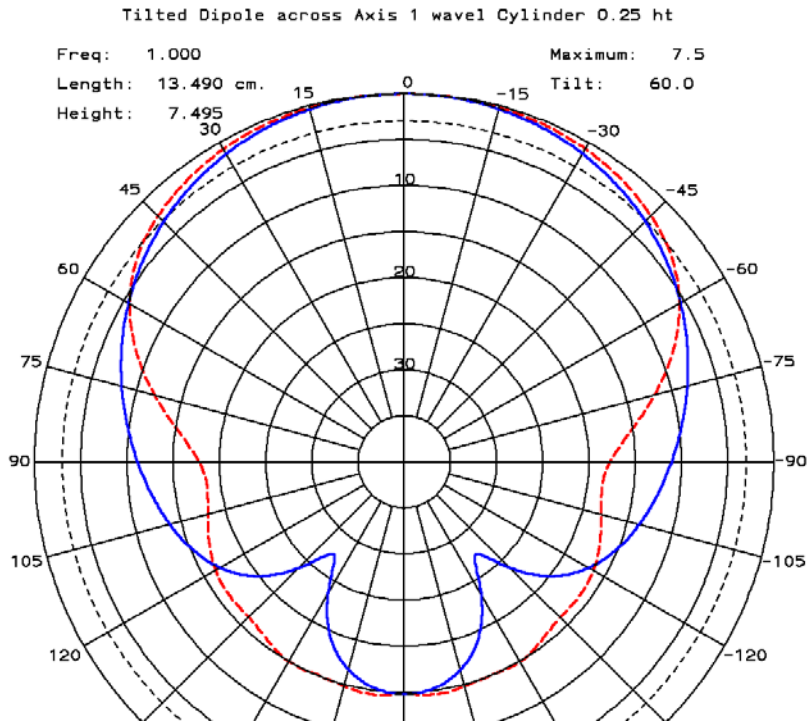


Figure 66 Vee Dipole 60° tilt 0.25 λ over 1.0 λ diameter Cylinder 6 λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Table 26 3-dB Beamwidths of Vee Dipole Mounted over 1.0 λ diameter Cylinder 6 λ long with Axis along H -plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	73.5	105.2	0.225	0	78.8	111.1
0.20	5	72.9	104.0	0.225	5	77.9	109.2
0.20	10	72.5	101.7	0.225	10	77.0	107.3
0.20	15	72.4	99.9	0.225	15	76.6	105.6
0.20	20	72.6	98.2	0.225	20	76.5	104.5
0.20	25	73.2	96.8	0.225	25	76.6	103.0
0.20	30	74.2	95.4	0.225	30	77.2	100.8
0.20	35	75.5	94.1	0.225	35	78.2	99.6
0.20	40	77.1	92.9	0.225	40	79.4	98.3
0.20	45	79.4	92.0	0.225	45	80.9	97.0
0.20	50	82.4	91.5	0.225	50	82.6	95.8
				0.225	55	84.9	95.3
				0.225	60	87.7	94.8

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	87.7	118.2	0.275	0	92.8	121.1
0.25	5	83.9	115.2	0.275	5	91.1	119.8
0.25	10	82.8	113.3	0.275	10	89.7	118.4
0.25	15	81.9	111.5	0.275	15	88.4	117.0
0.25	20	81.3	109.7	0.275	20	87.5	115.6
0.25	25	81.1	108.1	0.275	25	87.0	114.1
0.25	30	81.3	106.6	0.275	30	86.5	112.4
0.25	35	81.8	105.2	0.275	35	86.7	111.0
0.25	40	82.8	104.0	0.275	40	87.2	109.7
0.25	45	84.0	103.5	0.275	45	88.1	108.6
0.25	50	85.2	101.6	0.275	50	89.2	107.5

Chapter 5 Dipoles, Slots, and Loops

0.25	55	86.6	100.6	0.275	55	90.5	106.5
0.25	60	88.5	99.9	0.275	60	91.5	105.5
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	102.0	125.5	0.325	0	111.5	128.8
0.30	5	99.8	124.2	0.325	5	109.6	127.9
0.30	10	98.0	122.8	0.325	10	107.8	126.9
0.30	15	96.5	121.6	0.325	15	105.9	125.8
0.30	20	95.1	120.2	0.325	20	104.3	124.6
0.30	25	94.1	118.9	0.325	25	103.0	123.4
0.30	30	93.3	117.6	0.325	30	102.0	122.2
0.30	35	93.0	116.5	0.325	35	101.0	121.0
0.30	40	93.0	115.4	0.325	40	100.6	119.9
0.30	45	93.7	114.4	0.325	45	100.6	119.0
0.30	50	94.6	113.4	0.325	50	101.3	118.2
0.30	55	95.5	112.4	0.325	55	102.0	117.5
0.30	60	96.3	111.4	0.325	60	103.0	117.0
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	102.0	125.5	0.375	0	127.0	49.4
0.35	5	99.8	124.2	0.375	5	126.1	53.0
0.35	10	98.0	122.8	0.375	10	125.3	58.7
0.35	15	96.5	121.6	0.375	15	124.5	131.6
0.35	20	95.1	120.2	0.375	20	123.8	130.8
0.35	25	94.1	118.9	0.375	25	123.3	130.1
0.35	30	93.3	117.6	0.375	30	122.8	129.3
0.35	35	93.0	116.5	0.375	35	122.3	128.6
0.35	40	93.0	115.4	0.375	40	121.8	127.8
0.35	45	93.7	114.4	0.375	45	121.2	127.1
0.35	50	94.6	113.4	0.375	50	120.5	126.3
0.35	55	95.5	112.4	0.375	55	120.8	125.8
0.35	60	96.3	111.4	0.375	60	121.6	125.3

Vee Dipole over $\lambda/2$ diameter 6λ long Cylinder with H -plane along Cylinder Axis

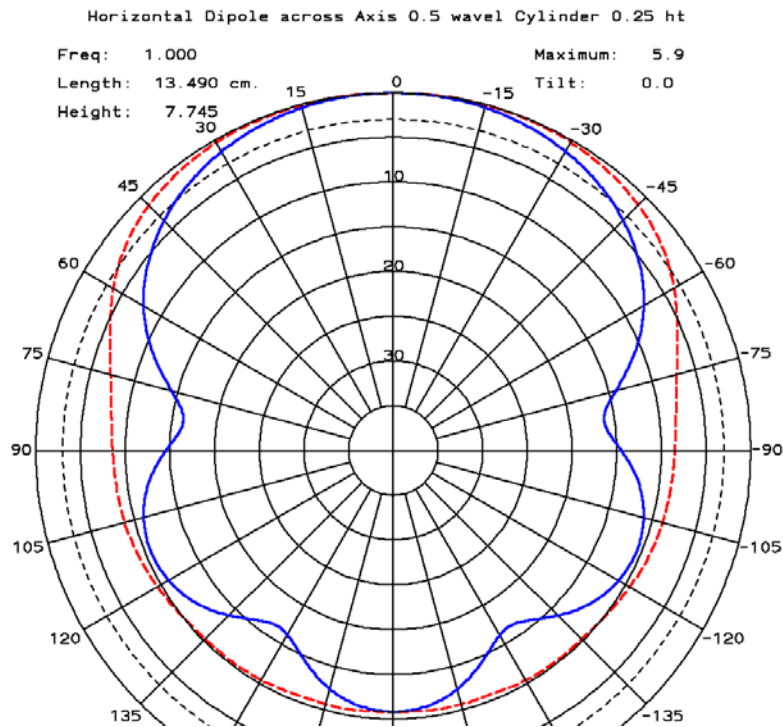


Figure 67 Horizontal Dipole 0.25λ over $\lambda/2$ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

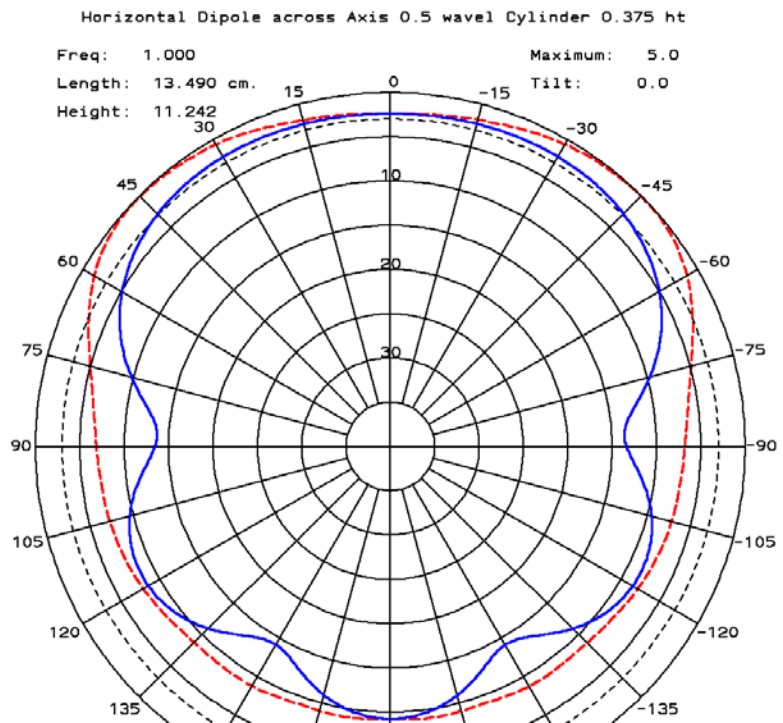


Figure 68 Horizontal Dipole 0.375λ over $\lambda/2$ diameter Cylinder 6λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Chapter 5 Dipoles, Slots, and Loops

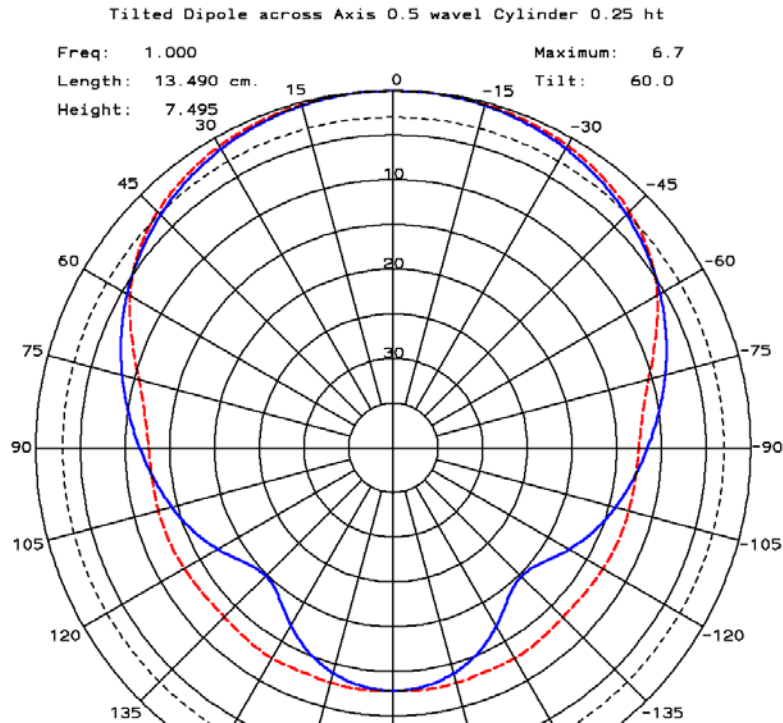


Figure 69 Vee Dipole 60° tilt 0.25 λ over $\lambda/2$ diameter Cylinder 6 λ long H -plane along Axis E -plane blue (solid) H -plane red (dashed)

Table 27 3-dB Beamwidths of Vee Dipole Mounted over $\lambda/2$ diameter Cylinder 6 λ long with Axis along H -plane for Heights, λ

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.20	0	73.1	100.8	0.225	0	76.9	105.8
0.20	5	72.9	99.2	0.225	5	76.5	104.0
0.20	10	73.1	96.1	0.225	10	76.2	102.3
0.20	15	73.6	94.8	0.225	15	76.2	100.7
0.20	20	74.3	93.5	0.225	20	76.5	99.2
0.20	25	75.3	92.3	0.225	25	77.0	97.7
0.20	30	76.6	91.1	0.225	30	77.7	96.4
0.20	35	78.2	90.2	0.225	35	78.6	95.2
0.20	40	80.3	89.3	0.225	40	79.9	94.1
0.20	45	82.7	88.5	0.225	45	81.5	93.1
0.20	50	85.7	87.8	0.225	50	83.4	92.2
				0.225	55	85.5	91.5
				0.225	60	88.0	90.8

Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.25	0	83.2	113.2	0.275	0	87.1	117.3
0.25	5	80.8	109.5	0.275	5	86.0	115.4
0.25	10	80.2	107.7	0.275	10	85.1	113.5
0.25	15	80.0	106.0	0.275	15	84.6	111.7
0.25	20	80.0	104.3	0.275	20	84.4	109.9
0.25	25	80.2	102.7	0.275	25	84.2	108.2
0.25	30	80.7	101.2	0.275	30	84.5	106.7
0.25	35	81.4	99.9	0.275	35	84.9	105.8
0.25	40	82.3	98.6	0.275	40	85.5	103.9
0.25	45	83.5	97.6	0.275	45	86.4	102.6

Chapter 5 Dipoles, Slots, and Loops

0.25	50	85.0	96.6	0.275	50	87.6	101.6
0.25	55	86.8	95.8	0.275	55	89.0	100.7
0.25	60	88.6	95.0	0.275	60	90.6	99.9
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.30	0	102.0	125.5	0.325	0	111.5	128.8
0.30	5	99.8	124.2	0.325	5	109.6	127.9
0.30	10	98.0	122.8	0.325	10	107.8	126.9
0.30	15	96.5	121.6	0.325	15	105.9	125.8
0.30	20	95.1	120.2	0.325	20	104.3	124.6
0.30	25	94.1	118.9	0.325	25	103.0	123.4
0.30	30	93.3	117.6	0.325	30	102.0	122.2
0.30	35	93.0	116.5	0.325	35	101.0	121.0
0.30	40	93.0	115.4	0.325	40	100.6	119.9
0.30	45	93.7	114.4	0.325	45	100.6	119.0
0.30	50	94.6	113.4	0.325	50	101.3	118.2
0.30	55	95.5	112.4	0.325	55	102.0	117.5
0.30	60	96.3	111.4	0.325	60	103.0	117.0
Height	Tilt	E-plane	H-plane	Height	Tilt	E-plane	H-plane
0.35	0	111.8	130.8	0.375	0	121.3	134.0
0.35	5	109.7	129.6	0.375	5	119.7	132.9
0.35	10	107.6	128.3	0.375	10	118.1	131.8
0.35	15	106.0	126.9	0.375	15	116.6	130.8
0.35	20	104.7	125.5	0.375	20	114.9	129.7
0.35	25	103.6	124.2	0.375	25	113.5	128.6
0.35	30	103.0	122.8	0.375	30	112.7	127.4
0.35	35	102.6	121.6	0.375	35	111.8	126.2
0.35	40	102.3	120.4	0.375	40	111.4	125.0
0.35	45	102.1	119.2	0.375	45	110.9	123.9
0.35	50	102.4	118.2	0.375	50	110.7	122.9
0.35	55	103.0	117.3	0.375	55	110.9	122.0
0.35	60	104.0	116.6	0.375	60	111.8	121.3