Table 1

Characteristics of HF Coastal Radars

Characteristics	System 1 5 MHz	System 2 12 MHz	System 3 25MHz	System 4 42MHz
Function	Long-range oceanographic measurements	Standard oceanographic measurements	Hi Resolution oceanographic measurements	Best resolution short range measurements
Maximum operational (measurement) range**	160-220 km average during (daytime)*	50-70 km	30-50 km	10-20 km
Range Resolution	3 – 12 km	2 - 3 km	1 – 2 km Hi-Resolution mode: 0.3-km	0.3 – 1km
Frequency range (MHz)	4 – 6 MHz	12 - 14 MHz	24 – 27 MHz	40-44 MHz
Modulation	Pulse swept frequency CW	Pulse swept frequency CW	Pulse swept frequency CW	Pulse swept frequency CW
Peak power into antenna	80 W	80 W	80 W	80 W
Pulse widths (μs)	1000-2000 us	300-600 us	300-600 us	30-100 us
Maximum duty cycle	50%	50%	50%	50%
Pulse rise/fall time (μs)	16/32	16	16	8/16
Transmitter Tuning Method	Digital	Digital	Digital	Digital
Receiver Tuning Method	Digital	Digital	Digital	Digital
Output device	Gated FET (Class AB operation)	Gated FET (Class AB operation)	Gated FET (Class AB operation)	Gated FET (Class AB operation)
Transmitter Stability	0.001 ppm	0.001 ppm	0.001 ppm	0.001 ppm
Receiver Stability	0.001 ppm	0.001 ppm	0.001 ppm	0.001 ppm
Transmit Antenna pattern type	Omni-directional (in horizontal plane)	Omni-directional (in horizontal plane)	Omni-directional (in horizontal plane)	Omni-directional (in horizontal plane)

Characteristics	**System 1** 5 MHz	**System 2** 12MHz	**System 3** 25MHz	**System 4** 42MHz
Transmit antenna type[2]	Quarter-wave monopole with ground plane	Quarter-wave monopole with ground plane	Quarter-wave monopole with ground plane	Quarter-wave monopole with ground plane
Antenna polarization[2]	Vertical	Vertical	Vertical	Vertical
Antenna main beam gain (dBi)[2]	8 dBi	8 dBi	8 dBi	8 dBi
Transmit antenna elevation beam width (deg)[2]	35°	35°	35°	35°
Transmit antenna azimuthal beam width (deg)[2]	Omni-directional	Omni-directional	Omni-directional	Omni-directional
Transmit antenna horizontal scan rate	Fixed antenna	Fixed antenna	Fixed antenna	Fixed antenna
Transmit antenna height	10 meters	4 meters	2 meters	1.2 meter
Receive antenna pattern type[2]	Electric & magnetic dipoles	Electric & magnetic dipoles	Electric & magnetic dipoles	Electric & magnetic dipoles
Receive antenna type[2]	Two crossed loops and a monopole as single unit	Two crossed loops and a monopole as single unit	Two crossed loops and a monopole as single unit	Two crossed loops and a monopole as single unit
Receive antenna polarization[2]	Vertical	Vertical	Vertical	Vertical
Receive antenna main beam gain (dBi)[2]	5 dBi	5 dBi	5 dBi	5 dBi
Receive antenna elevation beam width (deg)[2]	45°	45°	45°	45°
Receive antenna azimuthal beam width (deg)[2]	Beam width 90°-360°	Beam width 90°-360°	Beam width 90°-360°	Beam width 90°-360°
Receive antenna horizontal scan rate	Fixed antenna	Fixed antenna	Fixed antenna	Fixed antenna
Receive Antenna height	4 meters	4 meters	4 meters	4 meters
Receiver IF 3 dB bandwidth (Hz)	500 Hz	500 Hz	500 Hz	500 Hz
Receiver noise figure (dB)	12 dB with pulsing	12 dB with pulsing	12 dB with pulsing	12 dB with pulsing
Minimum discernible signal (dBm)	-163 dBm (in 1 Hz RBW) (specified system noise level)	-163 dBm (in 1 Hz RBW) (specified system noise level)	-163 dBm (in 1 Hz RBW) (specified system noise level)	-163 dBm (in 1 Hz RBW) (specified system noise level)
Suppression of Harmonics	YES	YES	YES	YES

* SeaSonde network consists of 2 or more remote units + a Central Station.

** Includes Training/Support.

*** Same client, separate order OK.

SeaSonde Idealized Antenna Element Patterns and Gains

Don Barrick June 2006

- **Objective** We get asked a lot about our antenna patterns. Jack Harlan recently sent a table to be filled out, with several questions relating to antenna patterns and gains. Even for the "idealized" pattern case, having a graphic display of these should prove useful. That is what this document attempts.

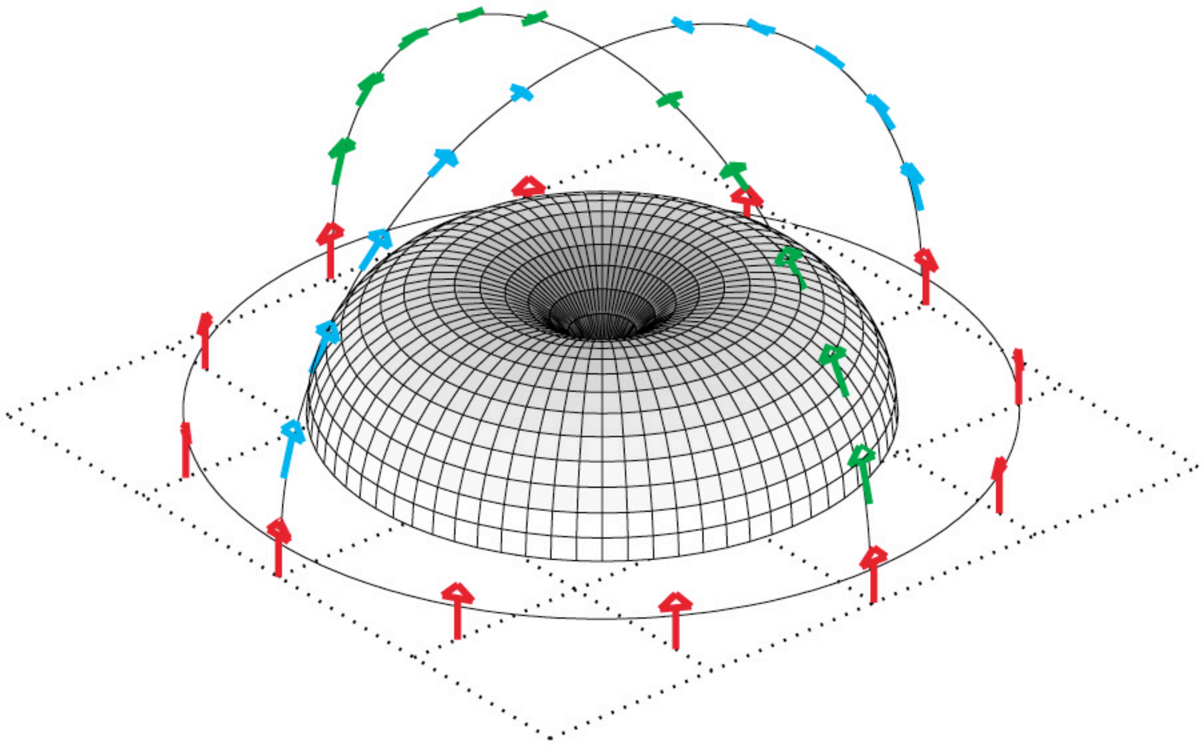
- **Assumptions** I have assumed perfect antennas with perfect patterns. These antennas are assumed to operate over a perfect ground plane. Losses into the antennas are not considered. Ground losses are not considered (all are good assumptions to lowest order). So the gain of our short antennas over the ground gets doubled because no power goes into the lower half space, but gets redirected upward. In reality, because the transmit antenna is a quarter-wave monopole, its gain (dB) is doubled again because of the half-wave aperture that it plus its image constitutes.

And so, there are four antennas under consideration here: the quarter-wave transmit monopole; the short receive monopole; and the small two crossed loops. The patterns of the transmit and receive monopole are essentially the same, but as mentioned above, the idealized directive gain of the transmit monopole is 8 dB, whereas that of the receive monopole and loops is 5 dB.

- **What Is Shown** The plots show three patterns as 3D depictions. The mesh grid represents the electric-field voltage amplitude response (i.e., absolute value). So these ***are not*** power patterns, nor are they depicted in dB. The whitest parts of the "donuts" are where the signal response is strongest. They tend to gray as the signal recedes into the nulls.

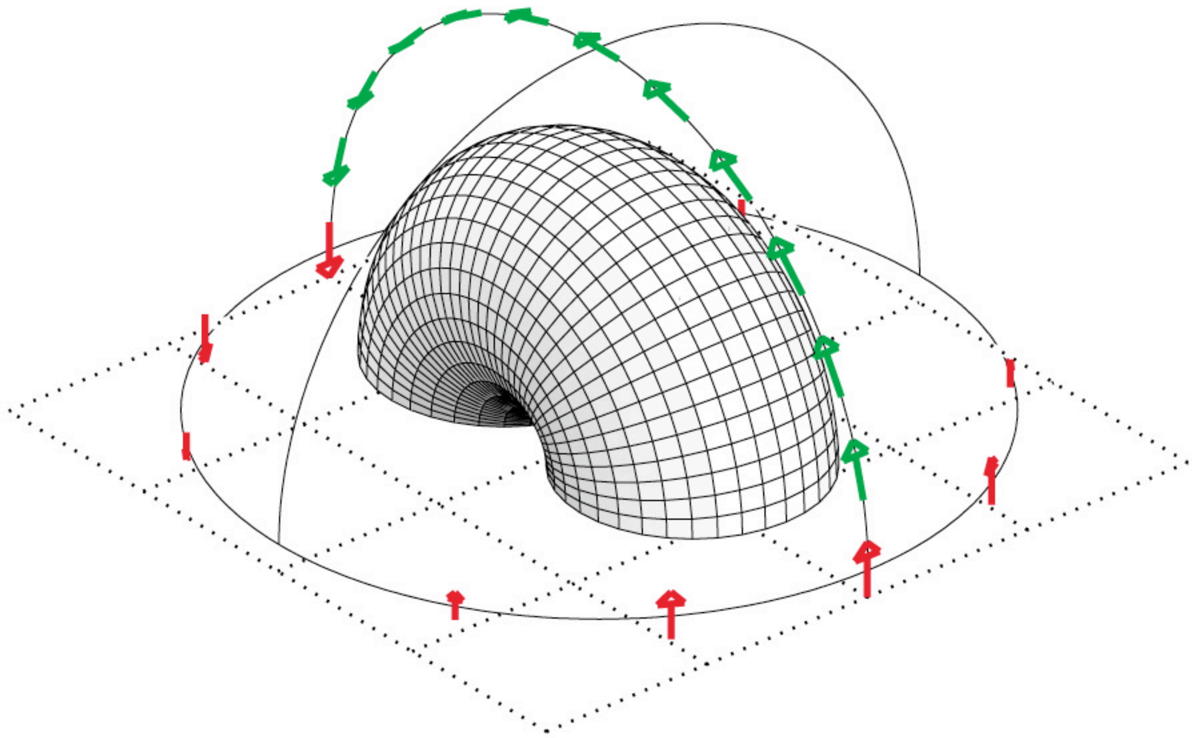
Over the top hemisphere above the pattern, I show arrows representing the electric field (E-field). These are done in the three principal planes (x, y, z). They are projected onto a sphere, as waves radiate in this manner from all antennas. This allows you to see how the field looks as you move through nulls and come out the other side (e.g., for the loops in the horizon plane). These vectors illustrate why loops have a positive and negative lobe, while the monopole is omni-directional in azimuth. These "overhead" field depictions also show why the loops receive signals from directly overhead (but have a null on the horizon), while the monopole has a null overhead but none on the horizon. Thus vertically propagating echoes from the ionosphere overhead are always seen much stronger on the loops.

In reality there is always a magnetic field (H-field) that accompanies the E-field. It is not shown nor important for us, because the sea favors the vertical electric field only. The H-field can be gotten from the E-field by dividing by the free-space impedance (377 ohms), although the H-field changes sign also when the E-field doesn't (e.g., when one passes around 360° in azimuth for the monopole).



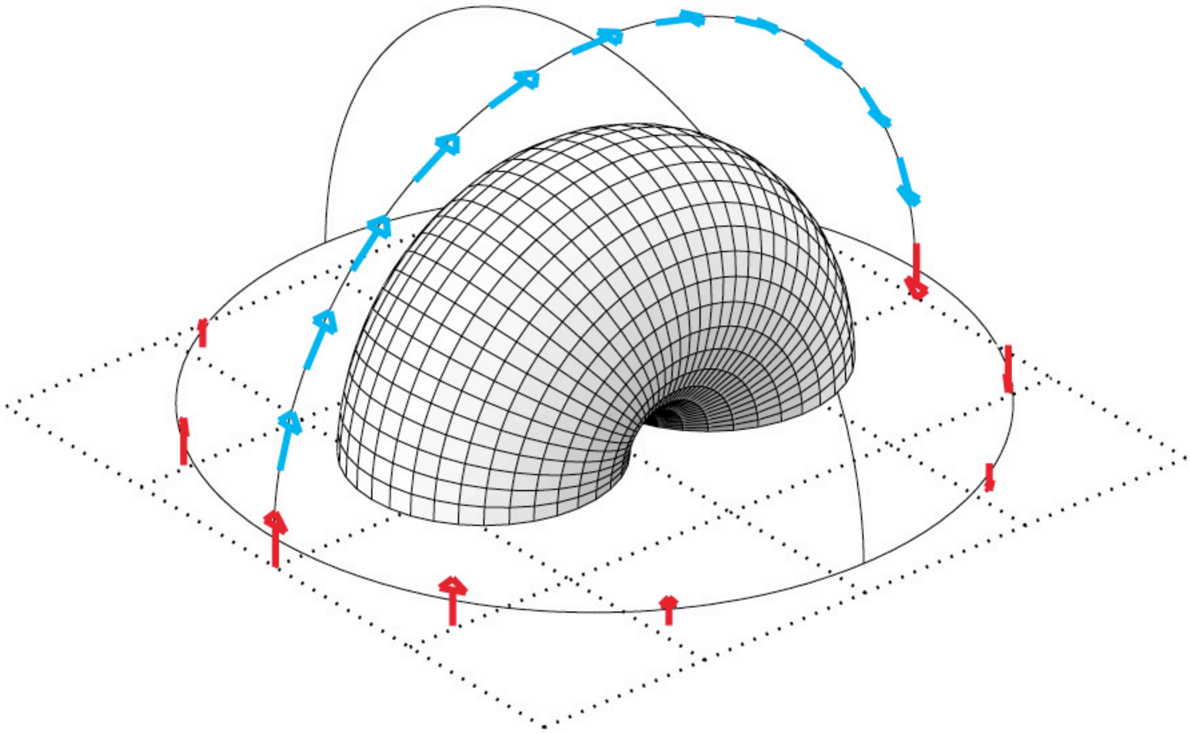
Monopole E-field voltage response pattern above the earth/ground plane. The pattern is maximum on the horizon plane and has a null overhead, along the axis of the monopole. Also shown are vectors in the three principal planes, representing the E-field response sense and magnitude.

- **Transmit quarter-wave monopole maximum idealized gain ~8 dB**
- **Receive short monopole maximum idealized gain ~5 dB**



Loop #1 E-field voltage response pattern above the earth/ground plane. The pattern is maximum in the plane of the loop and has a null on the horizon perpendicular to the loop plane. Also shown are vectors in the principal planes, representing the E-field response sense and magnitude; in this case the E-field in the plane through the null is zero.

- **Receive small loop idealized gain ~5 dB**



Loop #2 E-field voltage response pattern above the earth/ground plane. In the SeaSonde system, the two loops are always oriented orthogonal to each other but with the same physical/phase center. The pattern is maximum in the plane of the loop and has a null on the horizon perpendicular to the loop plane. Also shown are vectors in the principal planes, representing the E-field response sense and magnitude; in this case the E-field in the plane through the null is zero.

- **Receive small loop idealized gain ~5 dB**

Glossary of Important Terms:

Gain of Antenna: It’s the measure of the intensity of the antenna’s radiation pattern in the direction of strongest radiation to that of a reference antenna.When reference antenna is an isotropic antenna, it is expressed in dBi(decibels over isotropic).

Transmitter/Receiver Stability: Maximum wavelength allowed.(ppm).

Antenna Polarization: Polarization of the wave radiated by the antenna. In general polarization is the orientation of the electric field vector of the electromagnetic wave.

FET(Field Effect Transistor): FET is a transistor in which the electric field controls the shape and the conductivity of a channel in a semiconductor material. FET is generally a 4 terminal device(except Junction FET(JFET)), with the four terminals being Gate, Souce, Drain, Body. The voltage applied between gate and source terminals alters the current between Source and Drain terminals.

Modulation: It is the phenomenon of addition of information to a carrier signal. Information is added by varying various characteristics of the Carrier Signal like amplitude, phase, frequency.

Duty cycle : It is the ratio of the time ,the signal remains high to the time, the signal remains low.

Beam Width: It’s a measure of how directional , the antenna is. Common definition is the Half Power Beam Width.Its the angular separation between the half power(3dB) points of the main lobe, with respect to the peak effective radiated power of the main lobe.

Azimuth Beamwidth: The Azimuth Beamwidth of an antenna is the angular width including maximum radiation measured between the two points on the major lobe of the azimuth(horizontal) pattern 3 dB below the maximum.

Elevation Beamwidth: The Elevation (Vertical) Beamwidth of an antenna is the angular width including maximum radiation measured between the two points on the major lobe of the elevation (vertical) pattern 3 dB below the maximum.

Radiation Pattern: The types of geometrical distribution of transmitter power provided by an antenna is called the antenna's **radiation pattern.**

Efficiency of Antenna: Gain divided by the directivity in any direction.