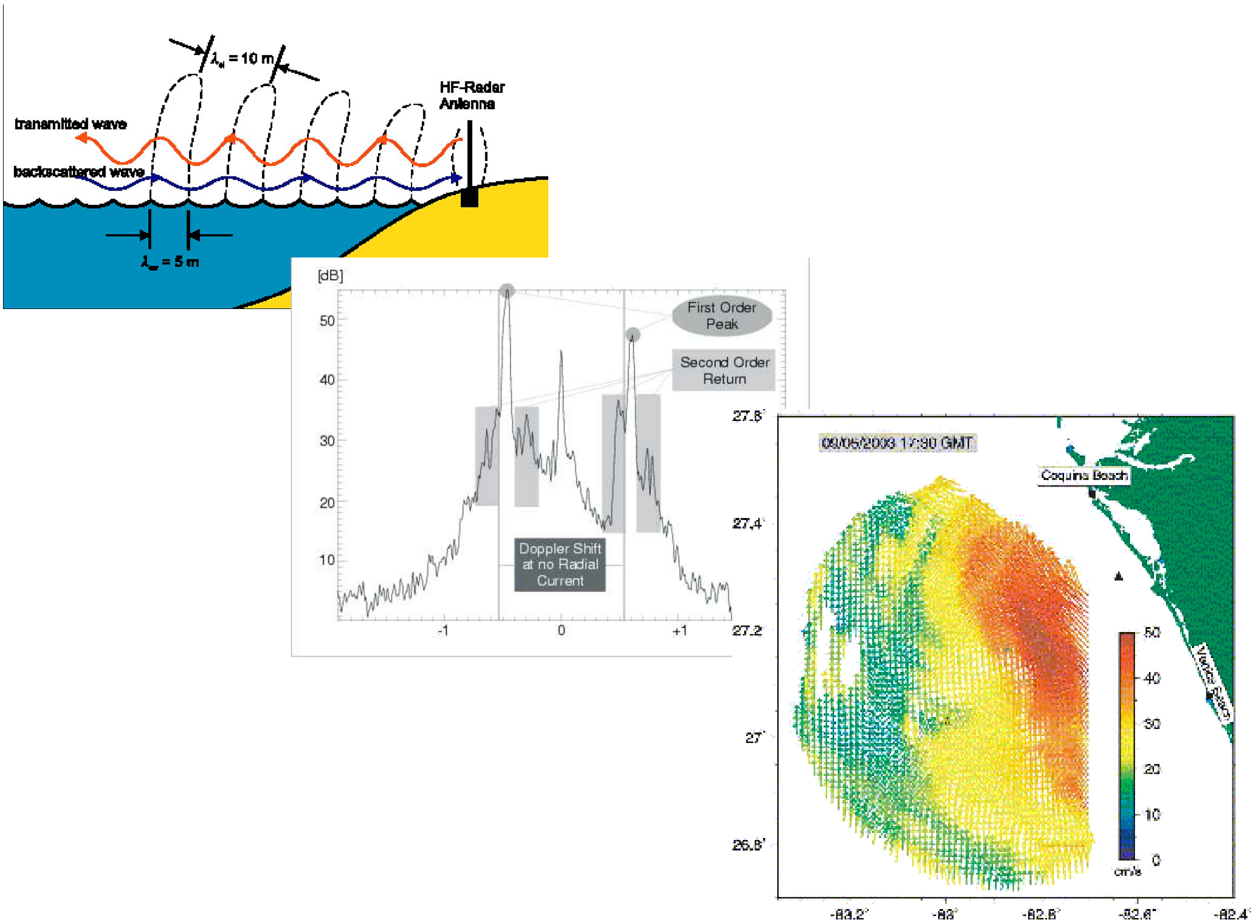
FMcw Radar "WERA"

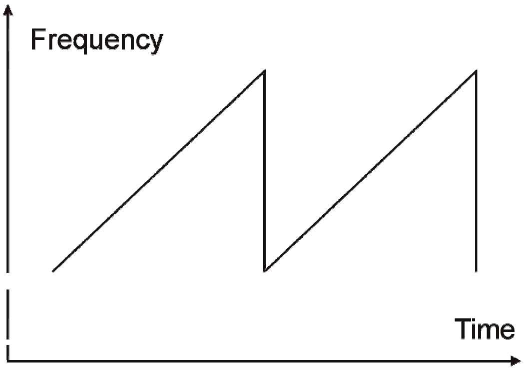
The WERA system (WavE RAdar) is a shore based remote sensing system to monitor ocean surface currents, waves and wind direction. This long range, high resolution monitoring system based on short radio wave radar technology. The vertical polarised electromagnetic wave is coupled to the conductive ocean surface and will follow the curvature of the earth. This over the horizon oceanography radar can pick up back-scattered signals (Bragg effect) from ranges of up to 200 km.



Contents:

1. Operation Mode

A continuously swept rf-signal is transmitted. The reflected signal has a frequency offset compared to the actual transmitted signal.



The radar is continuously transmitting with very low rf power, no gating or pulsing sequences are used. The required decoupling between transmitter and receiver has to be achieved by means of using separate locations for Rx and Tx antennae.

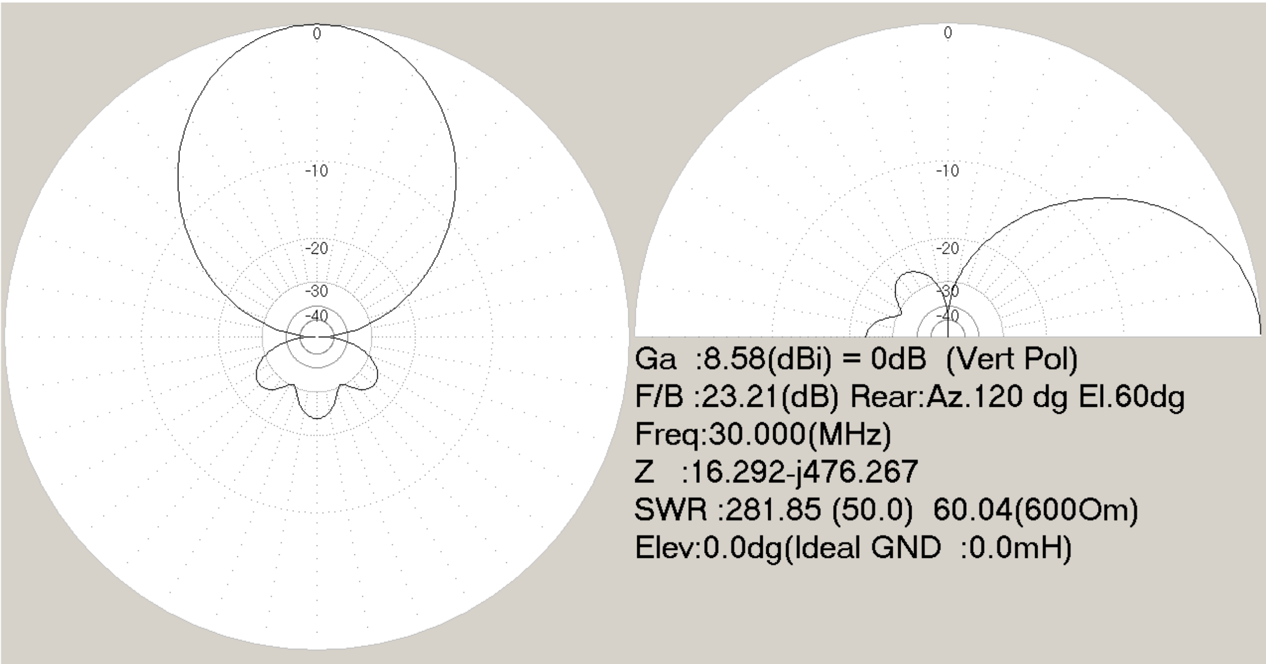
The receiver is continuously switched on, to pick up signals from all over the defined range. These systems provide best signal to noise performance due to the extreme low noise FMcw transmission mode.

The technical parameter of the transmitter:

1.	Max. amplifier output power: 30 Watts-cw	
2.	Antenna characteristic:	vertical polarized array of 4 short monopoles with radials directivity 99 % towards the sea, azimuth ± 60°
3.	Harmonic suppression:	> 60 dB
4.	Modulation:	FM-cw with very slow sweep period of typically 0.3 sec Bandwidth typical: 100 kHz preferred BW > 300 kHz to allow for frequency adaptation
5.	Automatic Freq. Selection:	The system will scan the allocated band to find a free gap for the required sweep bandwidth. The center frequency will be adjusted to match the sweep band with the free gap. If the gap is not wide enough, the sweep bandwidth will be reduced, resulting in a coarser range resolution. This frequency selection procedure will be carried out prior to each radar cycle, typically all 10 to 30 minutes.
6.	System control:	Remote controlled, to be switched off immediately if a primary license user may complain.

2. Antenna Pattern and Concept

The WERA transmit antenna array consists of 4 vertical monopoles to generate an antenna pattern as sketched below.



The geometrical orientation and the phase (0° and 126°) of the input signals can be derived from the input parameters of the simulator:

Name TX-Array Freq 30 MHz ☐ Lambda

Wire 4 automatische Segmentatic DM1 400 DM2 40 SC 2.0 EC 1 ☑ Verbindungen halten

No.	X1(m)	Y1(m)	Z1(m)	X2(m)	Y2(m)	Z2(m)	R(mm)	Seg.
1	0.0	0.0	1.0	0.0	0.0	3.5	14.0	0
2	0.0	5.0	1.0	0.0	5.0	3.5	14.0	0
3	1.5	0.0	1.0	1.5	0.0	3.5	14.0	0
4	1.5	5.0	1.0	1.5	5.0	3.5	14.0	0
next								

Source 4 ☑ Automatischer Wert

No.	PULSE	Phase dg	Voltage
1	W1B	126.0	0.25
2	W2B	126.0	0.25
3	W3B	0.0	0.25
4	W4B	0.0	0.25
next			

Load 4 ☑ Laste verwenden

No.	PULSE	Type	L(uH)	C(pF)	Q	f(MHz)
1	w1b	LC	3.0	0.0	30.0	
2	w2b	LC	3.0	0.0	30.0	
3	w3b	LC	3.0	0.0	30.0	
4	w4b	LC	3.0	0.0	30.0	
next						

This array configuration will be used to check the antenna pattern only. The distance along shore is 0.5 Lambda and perpendicular to the shore line 0.15 Lambda. The 4 elements are not tuned and matched perfectly and no radial elements are used in this simulation.

The optimization for the antenna poles is carried out with another simulation, e.g. for a 16.9 MHz system (see below).

Element # 1: Antenna pole (starting at 1.5 m above ground, 3 m long, 28 mm diameter

Element # 2 to 4: Radials, 2.12 m long (0.12 Lambda to get good VSWR), 2 mm diameter

Load: Inductivity of 2.6 µH to get 0.25 Lambda electrical length

Name Mono-3m-16MHz9-225-Rad-6508 Freq 16.900 MHz ☐ Lambda

Wire 4 automatische Segmentati DM1 400 DM2 40 SC 2.0 EC 1 ☑ Verbindungen halten

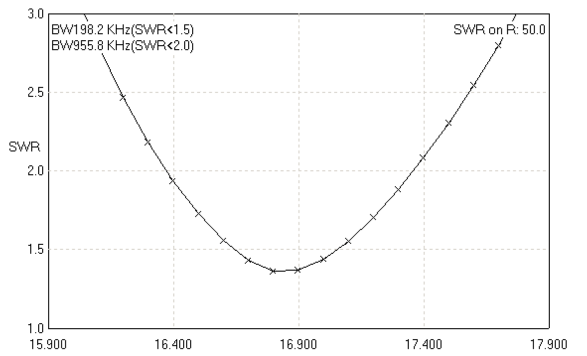
No.	X1(m)	Y1(m)	Z1(m)	X2(m)	Y2(m)	Z2(m)	R(mm)	Seg.
1	0.0	0.0	1.5	0.0	0.0	4.5	14.0	0
2	0.0	0.0	1.5	1.275	0.75	0.0	1.0	0
3	0.0	0.0	1.5	-1.275	0.75	0.0	1.0	0
4	0.0	0.0	1.5	0.0	-1.5	0.0	1.0	0

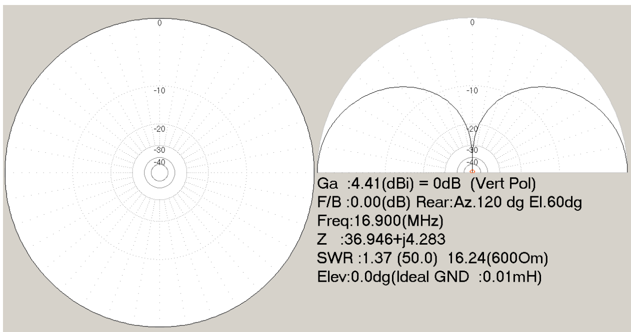
Source 1 ☐ Automatischer Wert

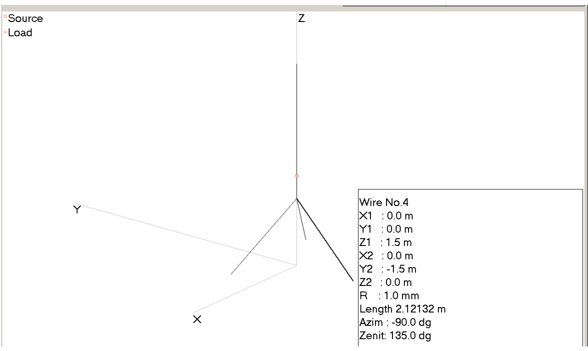
No.	PULSE	Phase dg	Voltage
1	w1b	0.0	1.0
next			

Load 1 ☑ Laste verwenden

No.	PULSE	Type	L(uH)	C(pF)	Q	f(MHz)
1	w1b	LC	2.6	0.0	40.0	
next						

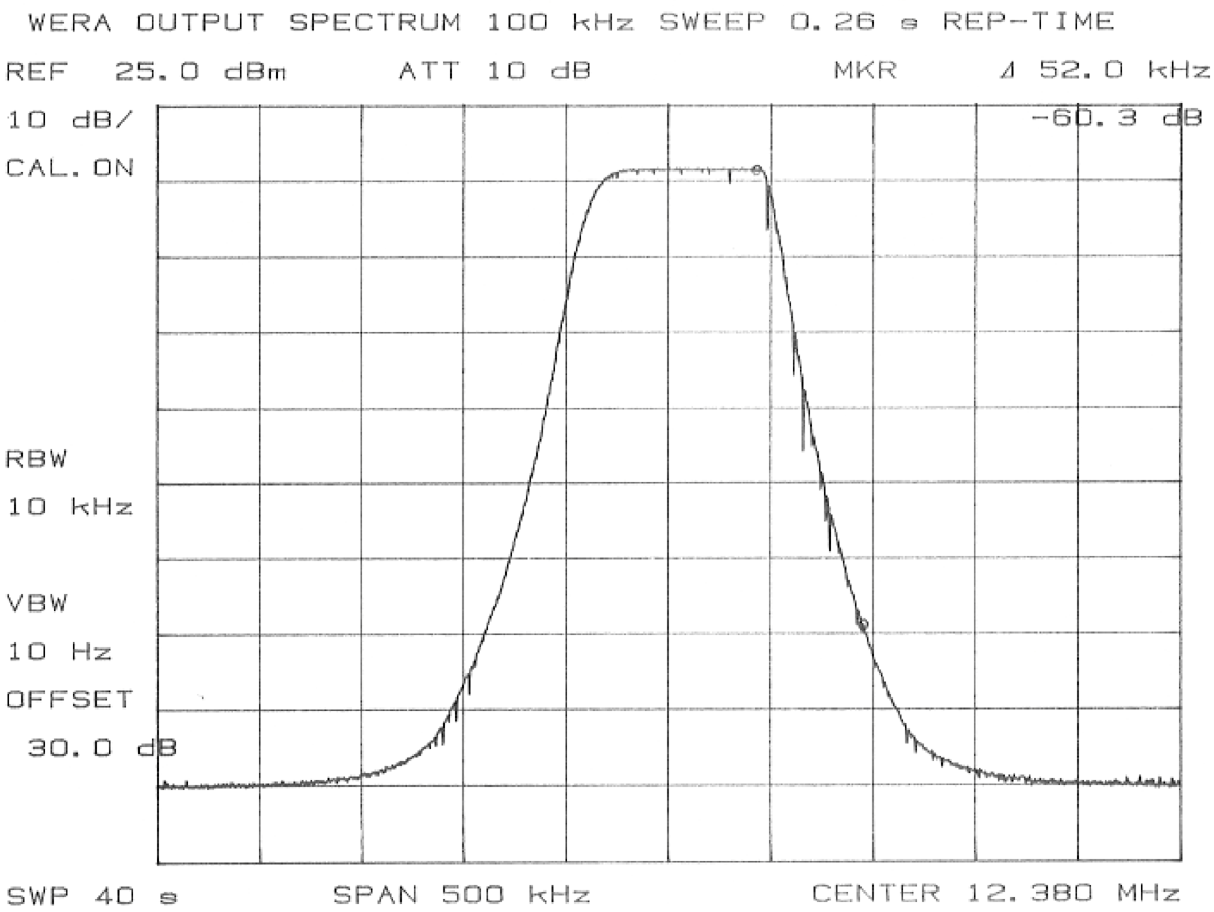






3. WERA Output Spectrum

The radar signal is a very slow swept carrier. Due to the saw-tooth shape a little portion of the transmitted energy will be transferred out of the band limits of the sweep range. Due to the phase continuous switching characteristic of the direct digital synthesizer this out-band energy has a very low level. The plot below displays a spectrum of a 100 kHz sweep with the typical 260 ms repetition time. The level drops down to -60 dBc at about 50 kHz out of band limits.

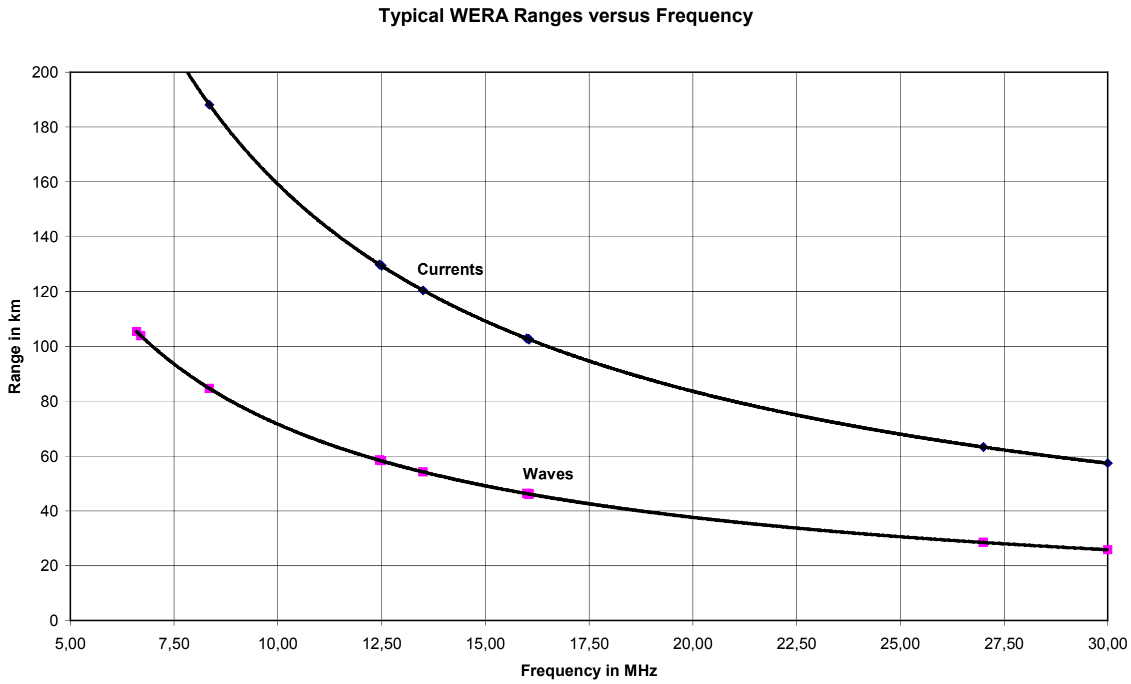


4. Listen before Talk Mode

The "Listen before Talk" mode uses a frequency scan of the entire band prior to the next sweep. Within 1 minute the band is scanned 16 times with a resolution bandwidth of 1 kHz to get 16 spectra. Within this "time over frequency map" the system looks for a frequency "slot" with the required bandwidth that has a noise level below -120 dBm/Hz. If this requirement can't be fulfilled, the system looks for a smaller slot for a reduced sweep width to get at least good data with coarse spatial resolution. If no gap with this low noise condition is found, the lowest noise gap is used with the smallest possible sweep width (typically 50 kHz).

5. Limiting Factors of Bandwidth and Center Frequency

The center frequency is chosen mainly to guarantee the required operating range. Low frequencies give longer ranges.



The sweep bandwidth affects the range resolution of the system. A wider bandwidth results in a higher spatial resolution.