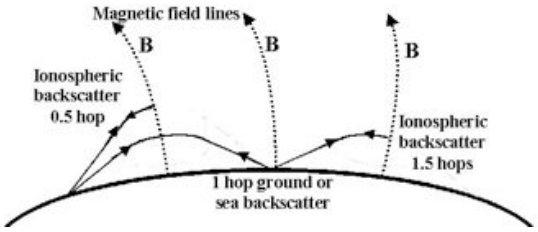
Scalable Ionospheric Analyser SIA 24/6

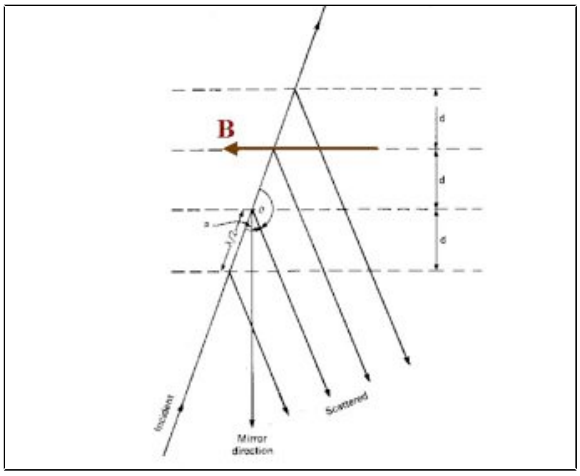
Technical Overview

Functional description

The ATRAD Scalable Ionospheric Analyser SIA24/6 is designed to observe ionospheric irregularities and their drift in the E and F regions. The radar operates as a coherent Doppler backscatter radar, with the radar beam directed perpendicularly to the geomagnetic field at E or F region heights. The required beam elevation angle varies with latitude with typical values between 45 and 90 degrees. The radar can also be fitted with additional switched antenna sets to allow alternative operating modes such as meteor detection.



The diagram above depicts the ray paths for single hop ground or sea scatter and 0.5 and 1.5 hop ionospheric scatter. The diagram to the right illustrates Bragg scattering mechanism from ionospheric irregularities aligned along the Earth's magnetic field direction (After Hargreaves, 1992).

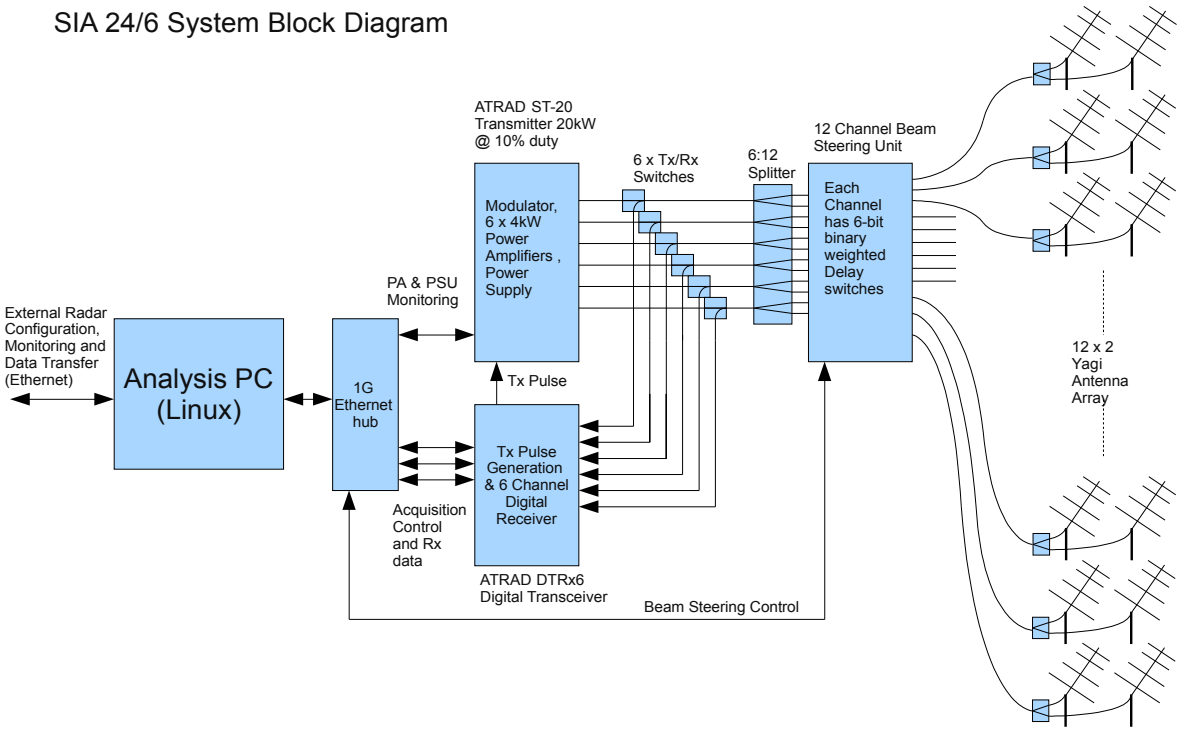


General Radar Characteristics

Radar Model Designation	SIA24/6
Frequency of operation	≈ 50 MHz
Peak envelope power	24 kW nominal
Maximum duty cycle	10%
Pulse coding	Enabled
Sounding range coverage	90-850 km
Antenna Array Configuration	12×2 array of horizontally polarised 5-element Yagi antennas for both transmit and receive. Column spacing: λ/√2 (4.243m at 50MHz) Row spacing: refer Appendix B Boom heights: refer Appendix B
Antenna Array Area ⌒ Length ⌒ Width	 ≈ 12 x λ/√2 ≈ 50m at 50MHz ≈ 6m at 50MHz
Beam Steering ⌒ Method ⌒ Steering range	 Relay switched cable delay beam steering ≈ ±20º in 2.5º steps in azimuth

Radar System Description

The SIA24/6 is based on standard ATRAD VHF Radar technology. This features the use of efficient solid-state power amplifiers, and sophisticated monitoring and control for enhanced reliability. A block diagram of the SIA24/6 radar is show below.



A small equipment hut is required to house the Transmitter, Receivers, Beam Steering, Data and Analysis PC. The 12 Beam Steering output ports are connected to the 2-way Splitters and the Antenna Array via 12 phase-matched feeder cables. The radar can operate stand-alone or be connected via a customer-supplied Ethernet network connection to allow full remote control and monitoring.

DTRx Digital Transceiver includes:

- Fully synchronous Transmit exciter, 6 channel Receiver and Digital IF acquisition
- 6 channel I and Q output data sent to the Analysis PC.
- Programmable receiver gain and bandwidth.
- Interfacing to the Beam-steering system and antenna selectors.

Analysis PC (with ATRAD software suite) includes:

- Radar Configuration and Control software.
- Data analysis and Display software.
- Data transfer to external hosts.

ST-20 Transmitter includes:

- ST-20 Tx Chassis (9RU high) fitted with 6 PA cards, a PA Controller/Modulator card and PA Driver card.
- The PA Controller/Modulator uses an Ethernet port for host programming of the required pulse characteristics and for monitoring of PA performance.
- Eltek-Valere modular compact DC power shelf providing the 50Vdc (150A maximum) to the Tx Chassis. This PSU includes an Ethernet port for monitoring and control.

Transmit/Receive Switches provide:

- Switching of the Transmit pulse through to the Beam-steering system and Antenna array.

- Switching is achieved with passive diode switches for simplicity and reliability.
- Low-losses for both the transmit and receive paths.
- Fast switching times.

Beam-steering system includes:

- 12 channels of RF delay switches each of 6 bits (binary-weighted).
- Delay switches comprise a relay and cable delay line.
- Modular construction for ease of maintenance.

Antenna Array includes:

- 12 phase matched feeder cables from the Beam-steering system.
- 12 x 1:2 Splitter/Combiners.
- 24 x 5-element Yagi antennas arranged in a 12×2 array.

Items not supplied by ATRAD

⁀ Site works, including antenna supports, fences, grounding stakes
⁀ Equipment hut and furniture
⁀ Connection of power, telephone and internet facilities
⁀ Operating licence

Appendix A: System Specifications

VHF Transmitter specification

Model	ATRAD ST-20
General description	20 kW VHF Power Amplifier, with Monitoring and Control.
Mechanical/Environmental	
Transmitter Sub-rack	19 inch Rack 9RU high 600mm deep
Operating temperature	0º to +40º ambient air temperature
Cooling	Forced air cooling using dual 172mm diameter high flow-rate fans. Fan speed controlled and monitored by the transmitter controller module.
RF Inputs/Outputs	
RF output connectors (6)	N type, each 4KW nominal peak.
RF Tx pulse input	BNC, 0dBm (~0.7Vpp into 50 Ohms)
DC Power Input	
Supply voltage	52V DC
Maximum Current	Nominal 100A (typ.) @ 10% duty cycle
Control Inputs/Outputs	
Control/Monitor Port	Ethernet RJ-45 (10MBit)
Tx Gate Input	BNC, TTL level
Monitoring/Protection	
Tx monitoring	Forward power, Load Return Loss, Supply voltage and Heatsink Temperature for each PA module and PA Driver module, Fan speeds, ambient temperature, and supply voltages. Transmitter disabled on over temperature, transmitter output reduced by approx. 6dB on VSWR fault.
RF Characteristics	
Power at output ports	4KW PEP nominal, ⁀0.5dB
Close in spectrum (emission bandwidth)	⁀ (1.2MHz / pulse width in ∓sec) for -20dBc
Efficiency (RF out/DC in)	⁀ 40% for shaped pulse
Maximum Duty cycle	10%, as determined by system parameters
Spurious emission	Better than -60dBc

Transmitter Power Supply specification

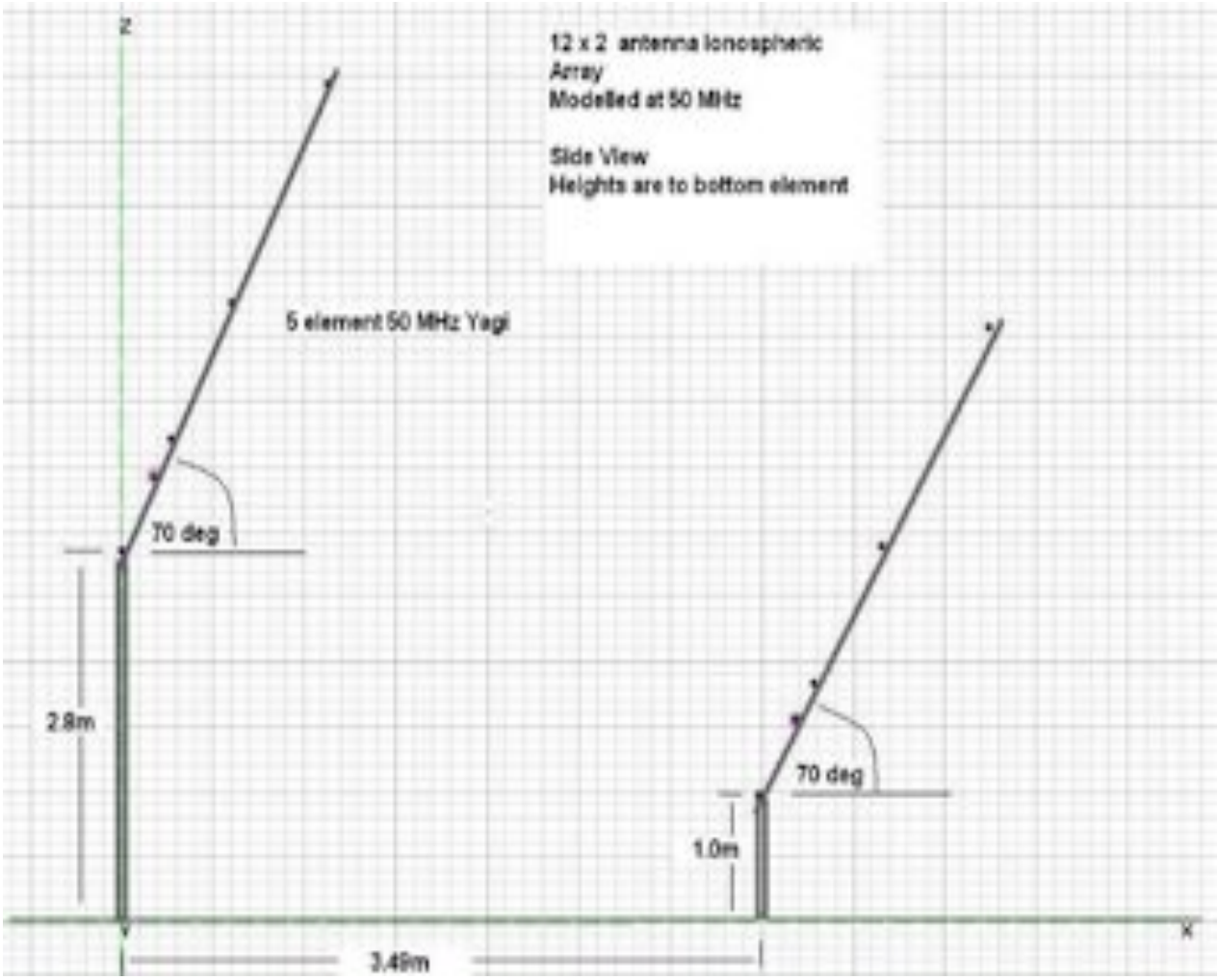
Model	Eltek-Valere FlatPack2 Modular PSU
General description	19” Rack-mount Modular PSU fitted with up to 4 x 2KW modules, N+1 redundancy capability.
Mechanical/Environmental	
PSU Sub-rack	19 inch Rack 2RU high 400mm deep
Operating temperature	0º to +40º ambient air temperature
Cooling	Each module has in-built variable speed fan.
AC Power Input	
Supply voltage	100-250Vac 45-66Hz
Maximum Supply Current	12.5A per module
DC Power Output	
Programmable voltage	45-56 Vdc typically set to 52Vdc
Maximum Current	37A per module, typical SIA system has 3 modules fitted providing redundancy (i.e. system will still operate if one module fails)
Efficiency (DC out/AC in)	>95% typical
Control Inputs/Outputs	
Control/Monitor Port	Ethernet RJ-45 (100MBit)
PSU monitoring	AC Supply voltages and Internal Temperatures for each PSU Module. System output voltage and current.
PSU protection	Over-current. over-temperature

DTRx Digital Receiver/Exciter Specifications

Model	DTRx6
General Description	Fully synchronous digital radar sub-system providing: - Transmitter pulse waveform generation, with programmable pulse width, pulse coding and PRF, - 6 channel double conversion receiver with direct IF sampling, digital quadrature down-conversion to baseband, and programmable filtering and range resolution.
Receiver:	
RF input	6 x SMA 50 Ohm
Receiver Noise figure	<3dB (incl. T/R switch)
IF Frequency	80MHz (direct 16-bit sampling at 120MHz)
IF Bandwidth	8MHz (-3dB)
Receiver Gain Control	80dB range (controlled via Ethernet)
Receiver Bandwidth Control	Programmable over a wide range from >1.2MHz to <35kHz, linked to selected Range Resolution. (controlled via Ethernet)
T/R switch recovery	<0.3∓sec
Data Acquisition:	
Minimum/Maximum Range resolution	From 50 to 10,000 metres in 25 metre steps
Maximum number of Range gates	1024
Minimum PRF/ Maximum PRF	1Hz/100kHz
Maximum IPP/ Minimum IPP	1Sec/10uSec
I/Q Output	2 x 1GBit Ethernet data streams direct to Atrad Analysis PC
Exciter:	
Transmit Carrier Output	SMA,~0dBm (750mVp-p)
Transmitter Gate Output	SMA, TTL

Appendix B: Antenna Array Modelling Example

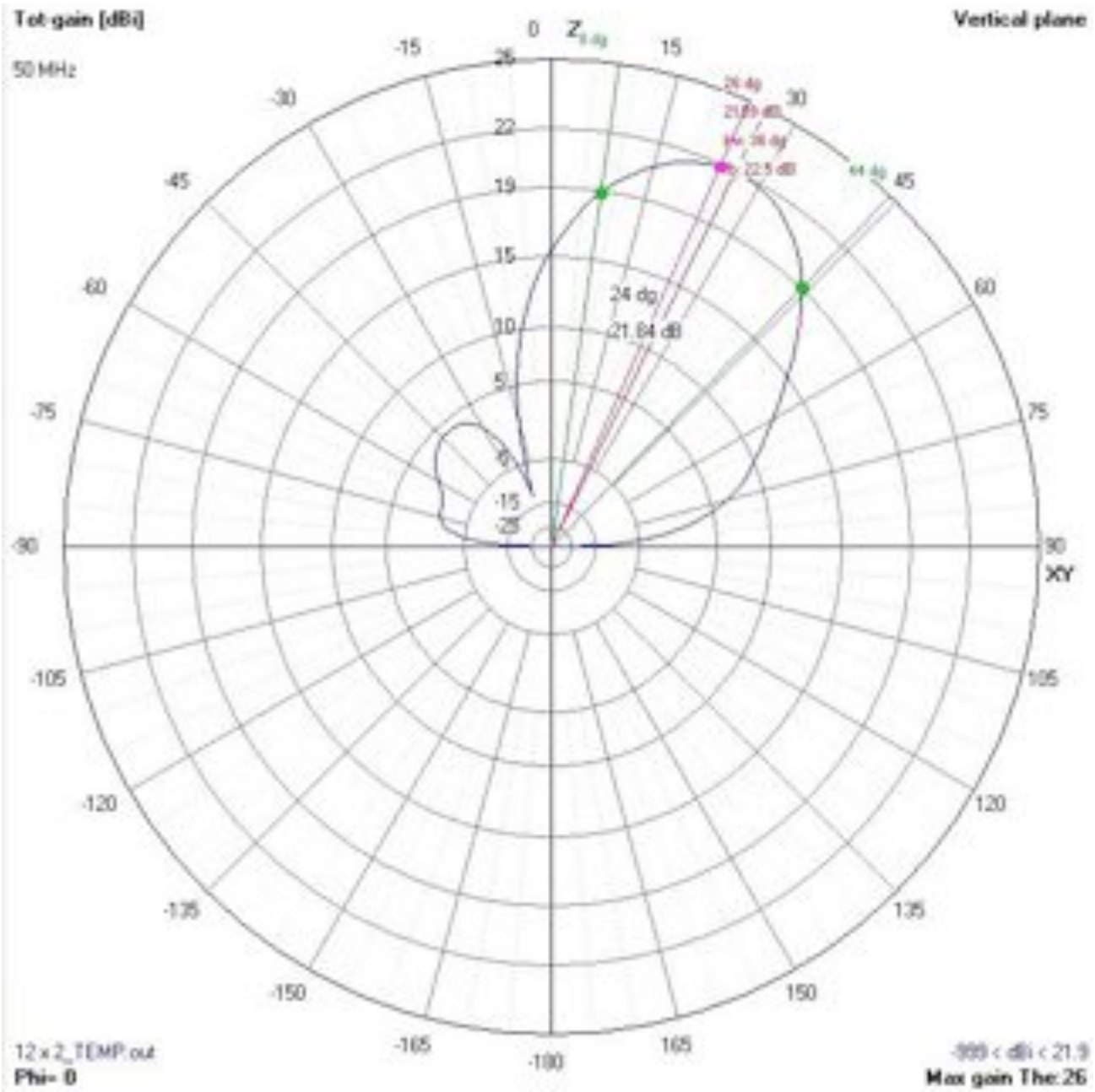
The array dimensions were chosen after extensive optimisation. The following diagrams are based on a 50MHz nominal frequency and a typical beam angle. All dimensions are scaled for the exact Radar frequency and the Beam angle appropriate to the radar geographic location.



Lateral view of array showing antenna mounting heights angles and spacings.

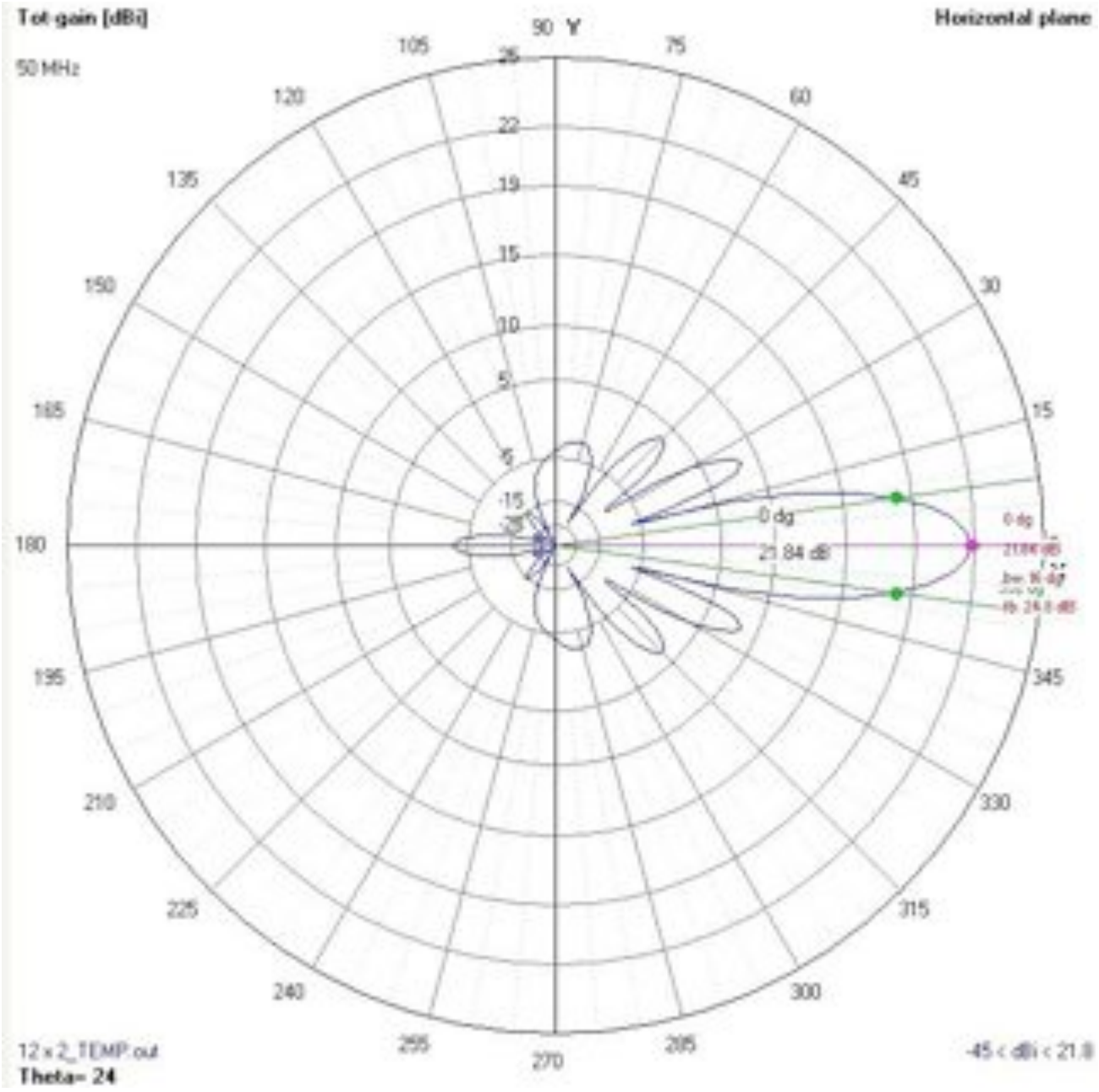
Antenna Array Vertical Plot
Note: horizontal is given as 90 degrees on this plot, read 24 degrees for 66 deg beam elevation from horizon.

Gain @ 66 (24) deg. From horizontal: 21.84 dBi
Maximum Gain: 21.89 dBi @ 64 (26) deg.
3 dB beamwidth: 36 deg.
F/B Ratio: 22.5 dB
Rear lobe gain 3.9 dBi

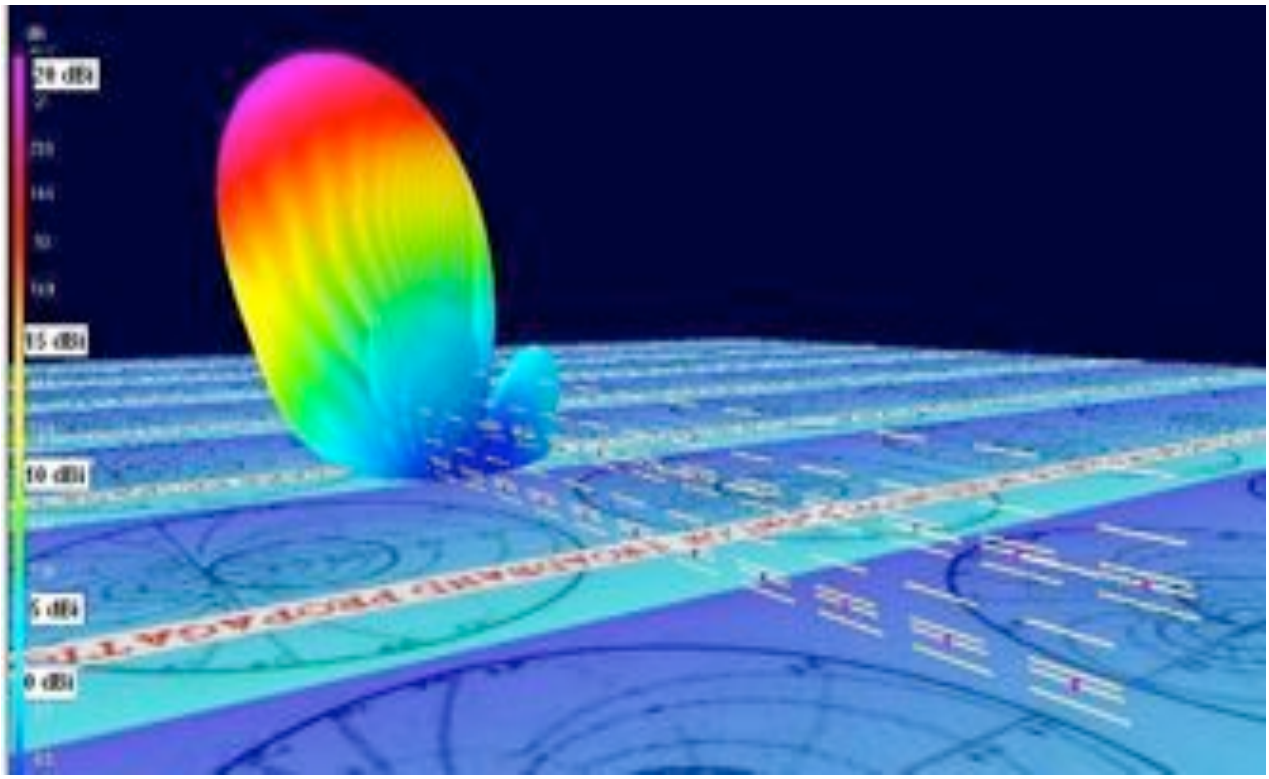


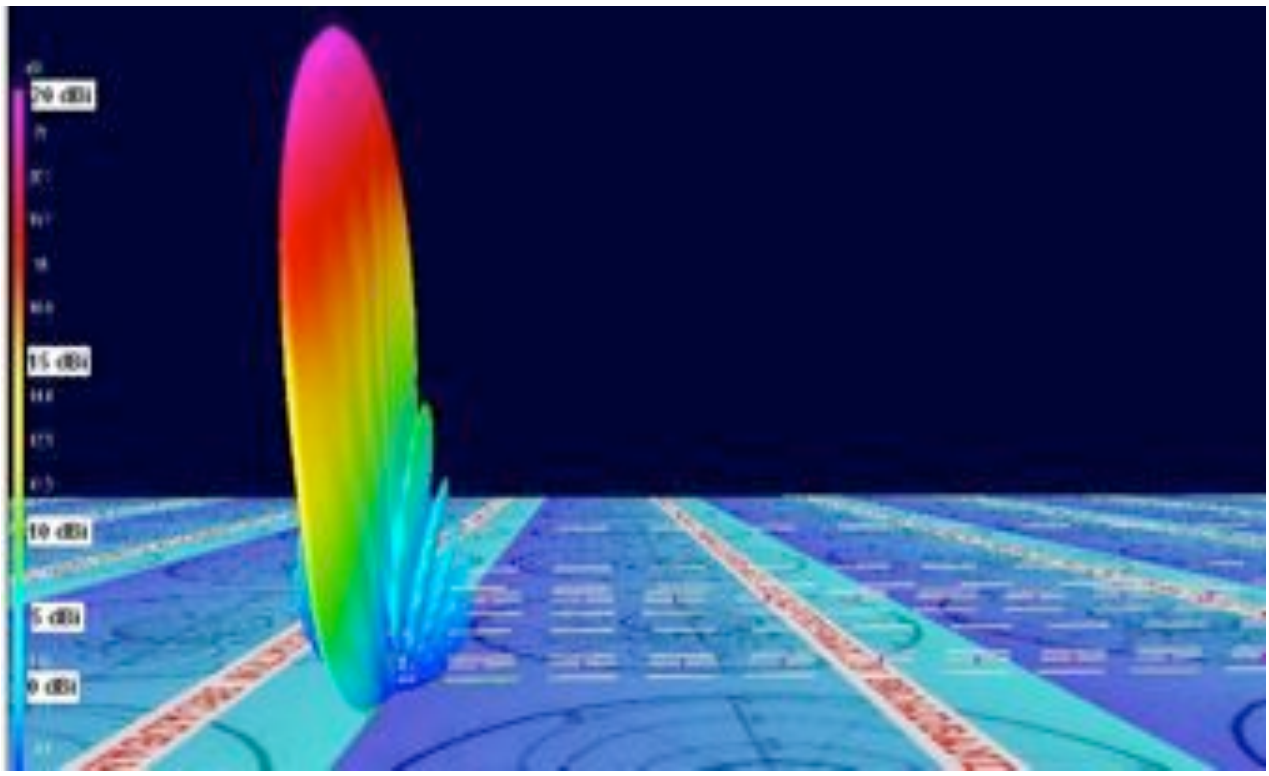
Antenna Array Horizontal Plot

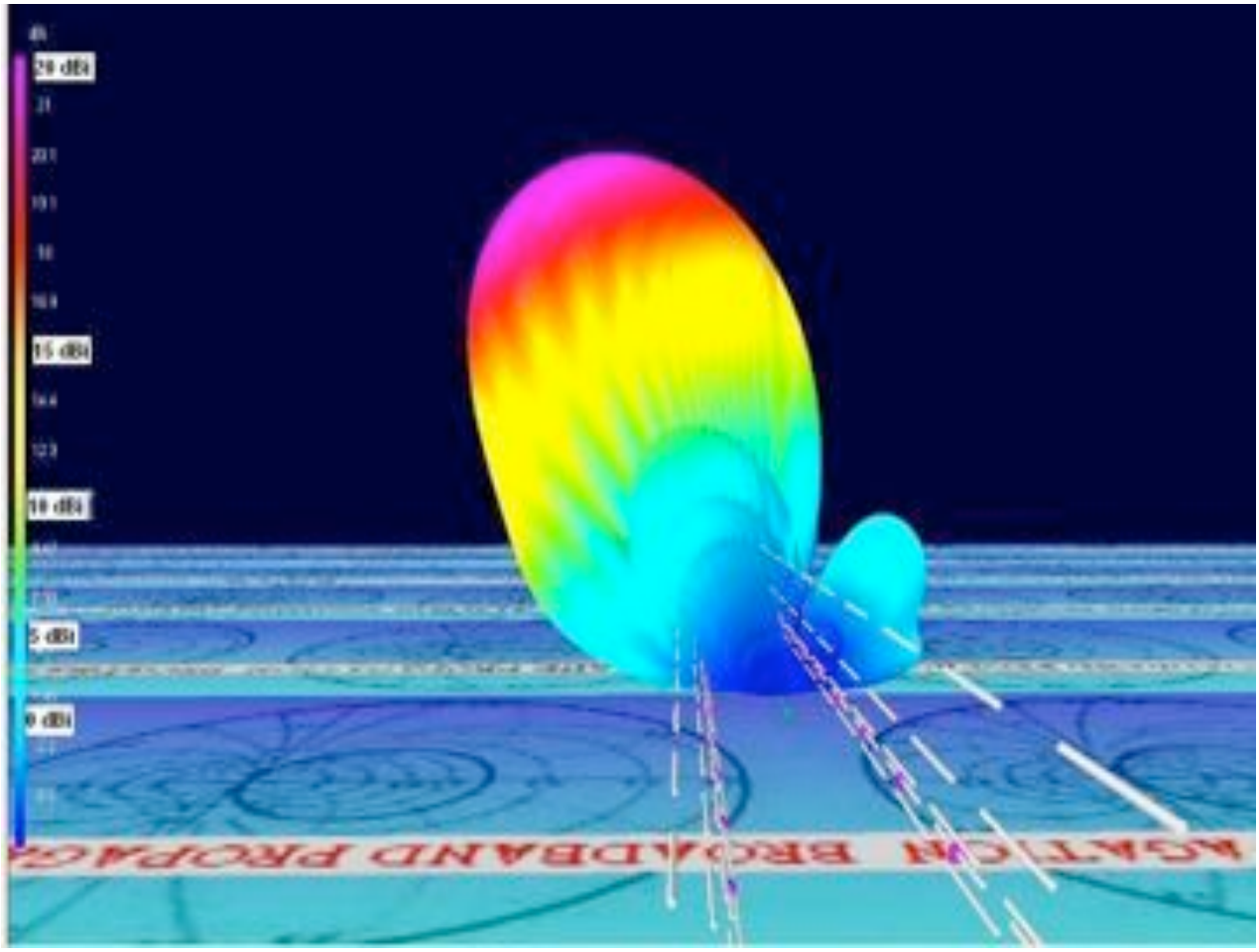
Theta = 66 (24) deg.
Gain @ 66 (24) deg. From horizontal: 21.84 dBi
3 dB beamwidth: 16 deg.



Antenna Array 3D Patterns

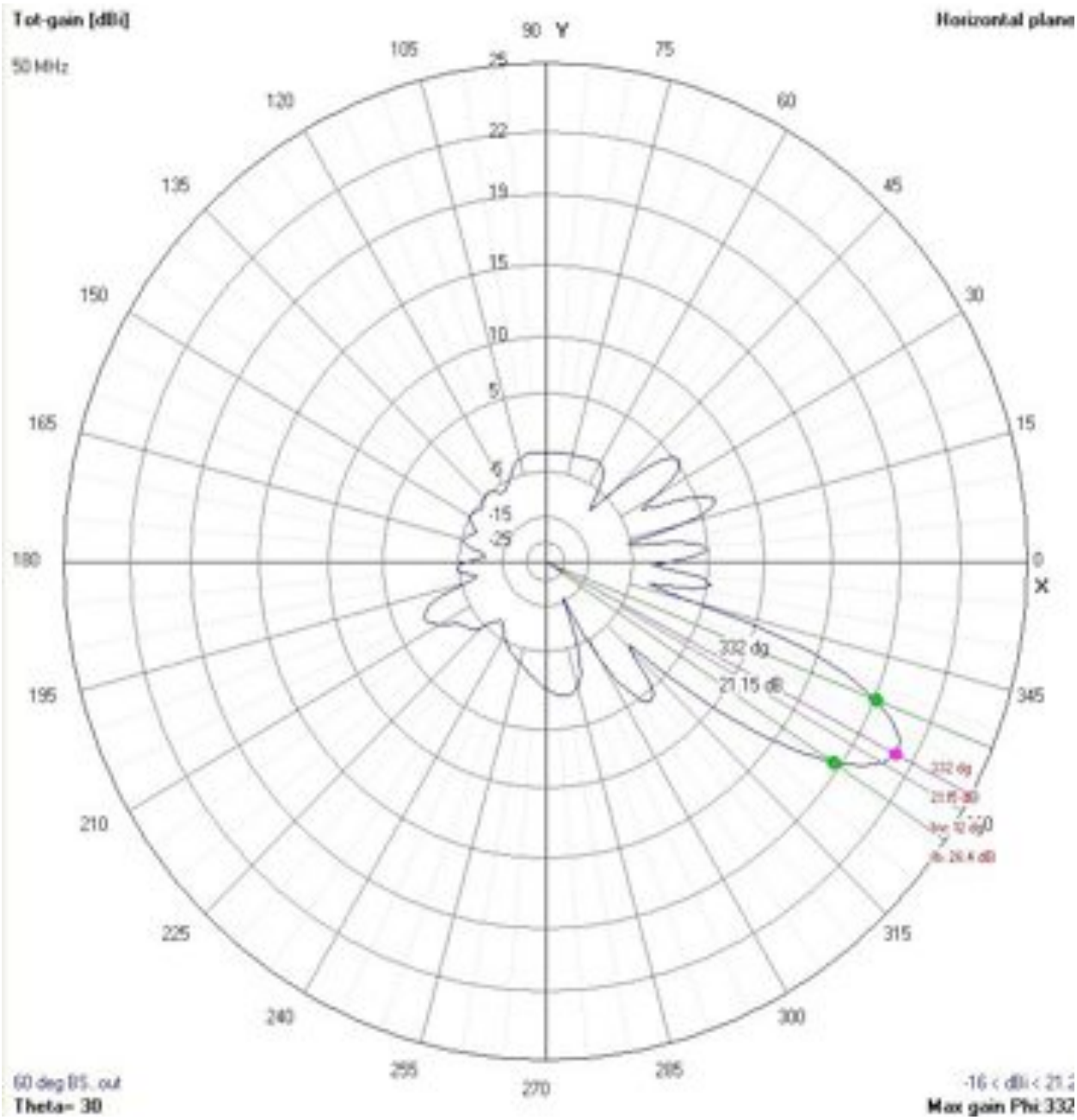




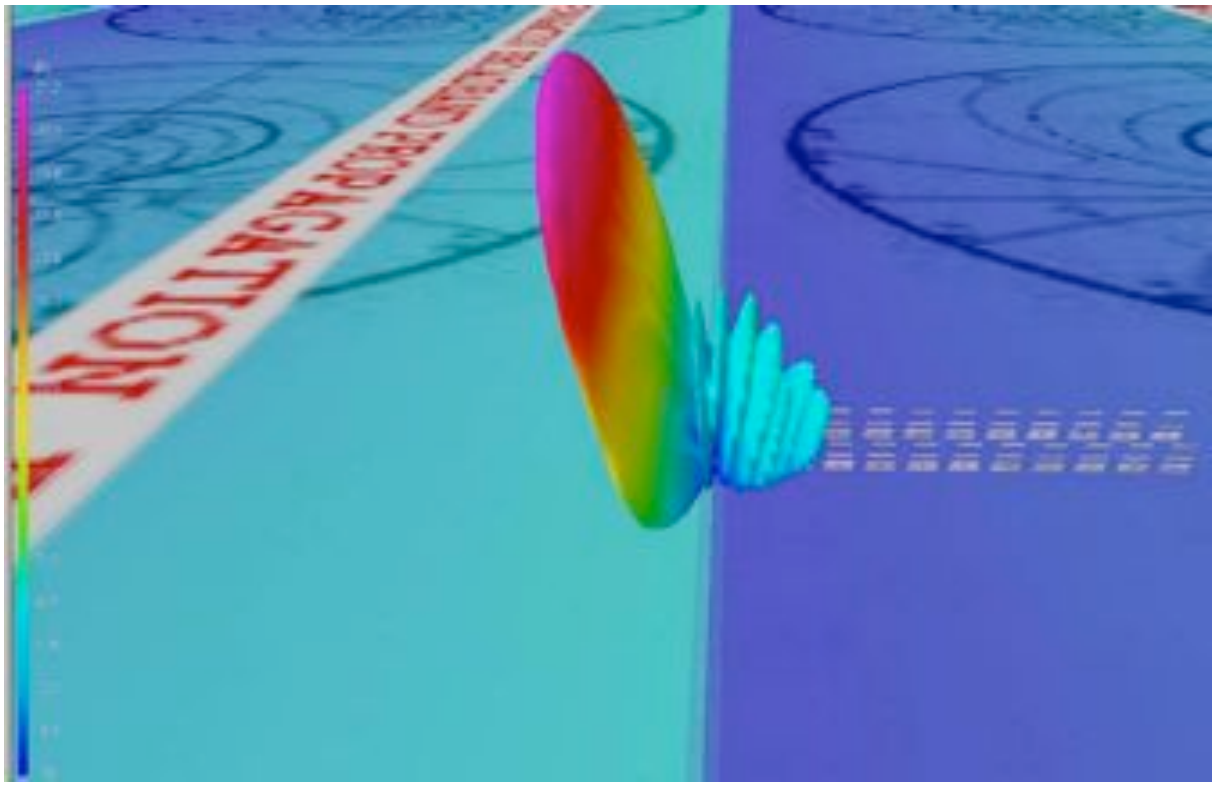

20 dBi
15 dBi
10 dBi
5 dBi
0 dBi

Beam Steering
Plots demonstrate the beam direction with 60 degree phase increments between antenna rows.

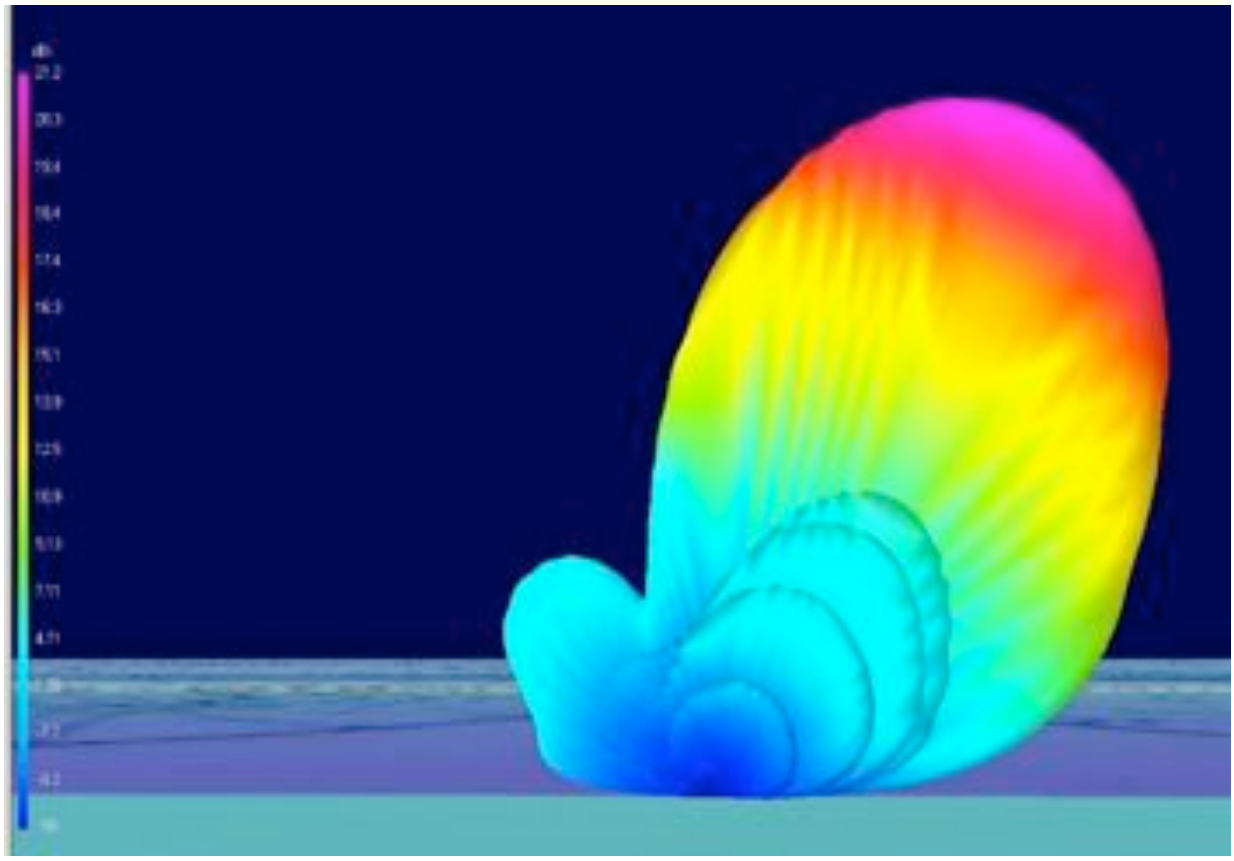
Horizontal Pattern



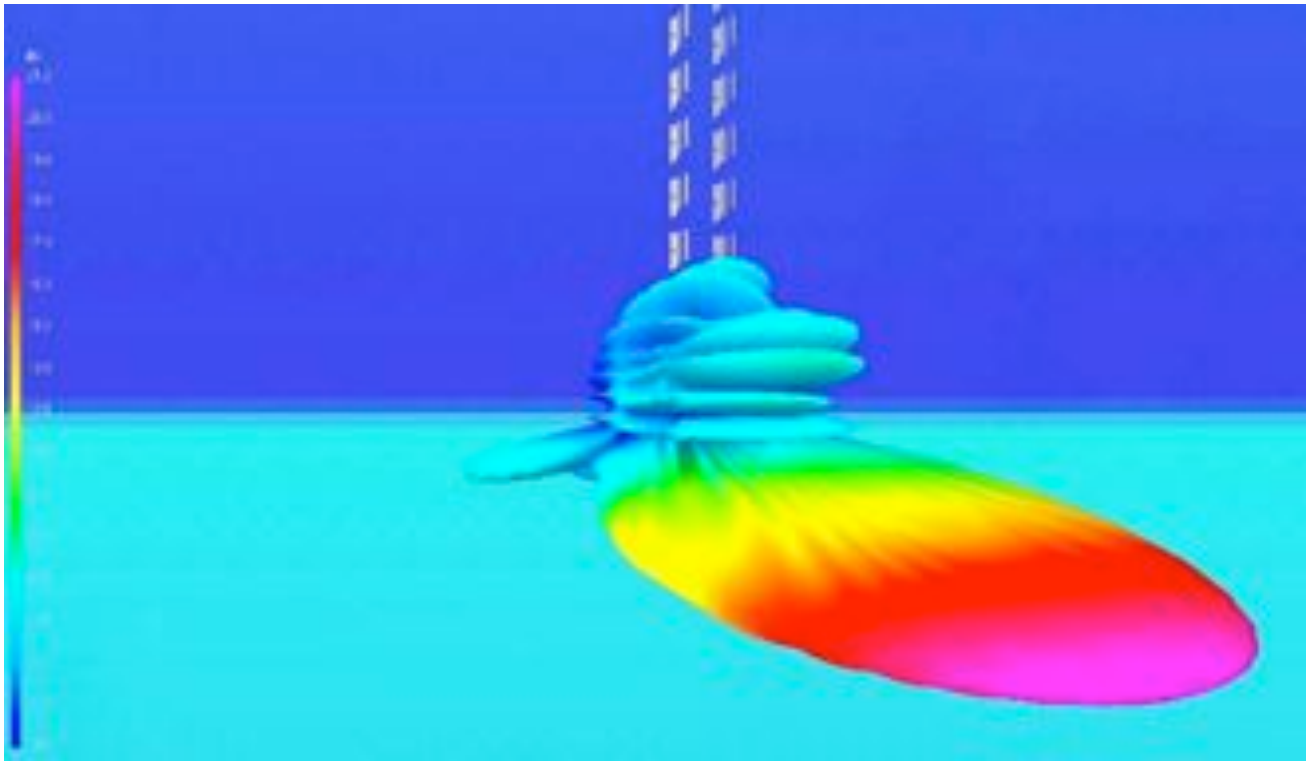
3D View



3D Side View



3D Top View



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