Grandstream Networks, Inc.

GWN7664ELR - Antenna Radiation Patterns

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Introduction

One of the major components of a wireless Access Point is the antenna. These radio components come in different shapes and sizes to fit specific deployment needs, and each access point can bundle multiple antennas for sending and receiving signals in order to benefit from the MIMO (Multiple Input/Multiple Output) technology and obtain higher throughput and signal resilience, also the arrangement of multiple antennas internally to a single WLAN access point can be used to influence the shape and behavior of the wireless signal (both on transmit and receive). To better understand how each GWN access point model broadcasts the wireless signals, this paper provides radiation patterns to help engineers during the deployment process.

The GWN7664ELR is an enterprise outdoor 802.11ax Wi-Fi 6 access point for medium-to-large businesses and enterprises who need to provide long-range coverage in outdoor spaces. It offers IP67-level weatherproof capability, dual-band 4x4:4 MU-MIMO with DL/UL OFDMA technology and a sophisticated antenna design for up to 6 Gbps wireless throughput that supports 1000+ clients and an expanded 300-meter coverage range. To ensure easy installation and management, the GWN7664ELR includes a built-in controller embedded within the product's web user interface. It is also supported by GDMS Networking and GWN Manager, Grandstream's free cloud and on-premise Wi-Fi management platform. The GWN7664ELR is the ideal Wi-Fi AP for voice-over-Wi-Fi deployment and offers a seamless connection with Grandstream's Wi-Fi capable voice and video IP phones. With support for advanced QoS, low-latency real-time applications, mesh networks, captive portals and a 2.5 Gigabit Ethernet port and a 2.5 Gigabit SFP port with PoE/PoE+, GWN7664ELR is an ideal outdoor Wi-Fi access point for enterprises, multiple floor offices, warehouses, hospitals, schools and more..

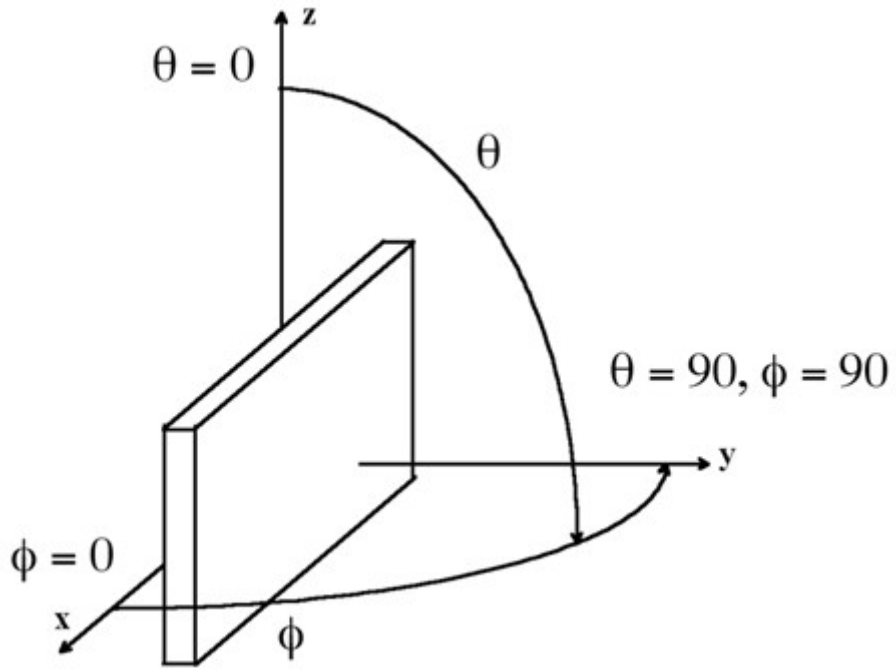
We begin this report with a glossary of basic definitions related to antennas' radio characteristics and then progress through the specific radiation patterns for the GWN7664ELR access point series.

Terminology

In this first part, we will provide a quick brief review of some fundamental concepts related to antennas and radio propagation:

Antenna: An antenna is a transducer between a feed signal and radiated wave over the space, it is usually attached to a transmitter/receiver unit and the radiated energy is characterized by the antenna's radiation pattern.

Antenna pattern: The radiation pattern or antenna pattern is the graphical representation of the radiation properties of the antenna and how it radiates energy out into space or how it receives energy (reciprocity). An antenna radiates energy in all directions, at least to some extent, so the antenna pattern is actually three-dimensional. It is common, however, to describe this 3D pattern with planar patterns called the principal plane patterns. These principal plane plots are commonly referred to as antenna radiation patterns.



Polar Coordinates

Isotropic radiator: An isotropic radiator is a hypothetical lossless antenna that radiates its energy equally in all directions. This imaginary antenna would have a spherical radiation pattern and the principal plane cuts would both be circles since any plane cut through a sphere would be a circle.

Gain: The gain of an antenna (in a given direction) is defined as the ratio of the power gain in that direction to the power gain of a reference antenna in the same direction, usually an isotropic radiator is set as reference and the value of the gain is expressed in dBi. It is important to state that an antenna with gain doesn't generate power and it does simply direct the way the radiated power is distributed relative to radiating the power equally in all directions, thus the gain is just a characterization of the way the power is radiated.

Efficiency: The efficiency of an antenna is the ratio of the power delivered to the antenna relative to the power radiated from the antenna. A high-efficiency antenna has most of the power present at the antenna's input radiated away. A low-efficiency antenna has most of the power absorbed as losses within the antenna or reflected away due to impedance mismatch which causes an antenna to not have an efficiency of 100%.

Antenna efficiency losses are typically due to:

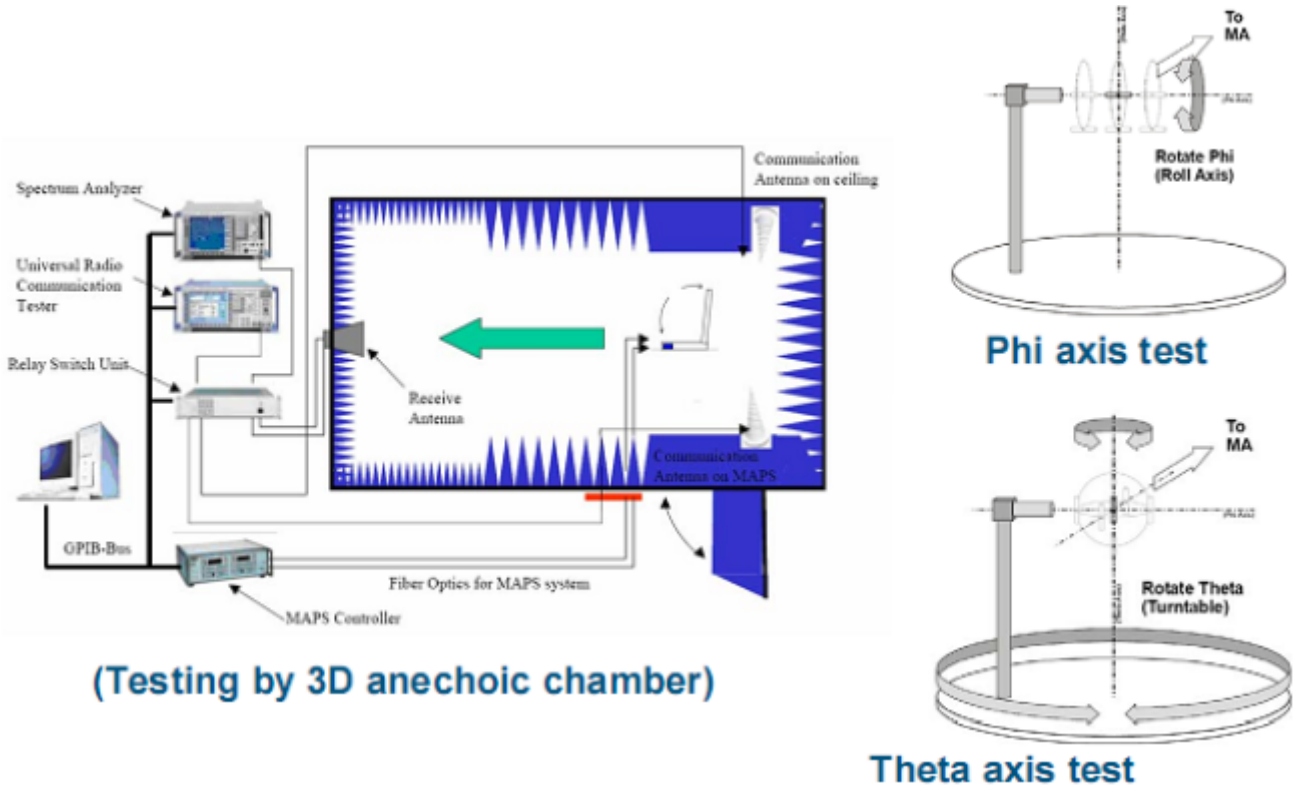
- Conduction losses (due to finite conductivity of the metal that forms the antenna).
- Dielectric losses (due to the conductivity of a dielectric material near an antenna).
- Impedance mismatch loss.

Test environment

This test report gives schematic diagrams with antennas distribution of GWN76XX access points series, along with the antenna radiation patterns of both 2.4Ghz and 5Ghz frequencies in order to help engineers during the deployment process.

Please note that these radiation patterns are gathered in a fully anechoic environment. Their shape will change in installed environments depending on the obstacles that the wireless signal might face. Every deployment will behave differently due to materials, geometries of structures, etc, and how these materials behave at 2.4GHz and 5GHz.

The below figure gives an overview of the used test environment:



Test Environment

GWN7664ELR Antenna Characteristics

Antenna Specifications

Characteristic	2.4 GHz	5 GHz
Frequency range (MHz)	2400-2500	5150-5850
Peak gain (dBi)	2G1: 6.01 - 2G2: 5.96 2G3: 6.02 - 2G4: 5.74	5G1: 6.79 - 5G2: 6.98 5G3: 7.09 - 5G4: 7.01
VSWR	<= 2.0:1	<= 2.0:1
Antenna type	PCB antenna	PCB antenna
Radiation properties	Omnidirectional	Omnidirectional
Impedance (Ohm)	50	50
Isolation (dB), as specified	<= -15	<= -15
RoHS compliant	Yes	Yes

GWN7664ELR antenna specifications

Antenna Patterns

The following plots compare the four antennas in each frequency band across the XZ, YZ, and XY planes. Each colored curve represents one antenna, as identified by the legend. Angular markings around each plot show the direction within that plane; the radial scale is retained in dB as labeled in the antenna datasheet.

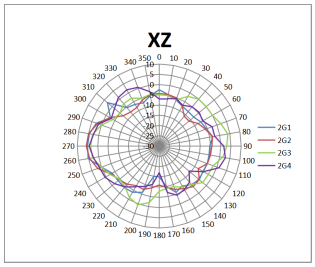
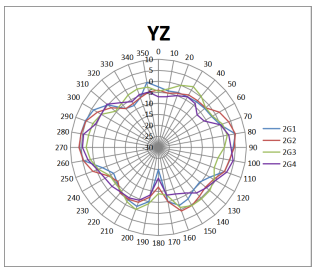
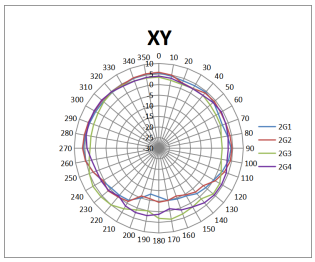
Plane	Spherical-coordinate cut	View when Z is vertical
XZ	$\phi = 0^{\circ}$	Vertical cut through the X and Z axes
YZ	$\phi = 90^{\circ}$	Vertical cut through the Y and Z axes

XY	Θ = 90°	Horizontal cut through the X and Y axes

Plane reference, using Θ measured from +Z and ϕ from +X toward +Y

The plane labels describe the test coordinate system. Relating these plots to an installed access point requires the corresponding device-to-axis orientation. Select a graph to open the source image at full size.

2.4 GHz Antenna Radiation Patterns

XZ	YZ	XY
		
GWN7664ELR 2.4 GHz XZ plane radiation patterns for 2G1, 2G2, 2G3, and 2G4	GWN7664ELR 2.4 GHz YZ plane radiation patterns for 2G1, 2G2, 2G3, and 2G4	GWN7664ELR 2.4 GHz XY plane radiation patterns for 2G1, 2G2, 2G3, and 2G4

2.4 GHz antenna radiation patterns

2.4 GHz Gain and Efficiency

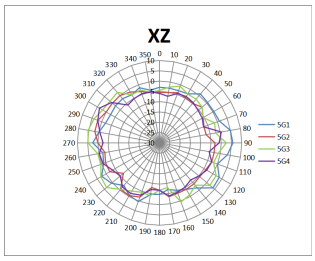
Gain (dBi) and efficiency (%) are paired for each antenna at every measured frequency. Values are rounded to two decimal places.

Frequency (MHz)	2G1		2G2		2G3		2G4	
	Gain (dBi)	Efficiency (%)	Gain (dBi)	Efficiency (%)	Gain (dBi)	Efficiency (%)	Gain (dBi)	Efficiency (%)
2400	5.68	77.83	5.40	79.55	6.02	83.95	5.66	76.85
2410	5.86	78.70	5.52	80.50	6.00	83.92	5.63	78.30
2420	6.01	78.99	5.60	81.15	5.77	83.45	5.62	79.69
2430	5.94	80.61	5.48	83.08	5.44	85.09	5.74	82.75
2440	5.63	81.09	5.26	83.09	5.19	85.14	5.67	83.46
2450	5.70	82.75	5.42	83.70	4.87	84.95	5.59	84.35
2460	5.64	84.28	5.43	84.27	4.82	84.87	5.53	85.42
2470	5.72	86.51	5.66	86.66	4.90	85.36	5.60	88.39
2480	5.78	86.64	5.85	88.14	4.85	84.14	5.69	90.34
2490	5.53	83.37	5.90	86.07	4.75	80.35	5.55	88.15
2500	5.39	81.99	5.96	84.47	4.91	77.62	5.24	86.40

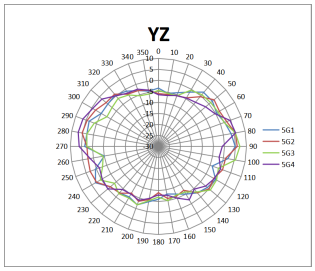
2.4 GHz measured antenna gain and efficiency

5 GHz Antenna Radiation Patterns

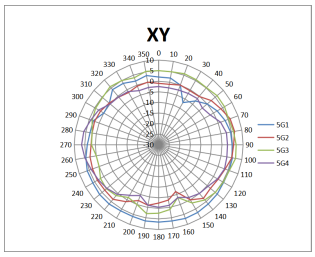
XZ	YZ	XY



GWN7664ELR 5 GHz XZ plane radiation patterns for 5G1, 5G2, 5G3, and 5G4



GWN7664ELR 5 GHz YZ plane radiation patterns for 5G1, 5G2, 5G3, and 5G4



GWN7664ELR 5 GHz XY plane radiation patterns for 5G1, 5G2, 5G3, and 5G4

5 GHz antenna radiation patterns

5 GHz Gain and Efficiency

Gain (dBi) and efficiency (%) are paired for each antenna at every measured frequency. Values are rounded to two decimal places.

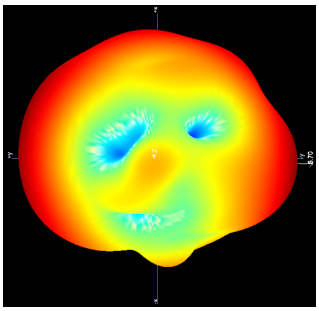
Frequency (MHz)	5G1		5G2		5G3		5G4	
	Gain (dBi)	Efficiency (%)	Gain (dBi)	Efficiency (%)	Gain (dBi)	Efficiency (%)	Gain (dBi)	Efficiency (%)
5150	6.79	87.29	5.69	61.49	6.97	79.21	6.22	73.38
5200	6.71	83.76	5.35	60.86	6.94	78.95	6.08	66.35
5250	6.45	83.75	5.26	60.66	6.53	80.14	6.09	58.87
5300	6.62	85.43	5.16	61.39	6.29	74.98	5.59	58.51
5350	6.29	84.66	5.60	64.48	6.73	75.50	5.46	58.17
5400	5.81	82.21	6.26	66.15	7.09	82.32	5.75	59.65
5450	5.82	78.29	6.84	69.77	6.68	80.43	5.63	62.39
5500	5.45	74.62	6.53	66.63	5.88	71.55	5.08	62.03
5550	5.44	74.80	6.70	65.89	5.71	72.37	5.00	58.34
5600	5.02	69.70	6.72	66.19	5.64	70.75	5.07	61.78
5650	4.93	66.16	6.89	68.54	5.39	68.12	5.17	62.34
5700	5.10	70.16	6.98	75.28	5.32	64.17	5.17	65.44
5750	5.16	64.89	6.29	69.19	4.77	62.99	5.37	67.10
5800	5.24	67.20	5.88	72.40	5.08	63.14	6.29	65.65
5850	5.17	67.66	5.83	75.89	4.68	65.07	7.01	69.36

5 GHz measured antenna gain and efficiency

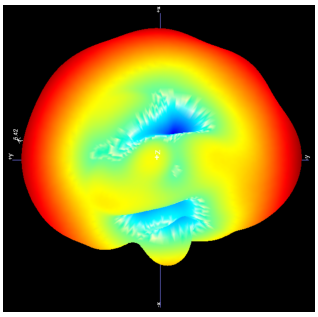
3D Radiation Patterns

The existing three-dimensional pattern views are retained below for comparison with the plane cuts.

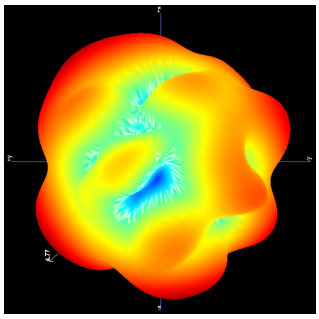
2.4 GHz 3D Patterns



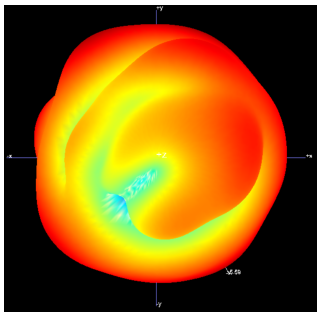
2G1 3D radiation pattern



2G2 3D radiation pattern

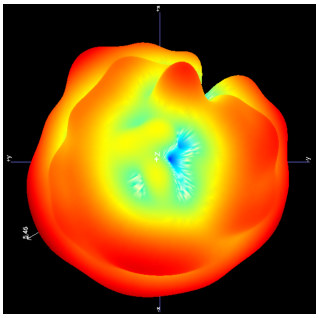


2G3 3D radiation pattern

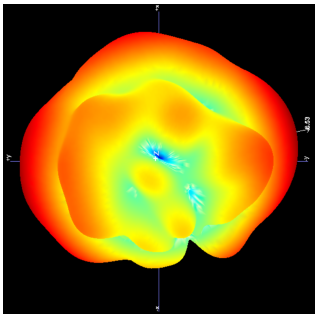


2G4 3D radiation pattern

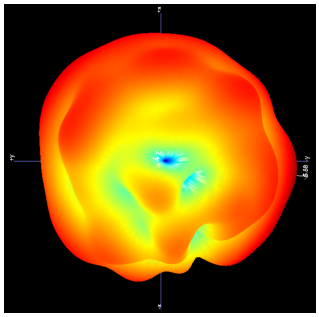
5 GHz 3D Patterns



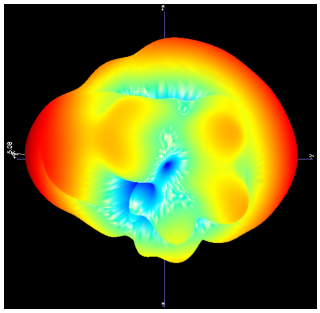
5G1 3D radiation pattern



5G2 3D radiation pattern



5G3 3D radiation pattern



5G4 3D radiation pattern