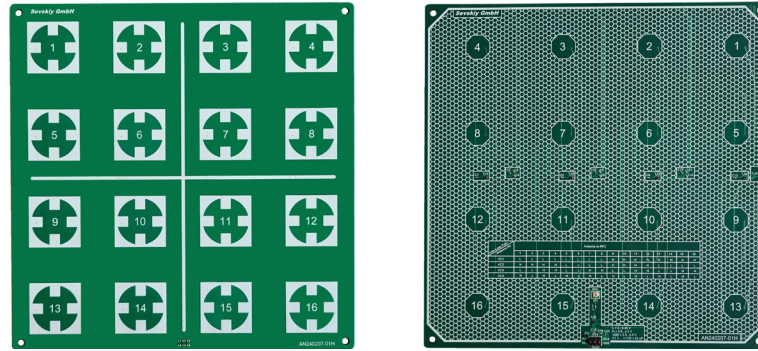


2400...2500 MHz Patch antenna array for direction finding applications (Bluetooth LE, AoA, AoD)



General information

The AN240207-01H is a compact 4×4 planar patch antenna array designed for two-dimensional direction-finding and localization applications in the 2.4...2.5 GHz ISM band, with primary focus on Bluetooth Low Energy (BLE) Angle of Arrival (AoA) systems.

The antenna array itself is fully passive and operates in conjunction with an external RF switching network. A single RF transceiver port is sequentially connected to each of the 16 antenna elements via RF switches controlled by digital control lines. This architecture enables phase-coherent signal reception from all antenna elements while maintaining a simple and cost-effective RF front-end. The 4×4 array geometry allows angle estimation in both horizontal and vertical planes, enabling two-dimensional direction finding based on phase differences measured between spatially displaced antenna elements.

In addition to Angle of Arrival (AoA), the antenna array concept is also compatible with Angle of Departure (AoD) systems, where a known antenna switching sequence is applied on the transmitting side and the receiving device determines the signal direction from phase variations. Both AoA and AoD techniques are standardized in modern BLE direction-finding solutions.

These features make the AN240207-01H well suited for indoor positioning systems, real-time location systems (RTLS), object and equipment tracking, proximity and presence detection, and other short-range wireless localization applications requiring two-dimensional angular resolution.

Electrical data

Antenna type	4x4 patch antenna array
Frequency bands	BLE 2450 MHz
Frequency range [MHz]	2400...2500
Return loss [dB]	-15
Peak gain of single array element [dBi]	-1...0.7
Radiation efficiency [%]	20...25
Nominal input impedance [Ohm]	50
Polarization	Circular (RHCP)
Radiation pattern	directional
Maximum input power [dBm]	+32

Mechanical data

Antenna PCB dimensions [mm]	200 x 200 x 2
Connector type ¹⁾	IPEX MHF1 / Hirose U.FL (UMCC) compatible 1) ¹⁾
PCB material	FR4
Weight [g]	200

Additional information

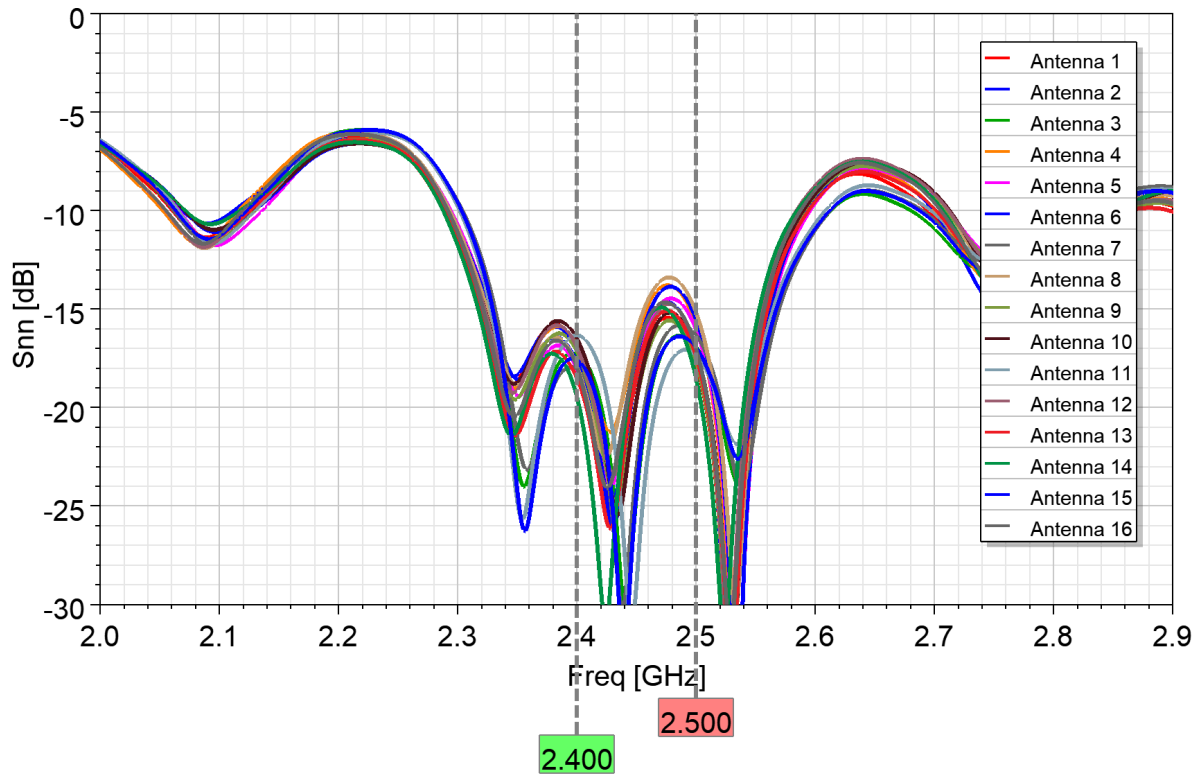
¹⁾ Other connector types can be offered on request.

Other designs, geometries or materials are possible on request.

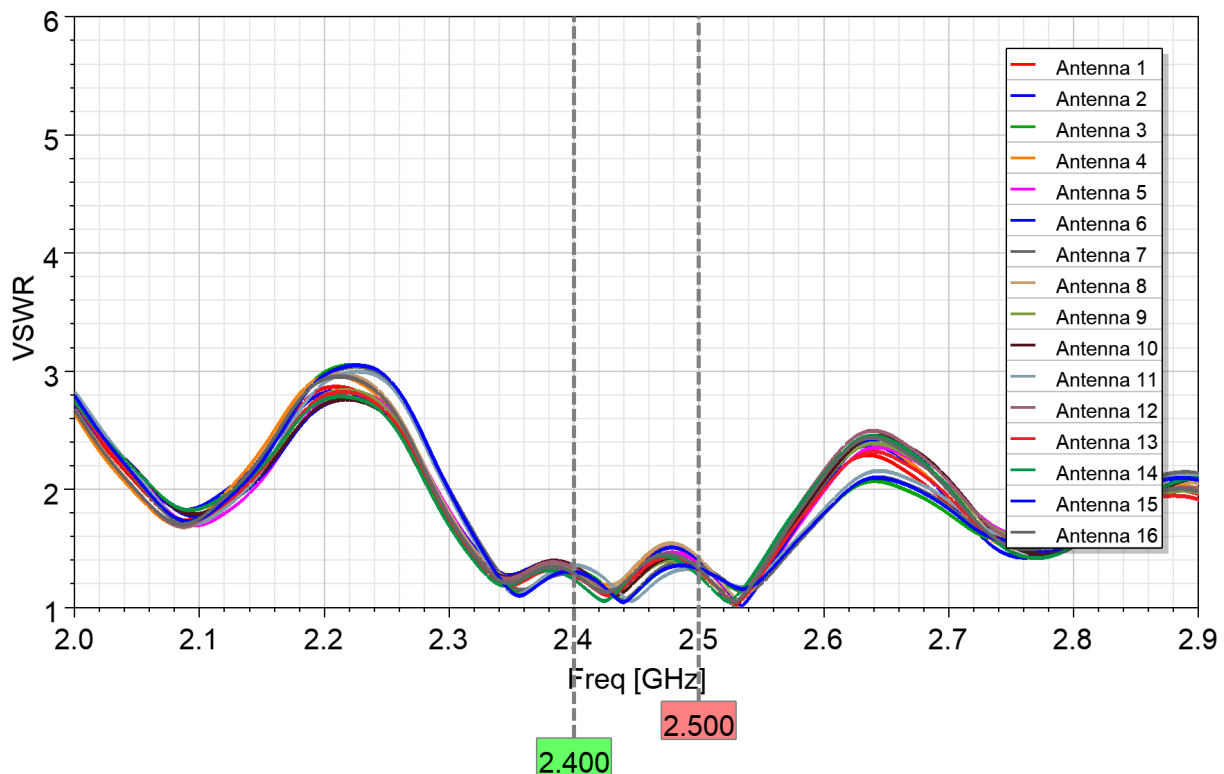
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Measured input impedance matching



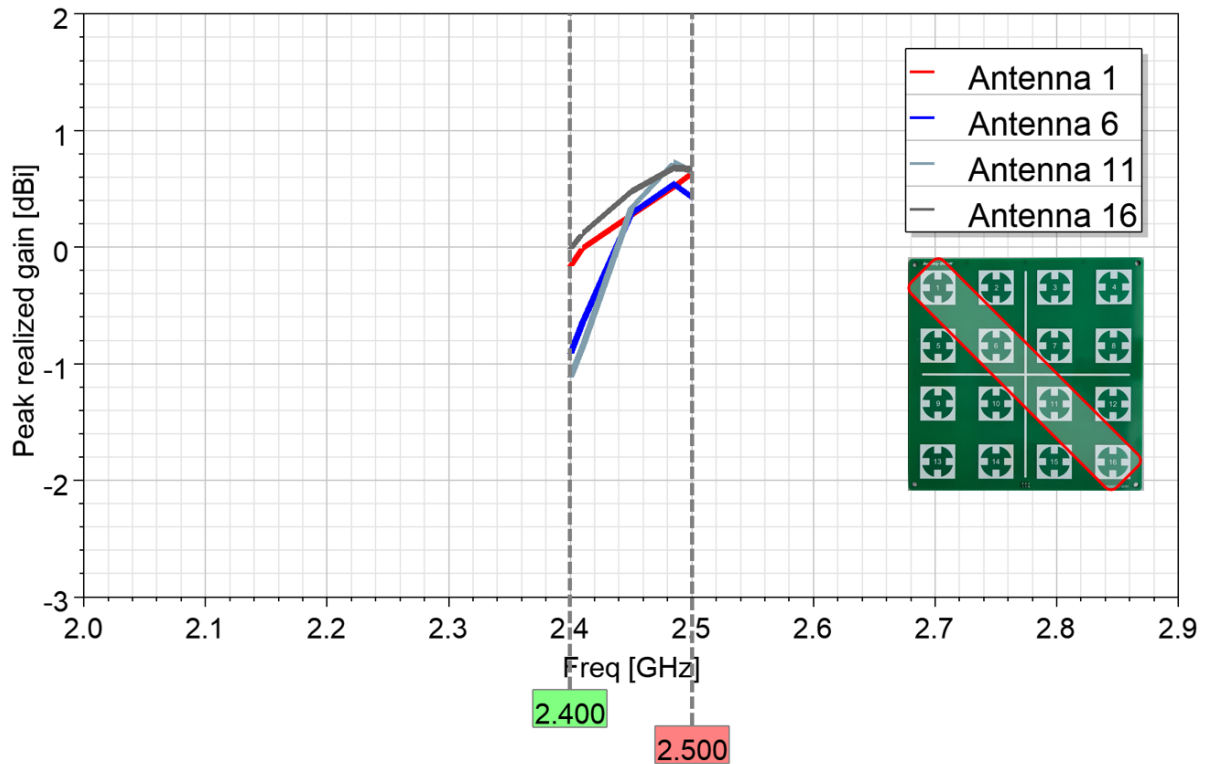
VSWR



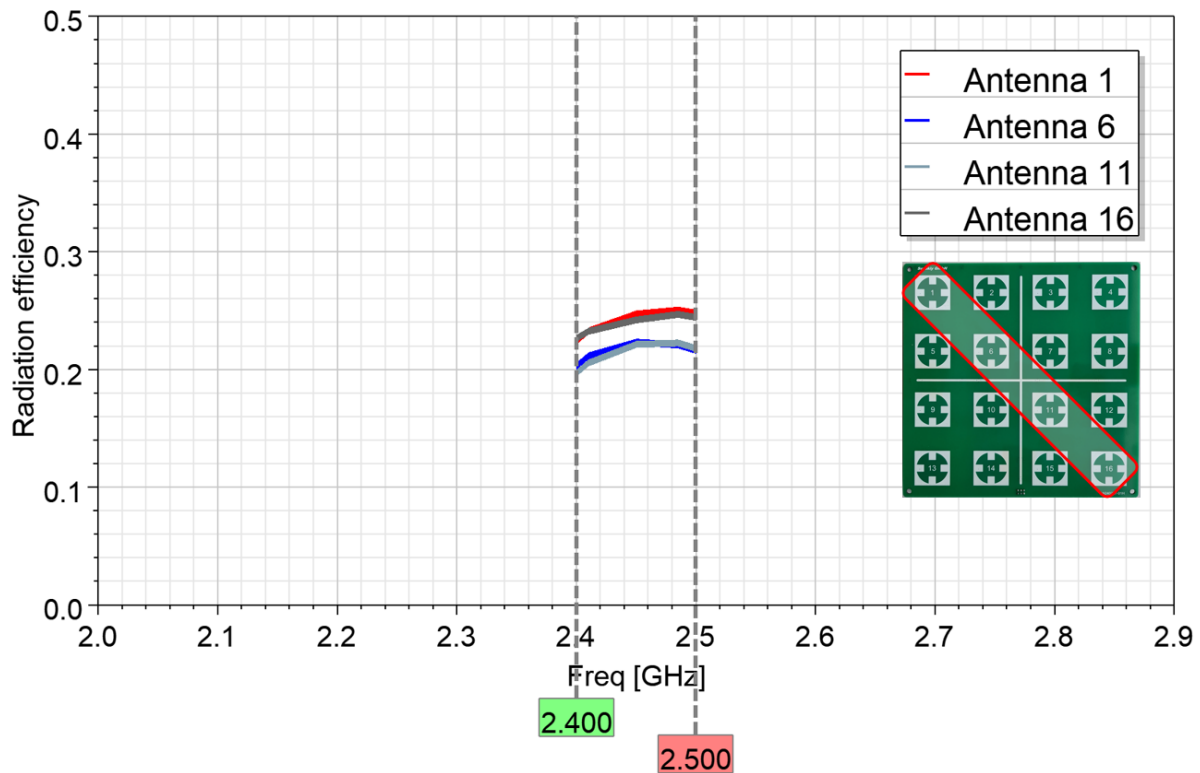
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Peak realized gain



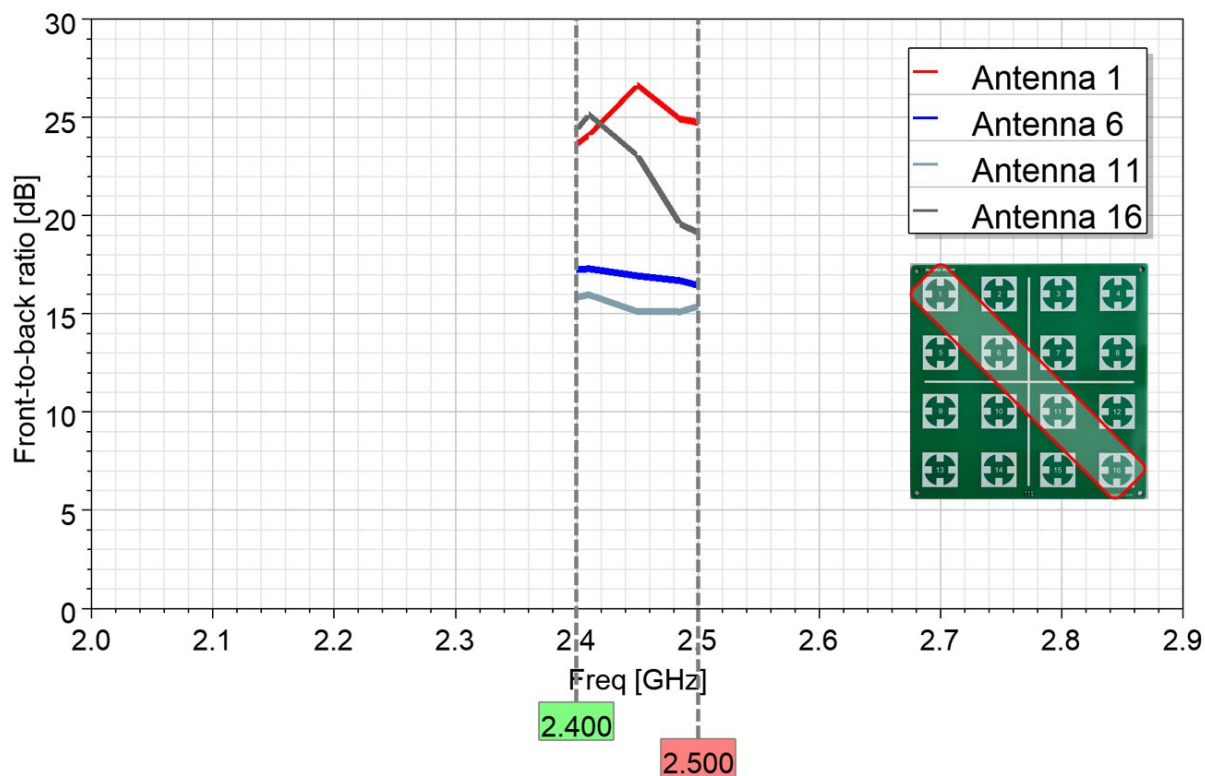
Radiation efficiency



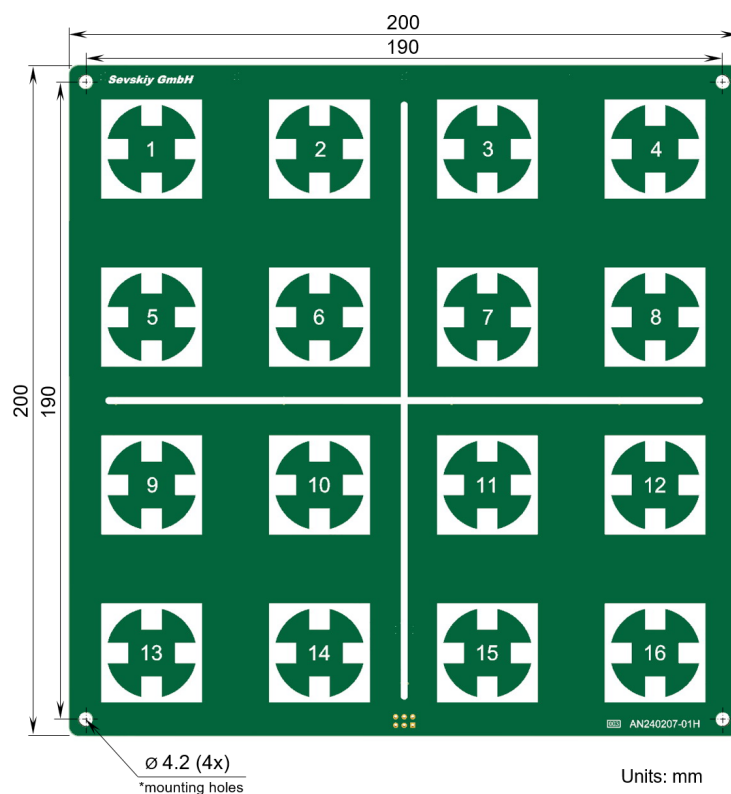
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Front-to-back ratio



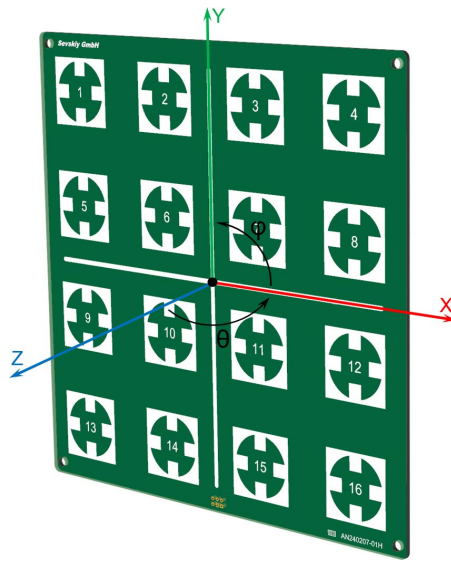
Product dimensions



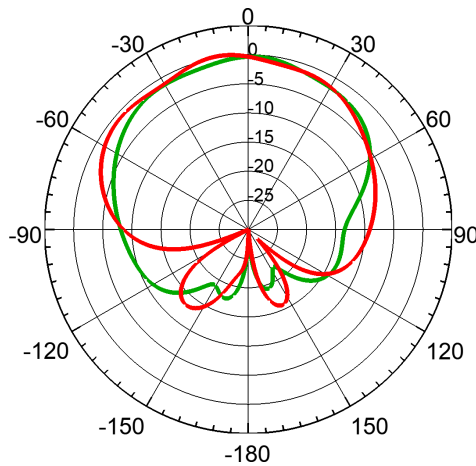
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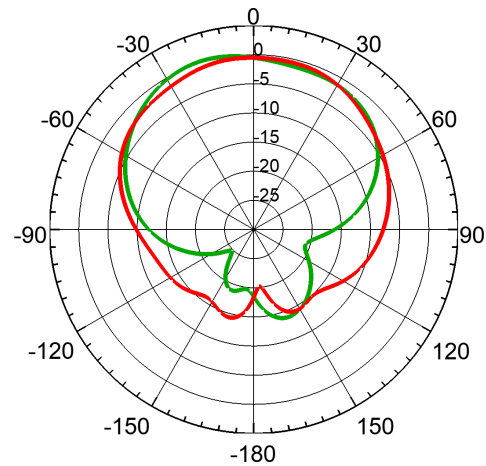
Radiation pattern at 2450 MHz



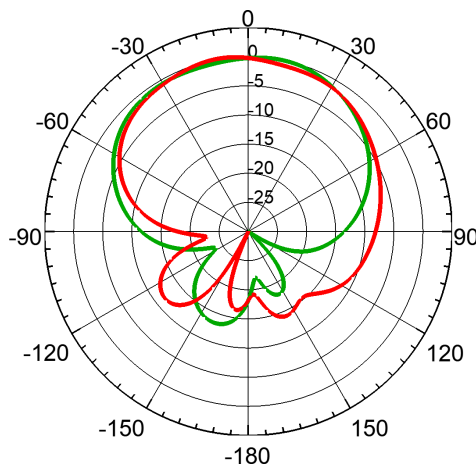
Total realized gain [dBi]
Phi=0°, plane XZ, green curve
Phi=90°, plane YZ, red curve



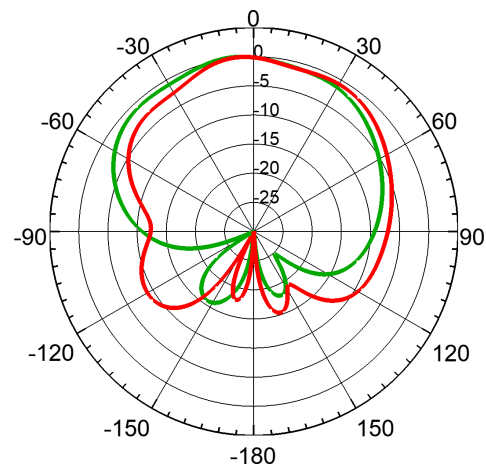
Antenna 1



Antenna 2



Antenna 3

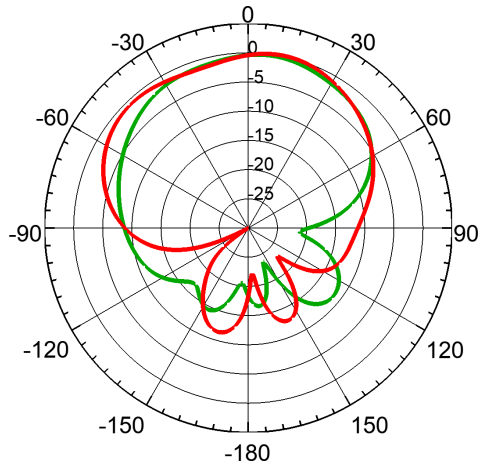


Antenna 4

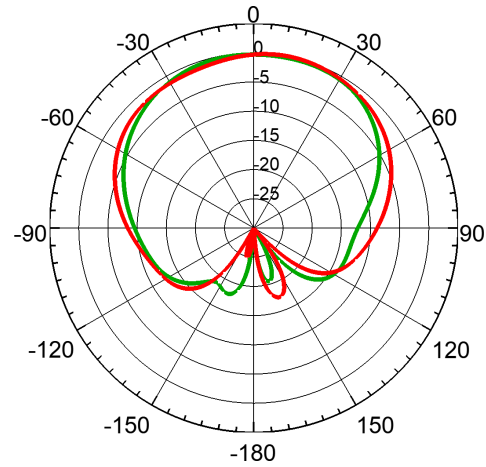
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2400...2500 MHz Patch antenna array for direction finding applications (Bluetooth LE, AoA, AoD)

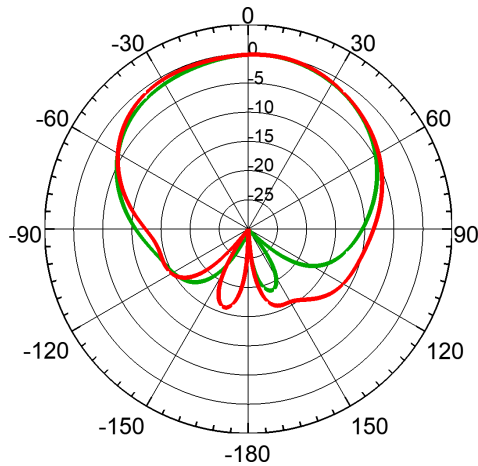
Radiation pattern at 2450 MHz



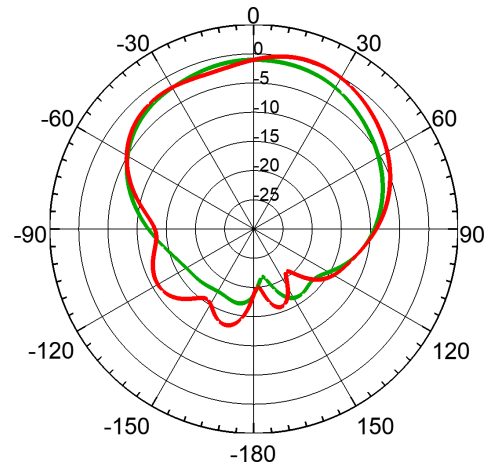
Antenna 5



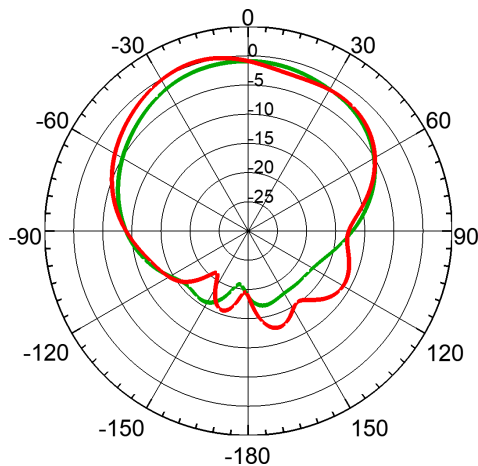
Antenna 6



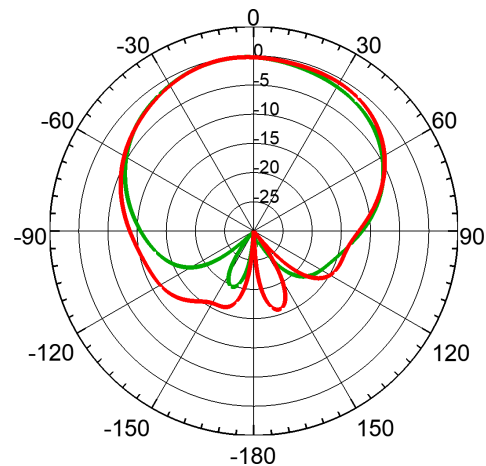
Antenna 7



Antenna 8



Antenna 9

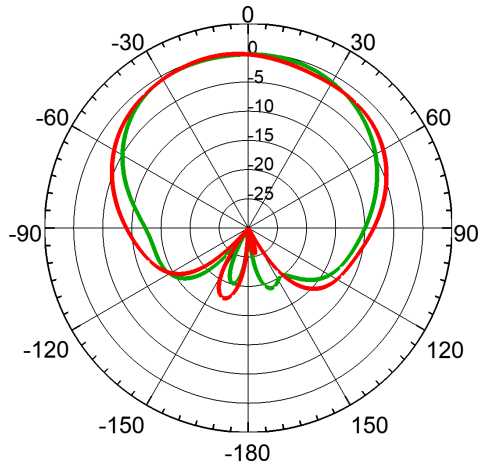


Antenna 10

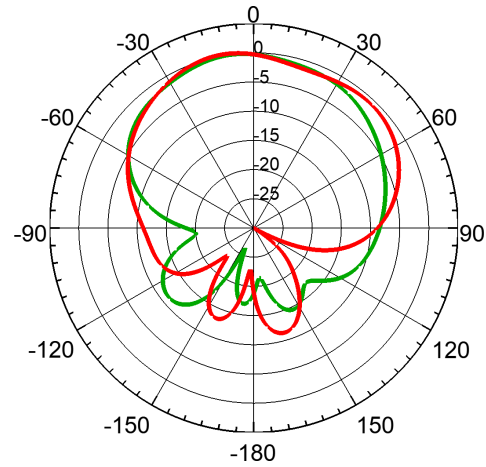
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2400...2500 MHz Patch antenna array for direction finding applications (Bluetooth LE, AoA, AoD)

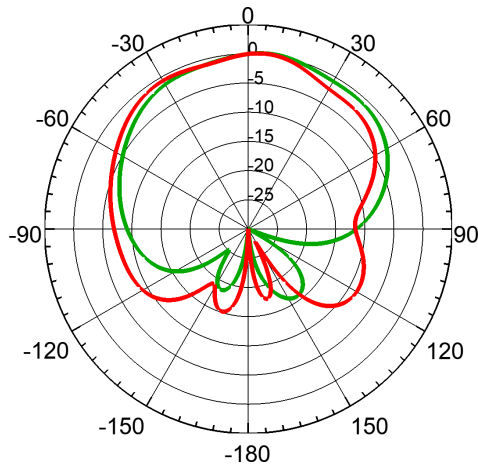
Radiation pattern at 2450 MHz



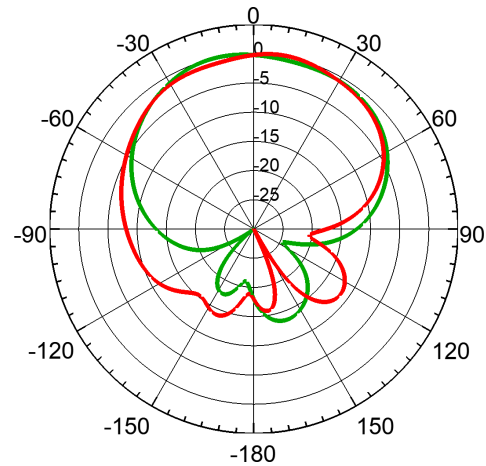
Antenna 11



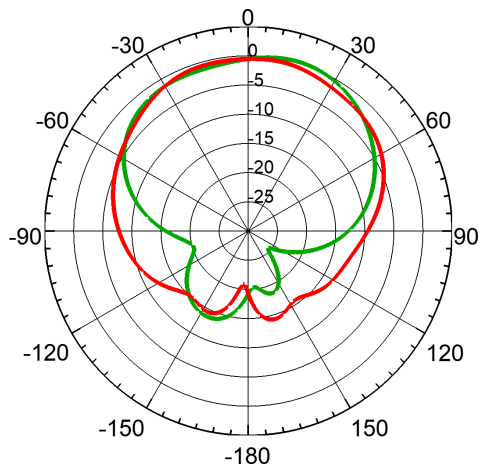
Antenna 12



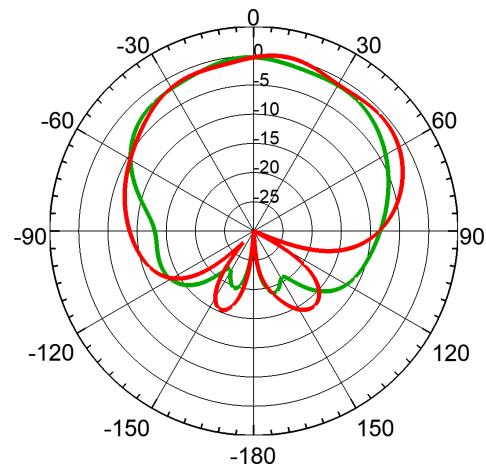
Antenna 13



Antenna 14



Antenna 15

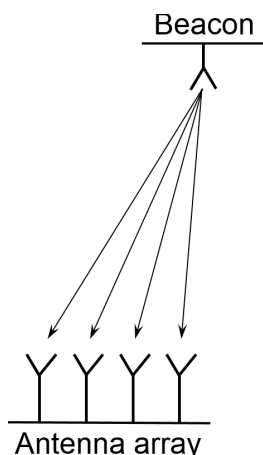


Antenna 16

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Angle of arrival (AoA) and angle of departure (AoD) principles



Angle of Arrival (AoA) is a direction-finding method in which a radio signal transmitted by a single-antenna device (beacon, not included) is received by a multi-element antenna array. The receiver sequentially switches between antenna elements using an RF switch and measures phase differences between adjacent, spatially displaced antenna elements. The incident signal angle is calculated based on these phase differences. The number of antenna elements and their geometry directly affect the achievable angular accuracy.

Angle of Departure (AoD) is a complementary method where the transmitting device sequentially switches between antenna elements and transmits a known signal sequence. The receiving device measures the phase of the received signal and determines the signal direction based on the known switching pattern.

Bluetooth® LE Direction Finding using Angle of Arrival (AoA) and Angle of Departure (AoD) is supported by the following chipsets (not included): nRF5340, nRF52833, nRF52820, nRF52811 (Nordic Semiconductor), EFR32MG13, EFR32BG13, EFR32BG22, EFR32MG22 (Silicon Labs), CC2642, CC2652 (Texas Instruments), CYW54591 (Cypress), as well as compatible BLE direction-finding modules based on these platforms.

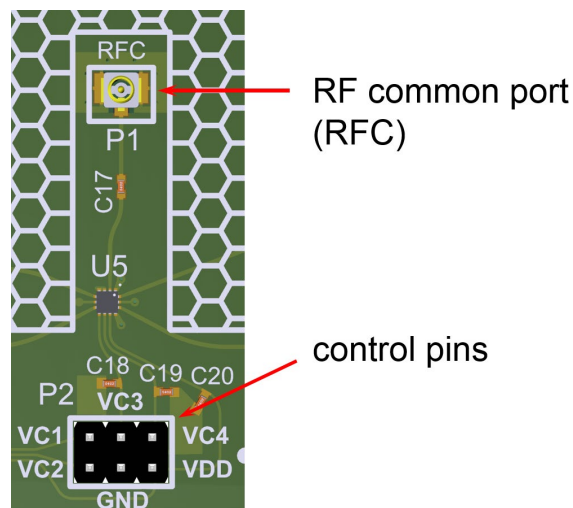
Electrical specifications of the RF switch

Parameter	Symbol	Description	Min	Typ	Max
Supply voltage [V]	VDD		2.5	3.3	3.5
Control voltage high [V]	H		2.5	3.0	3.3
Control voltage low [V]	L			0	0.45
Supply current [μA]	IDD			8	10
Switching speed [ns]	SS	50 % CTL to 90 % RF 50 % CTL to 10 % RF		400	500
Rise/fall time [ns]	t _{ON} /t _{OFF}	10% RF to 90 % RF 90 % RF to 10 % RF			500
Startup time [ns]	t _{START}	From VDD off to VDD on		500	1000

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Control pins description



Pin	Name	Description
1	VC1	Control voltage 1
2	VC2	Control voltage 2
3	VC3	Control voltage 3
4	VC4	Control voltage 4
5	VDD	Supply voltage
6	GND	Ground

Control signals table for switching individual antennas in antenna array

Low-Loss Path Antenna No	Antenna-to-RFC															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
VC1	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
VC2	H	H	H	H	L	L	L	L	H	H	H	H	L	L	L	L
VC3	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
VC4	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L

*H = 2.5...3.3 V, L = 0...0.45 V

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