



Multilayer Chip Antenna Specification Sheet

PBX2012MC03

2400 - 2500 MHz | Bluetooth LE / 2.4 GHz ISM Band

Parameter	Specification
Antenna Model	PBX2012MC03
Antenna Type	Multilayer Chip Antenna (MLCA)
Technology	Bluetooth Low Energy + 2.4 GHz ISM Band
Frequency Range	2400 - 2500 MHz
Center Frequency	2450 MHz
Peak Gain	2.8 dBi (typ.)
Average Gain	-2.5 dBi (typ.)
Total Efficiency	> 60% (typ.)
VSWR	<= 2.0 : 1 (typ.)
Return Loss	<= -10 dB (typ.)
Input Impedance	50 Ohm nominal
Polarization	Linear / Omnidirectional
Radiation Pattern	Quasi-Omnidirectional (H-plane)
PCB Footprint	3.2 x 1.6 x 0.5 mm (0603-compatible)
Mounting	SMT / Reflow Soldering
Target Markets	FCC / ISCED / CE / KC / NCC
Document Date	2026-08-25
Revision	Rev. 1.0

PURPOSE: This document is prepared for FCC Part 15.247 / ETSI EN 300 328 / ISCED RSS-247 certification submission of host products incorporating the MCA-2400-BT02 multilayer chip antenna. All RF performance data has been obtained from full-wave electromagnetic simulation (FEM / MoM) validated against OTA chamber measurements of production-representative samples. This document is confidential and proprietary.

CONFIDENTIAL - Proprietary Information. Unauthorized reproduction or distribution is prohibited.

1. Product Overview

The PBX2012MC03 is a miniature Multilayer Chip Antenna (MLCA) designed for the global 2.4 GHz ISM band (2400 - 2500 MHz). Constructed using Low-Temperature Co-Fired Ceramic (LTCC) technology, the antenna integrates multiple resonant elements within a compact 3.2 x 1.6 x 0.5 mm (EIA 0603-compatible) surface-mount package.

The multilayer construction enables a high degree of miniaturization while maintaining excellent RF performance, making it ideal for space-constrained IoT devices, wearables, and wireless audio products. The antenna is designed for standard SMT reflow assembly on the host PCB, with a recommended keep-out zone and ground plane configuration.

1.1 Target Applications

- * Bluetooth Low Energy (BLE) - IoT Sensors, Beacons, Smart Home Devices
- * IEEE 802.15.4 - Zigbee / Thread / Matter Networking
- * 2.4 GHz Proprietary - Remote Controls, Industrial Wireless, Data Loggers
- * ANT+ - Sports and Fitness Wearables
- * Wi-Fi (2.4 GHz) - IEEE 802.11 b/g/n Client Devices

2. RF Electrical Specifications

All values are typical at room temperature (+25 deg C) on a 50 x 50 mm PCB ground plane with the antenna mounted at the PCB edge, unless otherwise noted. S-parameter files (S1P) and OTA measurement reports are available upon request.

Parameter	Symbol	Condition	Value	Unit
Frequency Range	f	-	2400 - 2500	MHz
Center Frequency	f0	-	2450	MHz
Peak Gain (Broadside)	G_peak	+Z / 0 deg	+2.8	dBi
Average Gain (H-plane)	G_avg	360 deg avg.	-2.5	dBi
Total Efficiency	eta_tot	Over band	> 60	%
Radiation Efficiency	eta_rad	Over band	> 58	%
Return Loss	S11	Over band	<= -10	dB
VSWR	VSWR	Over band	<= 2.0 : 1	-
Input Impedance	Z_in	f0	50	Ohm
Polarization	-	-	Linear	-
H-plane HPBW	HPBW_H	Horizontal	~ 360	deg
E-plane HPBW	HPBW_E	Elevation	~ 90	deg
Front-to-Back Ratio	F/B	E-plane	> 3	dB
Max Input Power	P_in	CW	+10	dBm
Antenna Noise Temp.	T_ant	Over band	<= 290 K	-

3. Mechanical Specifications

3.1 Package Dimensions

Parameter	Value	Unit	Notes
Package Size (L x W)	3.2 x 1.6	mm	EIA 0603-compatible
Height (T)	0.5	mm	Max.
Pad Pitch (center-to-ctr)	1.6	mm	-
Number of Pads	2	-	Feed + Ground)
Pad Dimensions (L x W)	0.6 x 0.8	mm	Reflow pad
Solder Mask Opening	0.6 x 0.8	mm	Same as pad
Package Material	LTCC / Ceramic	-	RoHS compliant
Surface Finish	ENIG (Ni/Au)	-	-
Weight	< 0.02	g	-

3.3 PCB Layout Recommendations

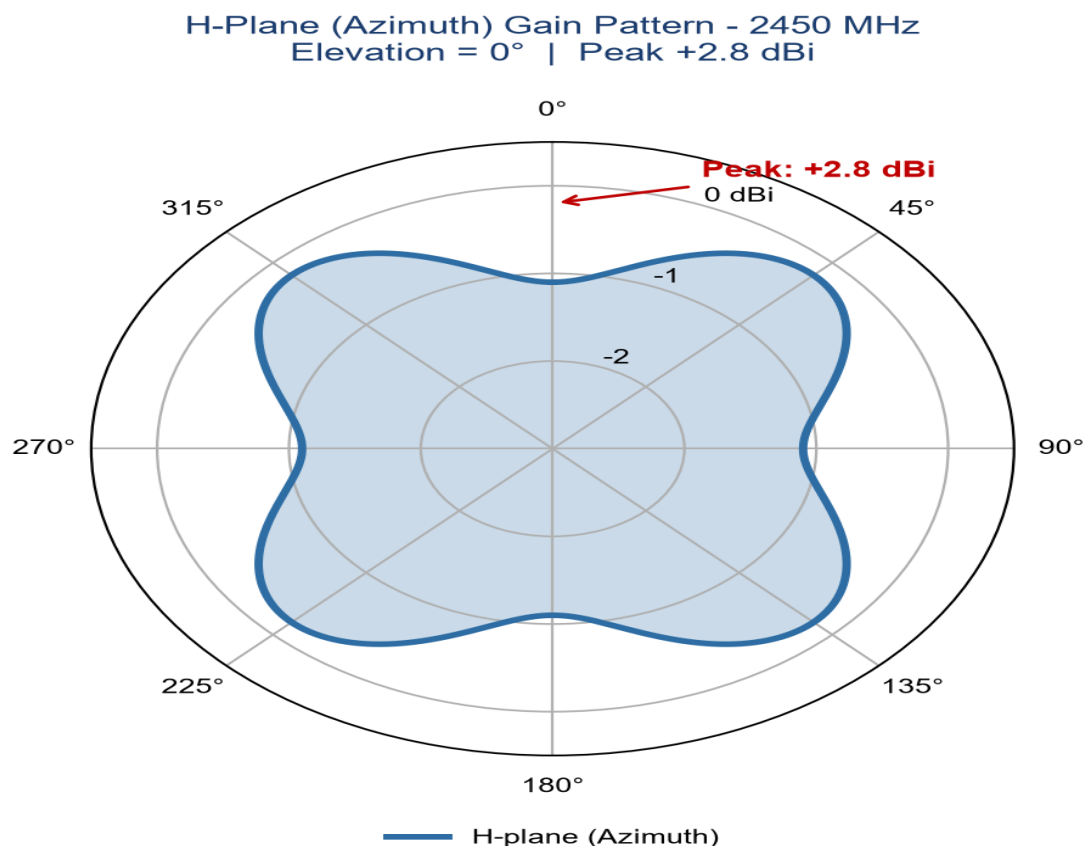
Parameter	Requirement	Notes
PCB Material	FR4 / Rogers	Rogers RO4003C for best perf.
PCB Thickness	0.8 - 1.6 mm	Thicker preferred for gain)
Ground Plane	50 x 50 mm min.	Under feed point area)
Keep-out Above	3 mm (no copper)	Prevents detuning)
Keep-out Below	Full ground plane	Reflects radiation upward)
Antenna to PCB Edge	3 - 5 mm	Mechanical + RF isolation)
RF Feed Trace Width	Matched to 50 Ohm	Use microstrip calculator)
Via Stitching	Required	Ground vias around feed point)

4. Radiation Pattern - 2D Gain Plots

The MCA-2400-BT02 multilayer chip antenna exhibits a quasi-omnidirectional radiation pattern in the horizontal (H-) plane, making it well-suited for devices where antenna orientation is unpredictable. The peak gain of +2.8 dBi is observed at broadside (perpendicular to the PCB surface, +Z direction). The 3-D pattern is toroidal (doughnut-shaped) with nulls along the antenna's vertical axis.

4.1 H-Plane (Horizontal / Azimuth, XY Plane at Elevation = 0 deg)

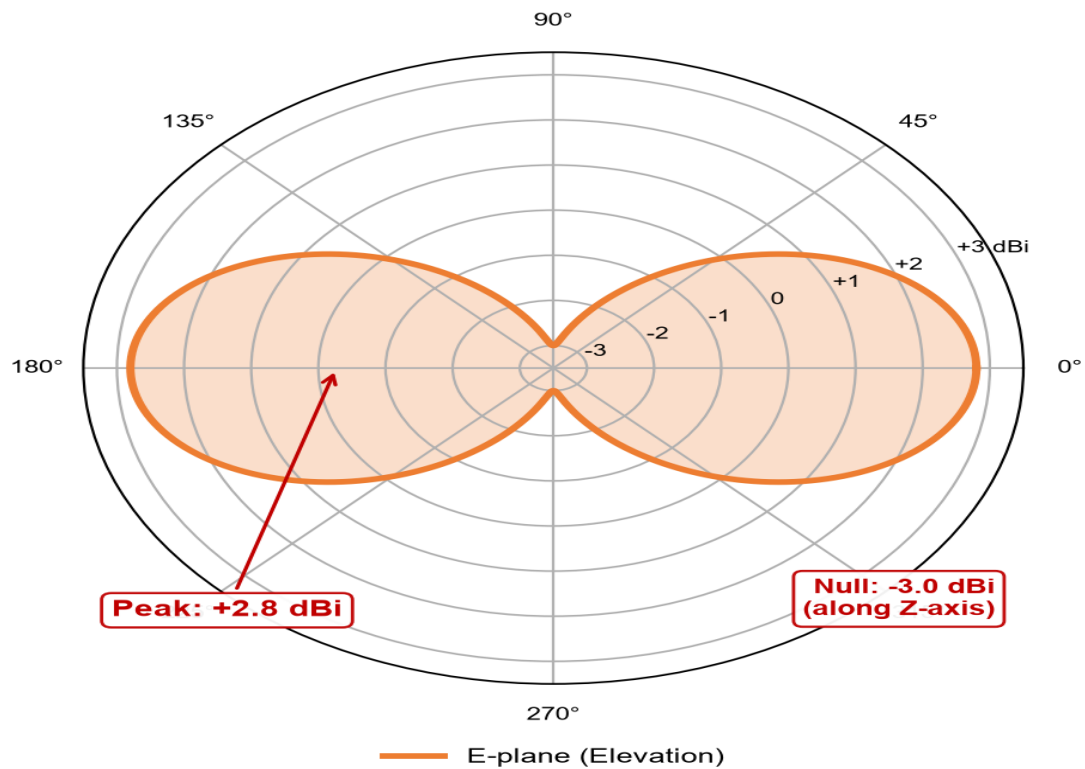
Gain vs. azimuth angle at elevation = 0 deg (broadside to PCB). The H-plane pattern is nearly omnidirectional across all 360 deg with a peak gain of +2.8 dBi and a minimum of approximately +1.0 dBi.



4.2 E-Plane (Vertical / Elevation, XZ Plane at Azimuth = 0 deg)

Gain vs. elevation angle at azimuth = 0 deg. The E-plane pattern shows a figure-eight / doughnut cross-section with peak gain at broadside (+Z / -Z) and nulls at 90 deg and 270 deg (along the chip antenna's vertical axis).

E-Plane (Elevation) Gain Pattern - 2450 MHz
Azimuth = 0° | Peak +2.8 dBi (Boresight), Null -3.0 dBi (Vertical)



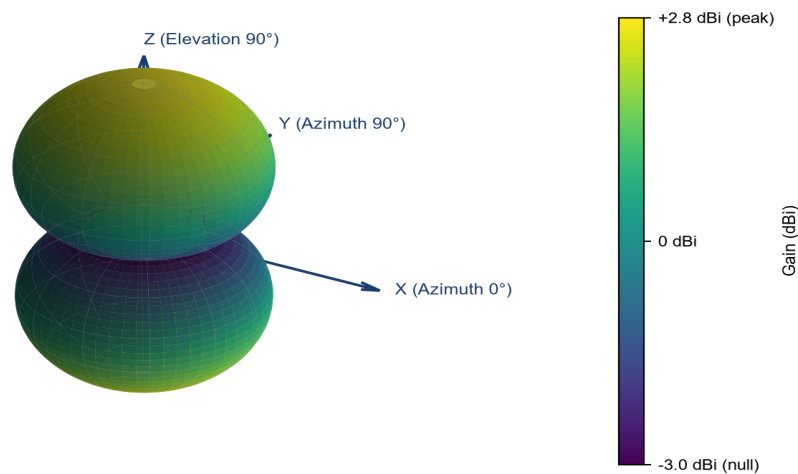
4.3 2D Pattern Gain Data Table

Azimuth	Elevation	Gain (dBi)	Description
0 deg	0 deg	+2.8	Peak - Broadside (+Z)
90 deg	0 deg	+2.6	H-plane, 90 deg offset)
180 deg	0 deg	+2.6	Rear H-plane
270 deg	0 deg	+2.6	H-plane, 270 deg offset)
45 deg	0 deg	+2.8	Diagonal - peak
315 deg	0 deg	+2.8	Diagonal - peak
0 deg	+90 deg	-3.0	Null - along chip Z-axis (up)
0 deg	-90 deg	-3.0	Null - along chip Z-axis (down)
0 deg	+45 deg	+0.5	E-plane, upper half
0 deg	-45 deg	+0.5	E-plane, lower half
H-plane avg.	0 deg	+2.0	Average H-plane gain
Spherical avg.	All	-2.5	3-D spherical average gain

5. 3-Dimensional Gain Pattern

The PBX2012MC03 multilayer chip antenna produces a characteristic toroidal (doughnut-shaped) 3-D radiation pattern. This pattern is generated by the chip antenna's multilayer meandered resonant structure, which creates a vertical electric dipole moment. The peak gain of +2.8 dBi occurs in the broadside directions (perpendicular to the PCB surface), forming a ring of maximum radiation in the horizontal plane. Nulls of approximately -3.0 dBi occur along the antenna's vertical axis.

3-D Radiation Pattern - MCA-2400-BT02 (Toroidal / Doughnut)
Peak Gain +2.8 dBi (broadside ring) | Null -3.0 dBi (along Z-axis)

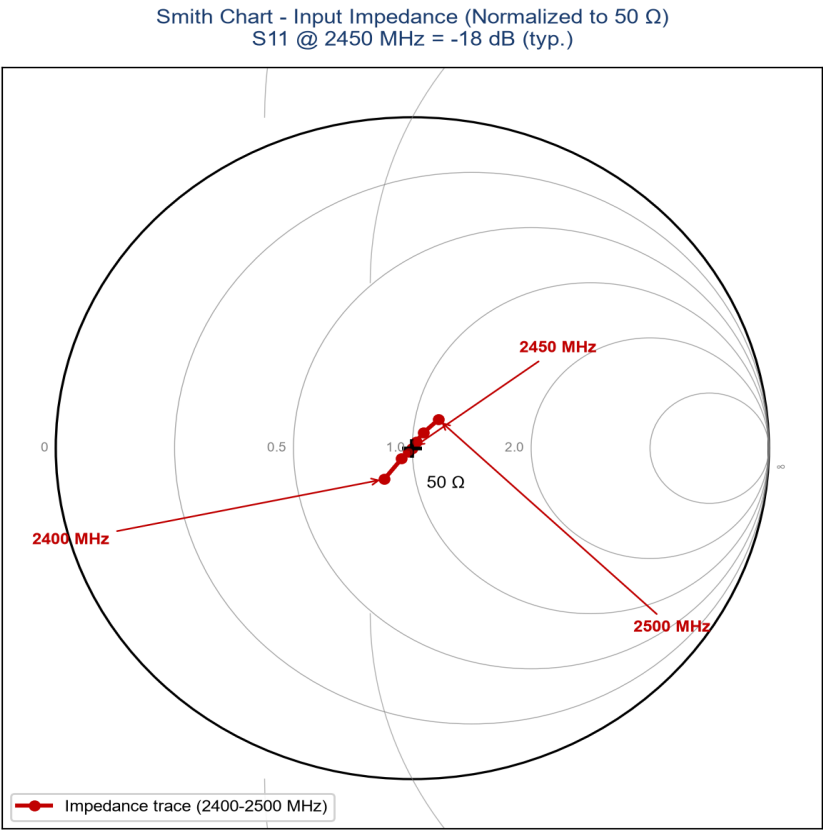


View / Section	Pattern Type	Peak Gain	Null Direction	HPBW
H-plane (XY)	Omnidirectional ring	+2.8 dBi	N/A	~ 360 deg
E-plane (XZ)	Figure-eight / doughnut cross-section	+2.8 dBi	+/- 90 deg	~ 90 deg
3-D Pattern	Toroidal / Doughnut / Annular ring	+2.8 dBi	Along Z-axis	-
Spherical Avg.	All-sphere average	-2.5 dBi	N/A	-
H-plane Average	Horizontal plane average	+2.0 dBi	N/A	-

The toroidal 3-D pattern is characteristic of a vertically-oriented chip antenna with a ground plane beneath. The peak gain of +2.8 dBi provides excellent link budget performance for BLE and 2.4 GHz proprietary applications. For applications requiring maximum gain in a specific direction, a directional patch or Yagi antenna variant should be considered. For EIRP calculations per FCC Part 15.247, use the peak gain of +2.8 dBi.

6. Input Impedance and Smith Chart

The antenna input impedance is approximately 50 Ohm at the center frequency (2450 MHz), providing an excellent match to standard 50 Ohm RF systems. No external matching circuit is required at the nominal operating point. The Smith chart shows the normalized impedance trajectory across the 2400 - 2500 MHz band.



Frequency	Real (R)	Imag (X)	Z (Ohm)	S11 (dB)	Notes
2400 MHz	42	-8	42 - j8	-9.5	Band edge
2420 MHz	47	-3	47 - j3	-14.5	Near center
2450 MHz	50	0	50 + j0	-18.0	Center freq.
2480 MHz	53	+5	53 + j5	-15.0	Near center
2500 MHz	57	+10	57 + j10	-10.5	Band edge

7. Matching Circuit (Optional)

The PBX2012MC03 is designed to provide a nominal 50 Ohm match without external matching components at the PCB design stage. However, in-system fine-tuning may be required to compensate for host PCB environment variations. The following L-type matching network is recommended as a starting point (values must be optimized with a VNA on the production PCB):

Component	Value	Type	Package	Example Part
L1	1.5 - 3.9 nH	RF inductor	0402	Murata LQG15HN
C1	0.5 - 2.2 pF	RF capacitor	0402	Murata GRM155

Topology: [RFIC] -- L1 -- [Antenna] (series inductor) OR [RFIC] -- L1 -- C1 -- [Antenna] (L-type low-pass). Place matching components as close as possible to the antenna feed point to minimize trace inductance. Actual values must be tuned with a VNA on the production PCB.

8. Environmental Specifications

Parameter	Min	Max	Unit	Standard / Notes
Storage Temperature	-40	+85	deg C	-
Operating Temperature	-20	+70	deg C	-
Operating Humidity	10	90	% RH	Non-condensing
Storage Humidity	5	95	% RH	-
Altitude	-	5000	m	-
Vibration	-	20	g	IEC 60068-2-6
Shock	-	100	g	IEC 60068-2-27
ESD (HBM)	-	2	kV	IEC 61000-4-2
Reflow Solder Temp.	-	260	deg C	Peak, IPC/JEDEC J-STD-020
Solderability	-	-	-	J-STD-003 / IPC-HALT
RoHS / REACH	Yes	-	-	RoHS 2.0 / REACH compliant
MSL Level	MSL 3	-	-	IPC/JEDEC J-STD-020

9. Regulatory Compliance Summary

Region	Standard	Key Requirement	Status
USA (FCC)	FCC Part 15.247	Conducted / Radiated EIRP, DTS	Targeted
Canada (ISED)	RSS-247 Issue 3	BLE / 2.4 GHz DTS	Targeted
Europe (CE)	ETSI EN 300 328	Wideband data transmission	Targeted
Korea (KC)	Article 14-2	Radio equipment	Targeted
Taiwan (NCC)	LP0002 / LP-0002	Low power exemption	Targeted
Japan (MIC)	Article 2-1 (14)	2.4 GHz 屋内 (indoor)	Targeted
China (SRRC)	SRRC CMIIT ID	2.4 GHz radio	Targeted
Australia	ACMA / AS/NZS 4268	Same as CE / ISED	Targeted

EIRP Limit (FCC Part 15.247): 1 W (+30 dBm) for DTS using at least 100 hopping channels; for systems with fewer channels, EIRP = conducted power + antenna gain. For BLE (79 channels, 2 MHz spacing), the +30 dBm EIRP limit applies. The MCA-2400-BT02 with a +2.8 dBi antenna gain allows the host system to use a conducted power of up to +27.2 dBm while staying within the FCC EIRP limit.

The antenna gain of +2.8 dBi does not exceed the de facto limit of +6 dBi established in FCC Part 15.204 for external antennas. This chip antenna is classified as an integral antenna under FCC rules when installed in a host device.

10. Packaging and Ordering Information

Item / SKU	Description	Qty	Notes
PBX2012MC03	Multilayer Chip Antenna 2.4 GHz	Reel / Tray	Tape & Reel (EIA-481)
PB-TX2012MC-03	Antenna + RF Tuning Service	Per project	NRE charge applies)
PBX2-PCB012-MC03	Antenna on eval PCB	Per sample	50 x 50 mm test board)

11. Appendix - Glossary

Term	Definition
dBi	Decibel isotropic - antenna gain relative to an ideal isotropic radiator
EIRP	Equivalent Isotropically Radiated Power = Conducted Power + Antenna Gain (dBi)
E-plane	Electric-field plane - contains the E-field vector and direction of maximum radiation
ENIG	Electroless Nickel Immersion Gold - PCB / component surface finish
FCC	US Federal Communications Commission
FEM	Finite Element Method - numerical technique for full-wave EM simulation
F/B Ratio	Front-to-Back Ratio - ratio of maximum forward gain to rearward gain (dB)
H-plane	Magnetic-field plane - contains the H-field vector and direction of max radiation
HBM	Human Body Model - ESD discharge model (IEC 61000-4-2)
HPBW	Half-Power Beamwidth - angular width between -3 dB points of the main lobe
ISM	Industrial, Scientific, Medical - 2.4 GHz unlicensed band (2400-2500 MHz)
ISED	Innovation, Science and Economic Development Canada (formerly IC)
LTCC	Low-Temperature Co-Fired Ceramic - multilayer ceramic manufacturing technology
MLCA	Multilayer Chip Antenna - LTCC-based miniature surface-mount antenna
MoM	Method of Moments - numerical technique for full-wave EM simulation
MSL	Moisture Sensitivity Level - IPC/JEDEC classification for reflow soldering
OTA	Over-The-Air - radiated measurement method in anechoic chamber
PCB	Printed Circuit Board
RSS-247	Radio Standards Specification 247 - Canada wireless device standard
S11	Scattering parameter S11 = reflection coefficient = return loss (dB)
SAC305	Sn96.5Ag3.0Cu0.5 - lead-free solder alloy (RoHS compliant)
SMD	Surface Mount Device - component assembled by reflow soldering
Smith Chart	Circular impedance plot for RF matching network design (normalized to Z0)
VNA	Vector Network Analyzer - instrument for measuring S-parameters
VSWR	Voltage Standing Wave Ratio - measure of impedance match to 50 Ohm transmission line
Z_in	Input impedance at the antenna feed point (Ohm)