



Cisco Aironet Series 1830/1850 Access Point Deployment Guide

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Revised: January 13, 2016,

Cisco Aironet Series 1850 Access Point

Abstract

This section covers the operation and installation of Cisco 1850 Series Access Point (AP) as part of a Cisco wireless LAN (WLAN) solution. Subjects related include:

- Overview of the 1850 AP and approved external antennas for the 1850e AP
- Product portfolio, AP comparisons, and product part numbers
- Product dimensions, mounting options, Ethernet, and RF cable recommendations
- Understanding AP spacing, powering options, and PoE negotiation
- Antenna options, radiation patterns, and external antenna deployments
- General considerations and WLAN best practices
- 802.11ac Wave-2 Primer, channel plans, .11ac clients, and variables that impact performance
- Looking at non-optimal installs and lessons learned
- New features, Auxiliary Ethernet port, and configuring Link Aggregation (LAG)
- Understanding multi-user MIMO and its elements and challenges
- Q&A and appendix

This document is intended for trained and experienced technical personnel familiar with the existing Cisco Wireless Networking Group (WNG) product line and features.

Overview of the Cisco AP 1850

Models

The Cisco 1850 series access point (AP 1850) is a first generation entry level 802.11ac (Wave-2) AP, positioned to best satisfy small and medium customers looking to deploy Wave-2 in areas such as K-12, retail and service provider markets.

Figure 1: AP 1850 Overview

Next-Generation Wave 2 802.11ac Access Points



The image shows three Cisco Aironet 1850 Series access points: one with four external antennas, one with an internal antenna, and one with a different antenna configuration. Below the devices is the text 'Cisco Aironet® 1850 Series' and a blue arrow pointing right with the text 'Gigabit Wi-Fi has fully arrived.'

- Next-generation 4x4 MIMO:4 spatial streams (SS) Wave 2 802.11ac access points
- Dual radio, 802.11ac Wave 2, 80 MHz
- 5 GHz 4x4 supporting
 - 3 SS MU-MIMO
 - 4 SS SU-MIMO
 - 1.7 Gbps Max 5-GHz PHY
 - 2.0 Gbps Max Aggregate PHY
- 2 x Gigabit Ethernet and USB 2.0
- Internal and external antenna models

Access points are available in two models:

- Internal antennas version labeled “i” has captured antennas (part of the housing and not removable). The “i” series is designed for indoor enterprise installations, where office aesthetics are a primary concern.
- External antennas version labeled “e” supports different types of antennas and can be mounted inside NEMA enclosures for use in the most demanding environments.

External Antennas for use with 1850e Access Point

- AIR-ANT2524DB-R – Dual-band (Black) dipole (4 required) – 2/4 dBi Dipole
- AIR-ANT2524DW-R – Dual-band (White) dipole (4 required) – 2/4 dBi Dipole
- AIR-ANT2524DG-R – Dual-band (Grey) dipole (4 required) – 2/4 dBi Dipole
- AIR-ANT2535SDW-R – Dual band (short) dipole (4 required) – 3/5 dBi Dipole
- AIR-ANT2524V4C-R – Dual-band Omni-directional (1 required) – 2/4 dBi Ceiling mount Omni use
- AIR-ANT2544V4M-R – Dual-band Omni-directional (1 required) – 4/4 dBi Wall mount Omni use
- AIR-ANT2566P4W-R – Dual band directional (1 required) – 6 dBi Patch wall mount use
- AIR-ANT2566D4M-R – Dual band directional (1 required) – 6 dBi Patch “Auditorium use”



Note These are all dual-band, dual-resonant antennas. Do not use single-band antennas on this product unless you choose to disable the other radio band within the AP.

Figure 2: Access Point Portfolio

Cisco Aironet Indoor Access Points Portfolio

Industry's Best 802.11ac Series Access Points



Figure 3: Access Point Comparisons

Indoor Access Points	Enterprise			
	AP-1700	AP-1850	AP-2700	AP-3700
Max PHY Data Rate (5GHz)	870 Mbps	1.7 Gbps	1.3 Gbps	1.3 Gbps
RF Design (MU-MIMO)	3x3:2, Dual SU-MIMO	4x4:4, SU-MIMO 4x4:3, MU-MIMO	3x4:3, Dual SU-MIMO	4x4:3, Dual SU-MIMO
Performance/Coverage/ Investment Protection	◆◆	◆◆◆	◆◆◆◆	◆◆◆◆◆
Max No. of Clients per AP	400	400	400	400
RRM	✓	✓	✓	✓
High Density Experience			✓	✓
Cisco CleanAir® Technology	Cisco CleanAir® Express	Spectrum Analysis*	✓	✓
Beam Forming	Tx BF	Tx BF	Cisco ClientLink 3.0	Cisco ClientLink 3.0
BandSelect	✓	✓	✓	✓
Video Stream	✓	✓	✓	✓
Rogue AP Detection	✓	✓	✓	✓
Adaptive WIPS	✓	✓	✓	✓
External Antenna Option		✓	✓	✓
Ethernet Ports	2 x GE	2 x GE	2 x GE	1 x GE
LAG Support	n/a	✓	n/a	n/a
USB		2.0		
Module Options				Security, 3G Small Cell, High-Accuracy Location

* Planning

Access points can be purchased as a single unit or in lots of 10 pieces referred to as an Eco-pack.

Eco-Packs save installation time and are easier to store as they take less space.

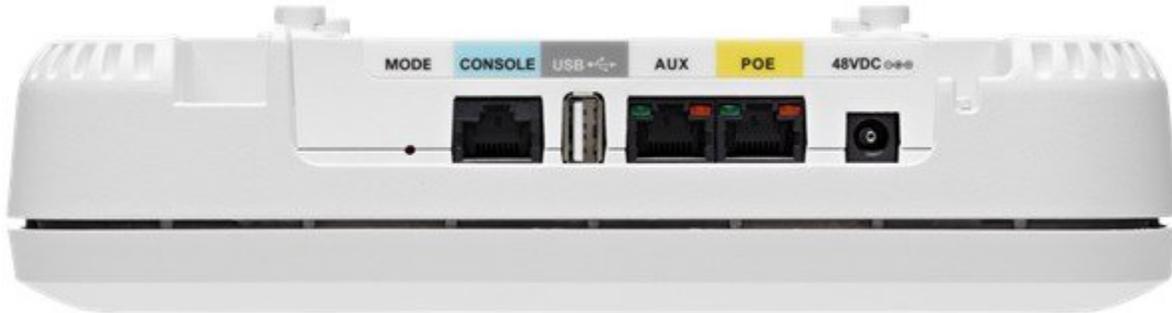
SKU	Description
AIR-AP1852I-x-K9	Single Unit, Internal Antenna Model
AIR-AP1852E-x-K9	Single Unit, External Antenna Model
AIR-AP1852I-UXK9	Single Unit, Internal Antenna Model, Universal Domain
AIR-AP1852I-UXK910	10-unit Eco-pack, Internal Antenna Model, Universal Domain
AIR-AP1852E-UXK9	Single Unit, External Antenna Model, Universal Domain
AIR-AP1852E-UXK910	10-unit Eco-pack, External Antenna Model, Universal Domain

"x" represents the regulatory domain.

Customers are responsible for verifying approval for use in their individual countries. To verify approval that corresponds to a particular country, or the regulatory domain used in a specific country, see <http://www.cisco.com/go/aironet/compliance>.

Physical Hardware and Mounting Options of an AP

Figure 4: AP 1850 Model port view



Ports are easily accessible. Mode button is recessed and requires a tool such as a paperclip to engage.

Note the vent holes below the ports. The AP 1850 is designed for indoor enterprise, not for rugged manufacturing areas or places such as Healthcare environments where the AP needs to be cleaned with diluted chemicals and so on.

AP 1850 has similar physical dimensions as other Cisco APs but with a few differences in physical appearance, most of which are cosmetic changes to distinguish the different models. The mounting options and bracket configurations are identical and interchangeable between Cisco 1140, 1600, 1700, 1850, 2600, 2700, and 3700 series APs.

Figure 5: Mechanical Dimensions AP 1850

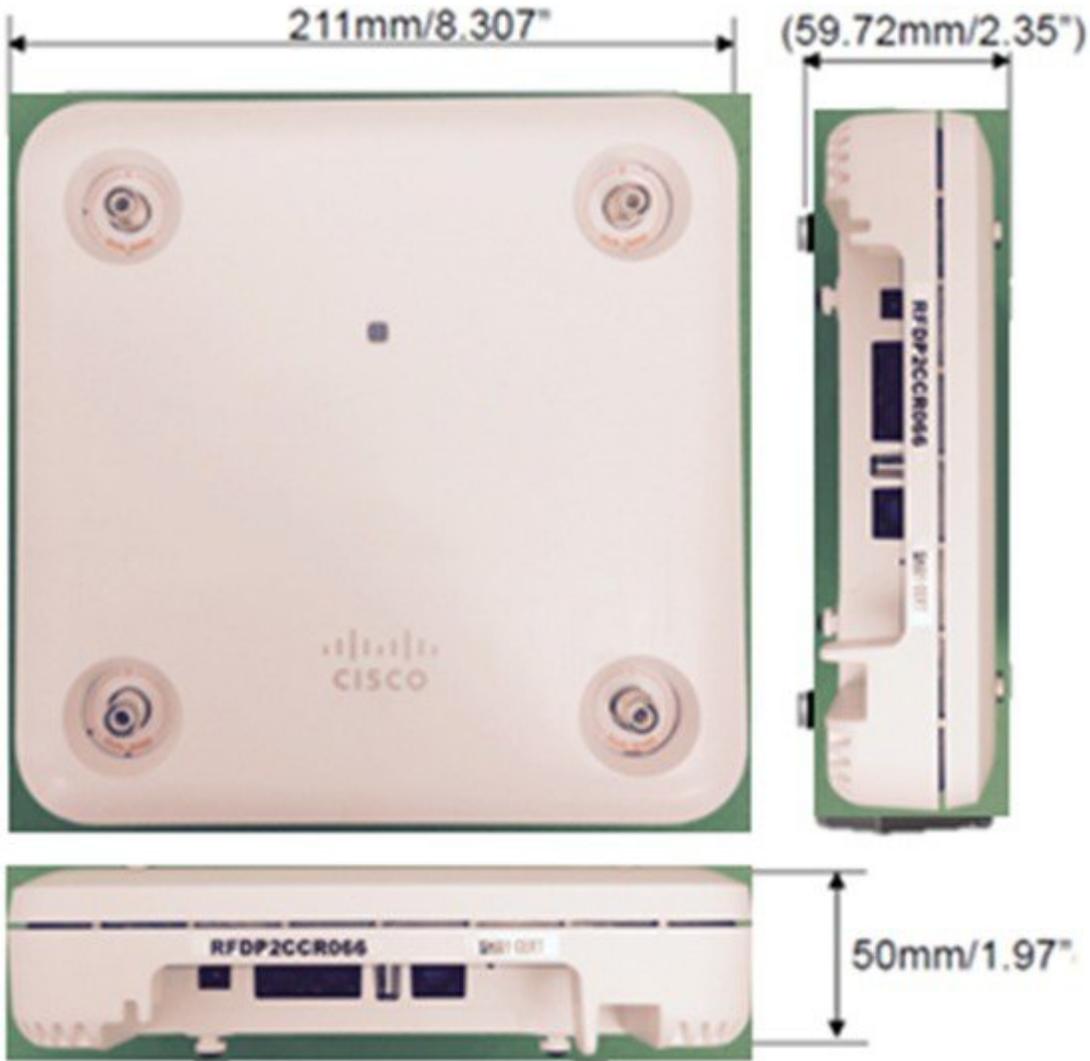
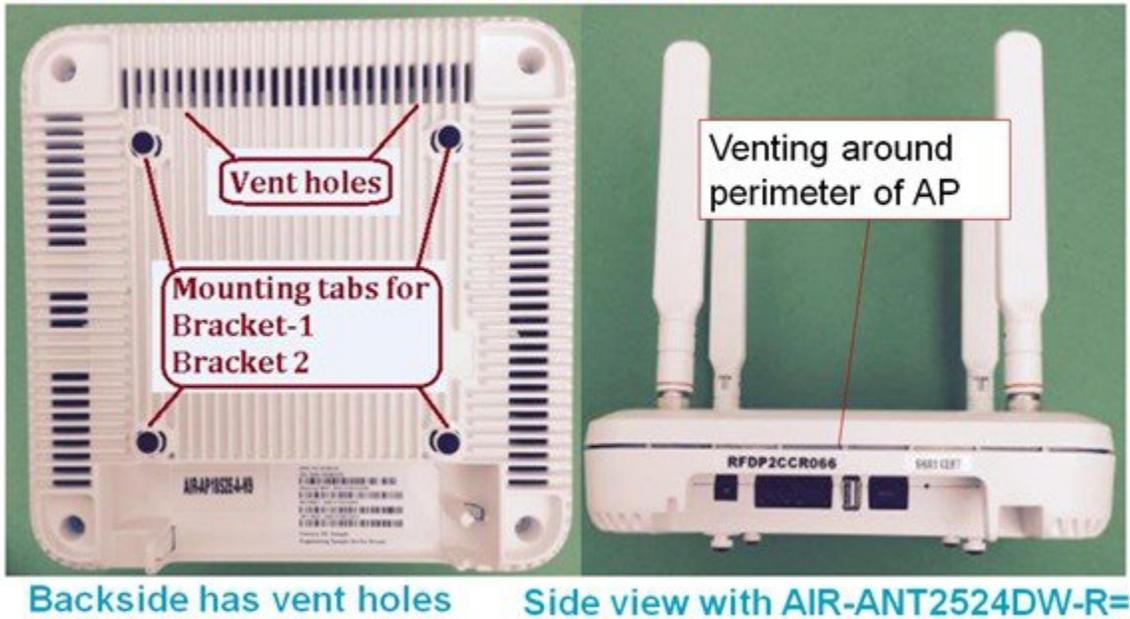


Figure 6: Mechanical Dimensions AP 1850

AP-1850 backside and side view

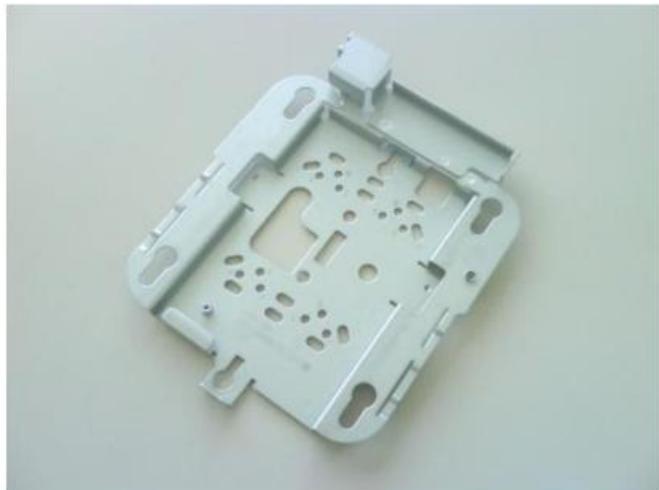


Different installation options are available depending upon the requirements of the customer. Brackets are available from Cisco as well as third-party companies. During the ordering process, the customer may choose one of two brackets (but not both). Each bracket is a zero-dollar (\$0) option at the time of configuration. If the customer does not choose a bracket, the selection default is AIR-AP-BRACKET-1, which is the most popular for ceiling installations. The other choice is a universal bracket that carries part number AIR-AP-BRACKET-2 (Figure 7: Access Point Bracket Choices, on page 10).

Figure 7: Access Point Bracket Choices



AIR-AP-BRACKET-1
AP Bracket: Low-Profile



AIR-AP-BRACKET-2
AP Bracket: Universal

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If the AP needs to be mounted directly to a ceiling on the grid work, then AIR-AP-BRACKET-1 is flush mounted and has the lowest profile. However, if the AP is mounted to an electrical box, other wiring fixture, inside a NEMA enclosure, or wall mounted, then AIR-AP-BRACKET-2 is a better choice. The extra space in the bracket allows for wiring, and the extra holes line up with many popular electrical boxes. When mounting the bracket to the ceiling grid work, some ceiling tiles are recessed. For this reason, two different styles of ceiling clips, such as recessed and flush rails are available

Figure 8: Different Clips are Available for Attaching to Ceiling Grid Work



AIR-AP-T-RAIL-R
Ceiling Grid Clip (Recessed)



AIR-AP-T-RAIL-F
Ceiling Grid Clip (Flush) 350078

Channel Rail Adapters – Cisco Part Number AIR-CHNL-ADAPTER

When mounting APs to ceiling channel rails such as the ones shown in [Figure 9: Example of Channel Rails, on page 12](#), an optional channel adapter AIR-CHNL-ADAPTER is used. The channel adapter comes in a two-pack and is attached to the ceiling grid clip shown in [Figure 8: Different Clips are Available for Attaching to Ceiling Grid Work, on page 11](#). Refer to [Figure 10](#):

AIR-CHNL-ADAPTER (left) Slides Onto the Rails, on page 12 and Figure 11: AIR-CHNL-ADAPTER Mounted to Rail Clip (left) and Finished Installation (right), on page 12.

Figure 9: Example of Channel Rails



Figure 10: AIR-CHNL-ADAPTER (left) Slides Onto the Rails

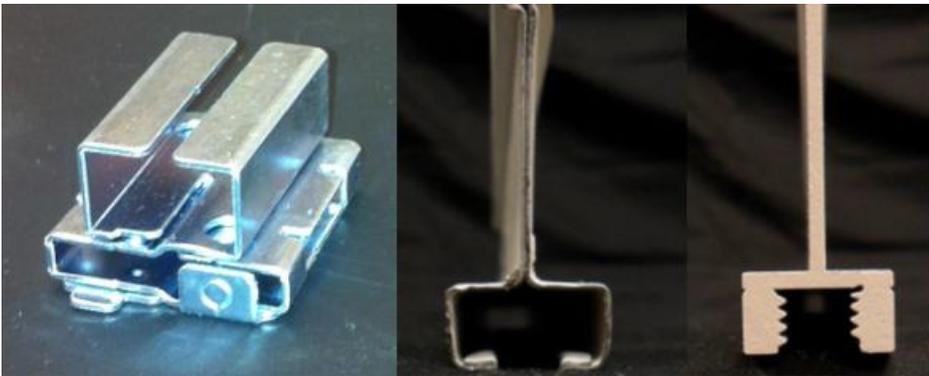
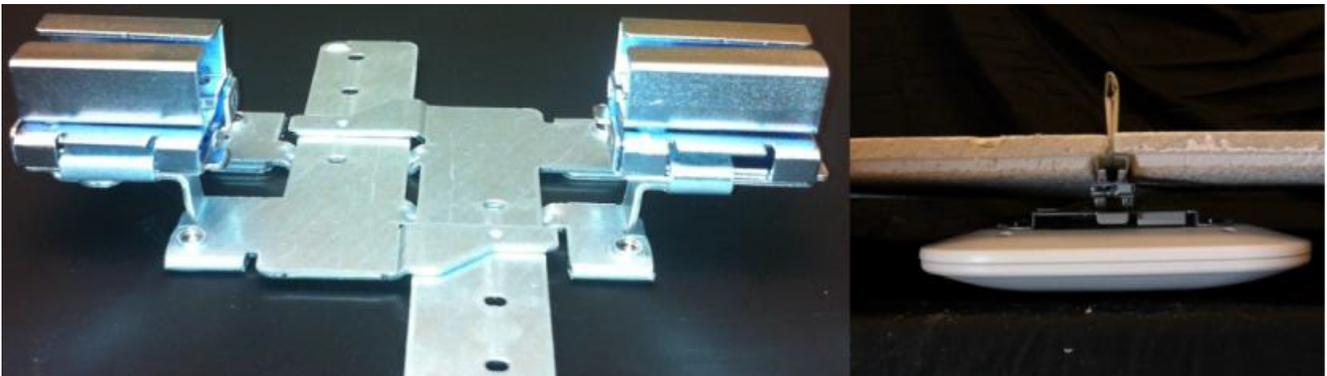


Figure 11: AIR-CHNL-ADAPTER Mounted to Rail Clip (left) and Finished Installation (right)



Wall Mounting the AP

When the AP needs to be wall-mounted, the installer should understand that walls can be a physical obstacle to the wireless signal. Therefore, maintaining 360 degree coverage may be compromised by the wall. If the wall is an outside wall and/or the goal is to send the signal in an 180-degree pattern instead, a directional antenna, often referred to as a “patch” antenna, may be a better choice assuming that the AP 1850e is used.

Avoid wall-mounting APs with internal antennas, such as the AP 1850i, unless you use the optional Oberon right-angle mount (Figure 12: Wall-Mounting APs Antennas Should be Vertical (Up/Down) or Use the Oberon Right-Angle Mounting Structure - Ideal for the “I” series such as 1850i, 2700i, 3600i or 3700i Oberon P/N 1029-00), on page 13). The internal antenna model is designed to mount to a ceiling to provide 360-degree coverage. If wall-mounted in a non-ceiling orientation, the signal may penetrate the floor above and below causing unintended coverage. This results in additional and needless roaming access when a mobility client, for example a user with Wi-Fi phone, walks by on an adjacent floor.

Instead, use the AP 1850e (with dipoles or patch antennas) or use an optional wall mount that puts the AP 1850i or AP 1850e into a ceiling type orientation when mounted to a wall.



Note APs with internal antennas such as the AP 1850i that are wall mounted should use the Oberon mounting bracket unless roaming is not an issue, for example, hotspot, kiosk, or small venue scenario.

Figure 12: Wall-Mounting APs Antennas Should be Vertical (Up/Down) or Use the Oberon Right-Angle Mounting Structure - Ideal for the “I” series such as 1850i, 2700i, 3600i or 3700i Oberon P/N 1029-00)



Oberon model 1029-00 is a right angle mount works with “i” and “e” models to put the AP in the right antenna orientation. If the unit is an “e” model with dipoles that can be mounted (far right), then an Oberon wedge mount is not required.

See http://www.oberonwireless.com/WebDocs/Model1029-00_Spec_Sheet.pdf.

Above the Ceiling Tiles

The AP 1850 series is rated for installation in the Plenum area (UL-2043). Many customers prefer to locate the AP in such a way that nothing is visible on the ceiling. In some cases, this is preferred for aesthetic reasons, so customers may install the AP above a drop ceiling. This may also be preferred in high theft areas such as classrooms or in areas where policy dictates that nothing can be visible on the ceiling.

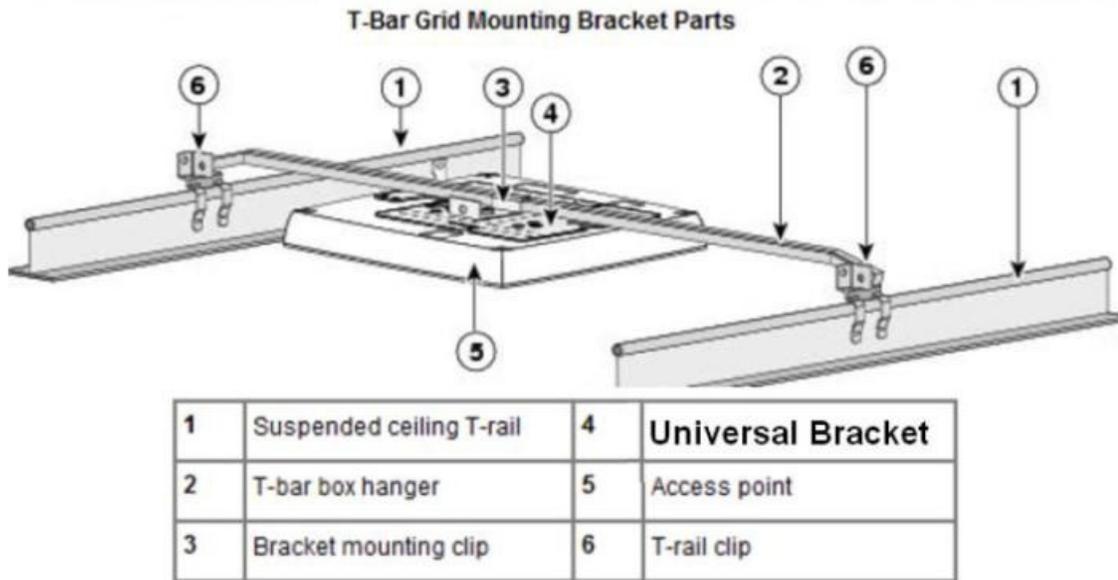
To meet this hard requirement, optional T-Bar hangar accessories such as Erico and Cooper, can be used (Figure 13: Example of How to Hang an AP Above the Ceiling Tiles, on page 14). These accessories are manufactured by third-party companies. The Erico Caddy 512a, the Cooper B-Line BA50a, or similar T-Bar Grid T-Bar hangars can be used.

For more information, see:

www.erico.com

www.cooperindustries.com

Figure 13: Example of How to Hang an AP Above the Ceiling Tiles



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Note Installing APs above the ceiling tiles must be done only when mounting below the ceiling is not an option. The tiles must not be conductive; such installations will degrade advanced RF features such as voice and location, so verify coverage and performance. Always, try to mount the AP as close to the inside middle of the tile as possible, and avoid areas with obstructions

Figure 14: Installing AP above ceiling tiles: Pick an area Clear of Obstructions and Avoid Ceiling Clutter



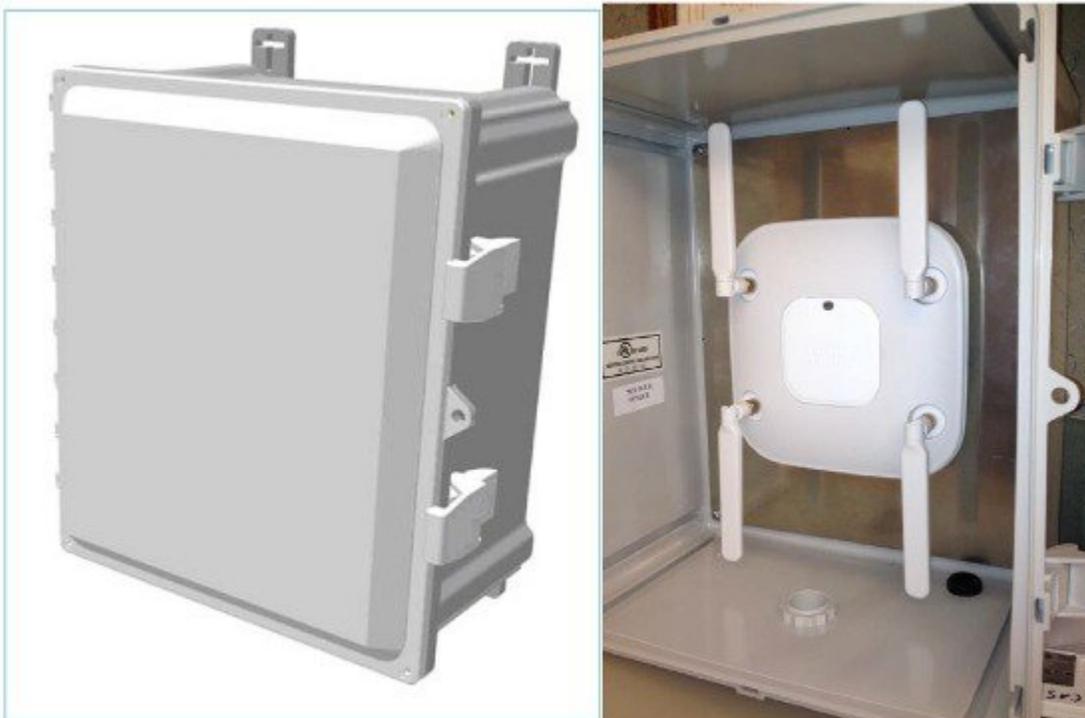
Stadium / Harsh Environments

Customers needing to install the APs in harsh environment such as sporting areas, stadiums, open garden areas, or warehouse freezers, where it may be exposed to weather, may use a NEMA type enclosure.

**Note**

Some APs may not be certified for outdoor deployments in a NEMA enclosure. This varies around the world, for example some regulatory agencies permit AP outdoor NEMA enclosures if the AP is indoors such as a freezer or garden area but may prohibit its usage outdoors. This seems to vary with regard to weather radar compliance, UNII-1 compliance, and so on. Check with your Cisco account team or the communications regulatory agency that has jurisdiction in your area.

Figure 15: Example of NEMA 16x14x8 Enclosure with Pressure Vent on Bottom



Third-party sources for NEMA type enclosures include:

www.oberonwireless.com

www.sparcotech.com

www.terra-wave.com

When using a NEMA type enclosure, ensure that the cables exit out of the bottom of the enclosure so that rain and moisture do not run down the cable into the enclosure. Also, the color of the enclosure may affect the heat rating; for example, a black enclosure gets much hotter in the sun than a white one. You may also want to use a pressure vent to prevent moisture accumulation.

Ethernet Cable Recommendation

While the AP 1600, 1700, 1850, 2600, and 3600 work fine with CAT-5e cable, for newer cable installations, it is recommended that the customers use CAT6a. Because, CAT6a is the cabling required by the 10GE standard.

Antenna Cable Recommendation

Whenever practical/possible, ensure that the antenna cable runs as short as possible. Cisco offers low loss (LL) and ultra low loss (ULL) cables, which have the same characteristics as Times Microwave LMR-400 and LMR-600.

Cisco cables carry the part number AIR-CAB (Aironet Cable) and its length parameter. For example, a 20 Ft length of LL cable with RP-TNC connector is Cisco AIR-CAB-020LL-R. These heavy black cables are not Plenum rated and are primarily for outdoor use or manufacturing areas.

Figure 16: When Drilling Holes for Cable, Allow for Size of Connector (Typically 5/8 Inch) Drill Bit



Access Point Spacing Recommendations

If you have an Wi-Fi device such as an AP and you are going to use another AP in the vicinity on a different channel, it is recommended that you space each AP apart by approximately 6 ft (2 meters). Avoid clustering the APs or the antennas from different APs together, because this could cause degradation in performance. This recommended distance is based on the assumption that both devices operate in the unlicensed band and do not transmit RF energy more than 23 dB, that is, 200 mW. If higher power is used, space the APs farther apart.

If you have other devices that transmit, especially if they operate in the same frequency ranges, for example, frequency hopping legacy APs or other devices that operate close in frequency to those of the AP (think below or above the 2.4 and 5 GHz band), you should consider moving or separating the devices as far as you can. After you have done this, check for interference by testing both devices at the same time under heavy utilization (load) and then characterize each system independently to see how much, if any, degradation exists.

To comply with FCC, EU, and EFTA RF exposure limits, antennas should be located at a minimum of 7.9 inches (20 cm) or more from the body of all persons. For more information, see the Declarations of Conformity section in the [Cisco Aironet 1850 Series Access Points Hardware Installation Guide](#).

Installations in IDF Closets (Telecommunications or Other Electrical Equipment)

When installing APs near electrical or telecommunications equipment, keep all wiring and metal away from the antennas and avoid placing the antennas near electrical lines. Do not route wiring electrical or Ethernet in the near field (6-15 inches) from the antenna. Try to refrain from installing the AP in the electrical closet, because the best place for the AP is as close to users as possible/practical. If you have remote antenna cables from such a closet, you may be required to use Plenum rated cable (see local fire/safety regulations for more on this).

Below are a few URLs for understanding interference:

http://www.cisco.com/en/US/prod/collateral/wireless/ps9391/ps9393/ps9394/prod_white_paper0900aecd807395a9_ns736_Networking_Solutions_White_Paper.html

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/white_paper_c11-609300.html

Installations Inside and Around Elevators

Elevator coverage can sometimes be accomplished by placing APs in the near field of an elevator, typically on each floor near the elevator door. Because, elevators often have metal doors and the shafts are often concrete or contain other materials that degrade Wi-Fi coverage. It is important to check the coverage inside the elevator. Though such coverage can be challenging, it is often do-able, especially if the elevator is only a few floors.

High rise elevators are more challenging because roaming issues are problematic; the client is cycling through a large number of APs quickly. Some companies that do in-elevator advertising put a patch antenna on the floor inside the shaft and a patch antenna on the bottom of the elevator car, while other companies use leaky coaxial cable running on the side of the shaft.

When installing any Wi-Fi equipment inside the elevator cars or shafts, local regulations need to be followed. Because, many times such installations are prohibited either for safety reasons or because the building owner or local fire department may prohibit the same. Only elevator repair persons or contractors who have experience with this kind of work should be in those areas.

Understanding AP 1850 Powering Options

Figure 17: Local 48 Volt DC Power Supply

1850 Local Power Supply – AIR-PWR-C=

Note: This is a 40 Watt supply older AIR-PWR-B= was only 18 Watts



Cable 16AWG Length approx. 1500mm (4.9 Ft)

Calculated MTBF @25C is 741K hours

Calculated MTBF @40C is 404K hours

Note: AIR-PWR-B= is not supported with AP-1850

PoE Negotiation

When the AP negotiates 802.3at (high power), it always tries first to negotiate using Cisco Discovery Protocol (CDP). If the negotiation fails, the AP will attempt to negotiate using Link Layer Discovery Protocol (LLDP). LLDP is a vendor-neutral method for advertising device identity and capabilities.

So, the AP 1850 first uses CDP to get 20.9 W and reserve that amount of power. If CDP fails, the same process starts using LLDP. So, a non CDP response time out (often approaching 60 seconds) would need to occur before the LLDP negotiation starts. In both cases, the requirement is obtain 20.9 W power.

If the AP has enough power, it shows Full Power in the PoE settings. See [Figure 18: Power over Ethernet showing Full Power Mode, on page 19.](#)

Figure 18: Power over Ethernet showing Full Power Mode



However, if the power source equipment such as PoE switch, mid-span, or injector lacks the ability to properly negotiate high power, go to “ANY” mode and take whatever power the device can provide, which would likely be 15.4 W (802.3af).

If the power source is limited to 15.4 W (802.3af), then the AP negotiates and reserves 15.4 W.

The AP functions with the available power sourcing. If the power is not enough to be fully functional, then the AP makes an effort to shut down and re-negotiate to be able to function at 15.4W. Also, the AP indicates LOW or MEDIUM power on the controller and functions at reduced capability. See [Table 1: Power over Ethernet options, on page 19.](#)



Note If the power source does not support Cisco Discovery Protocol, for example third party switch, then uncheck its usage. See [Table 1: Power over Ethernet options, on page 19.](#)

Table 1: Power over Ethernet options

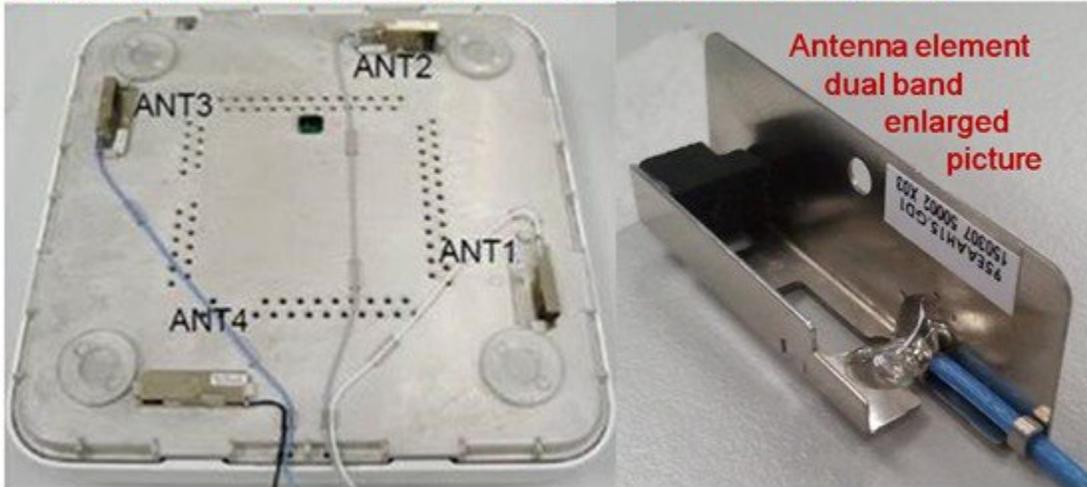
Powering Options	Power Budget ¹	Capability
802.3at, Enhanced PoE, PoE+	19.93 W	Fully Functional
Cisco Power Injector AIR-PWRINJ4=(30 W)	19.93 W	Fully Functional
Cisco Local Power Supply, AIR-PWR-C=	19.93 W	Fully Functional
802.3af, Cisco Power Injector AIR-PWRINJ5=	12.95 W	1852i: Full radio function 1852e: 2.4 GHz radio will shift to 2x3 AUX and USB port disabled for both 1852i/e

¹ This is the CDP/LLDP value that we ask in software, switch pads another 2 - 3 W for cable loss at 100 m.

Approved antennas and Radiation Patterns

Figure 19: Picture of the internal antennas within the AP 1850

1850 Access Point – A look inside at the antennas



The internal antennas are rated at 3 dBi at 2.4 GHz and 5 dBi at 5 GHz.

Figure 20: Radiation pattern at 2.4 GHz

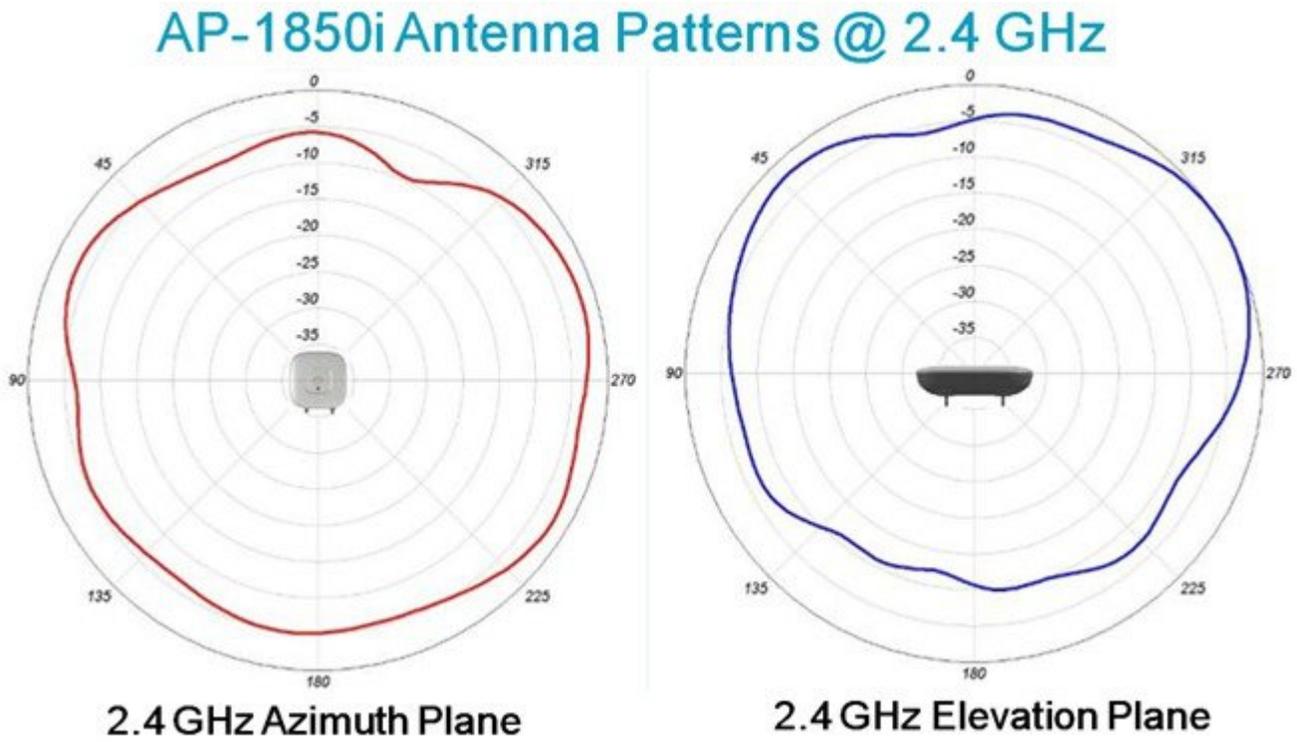
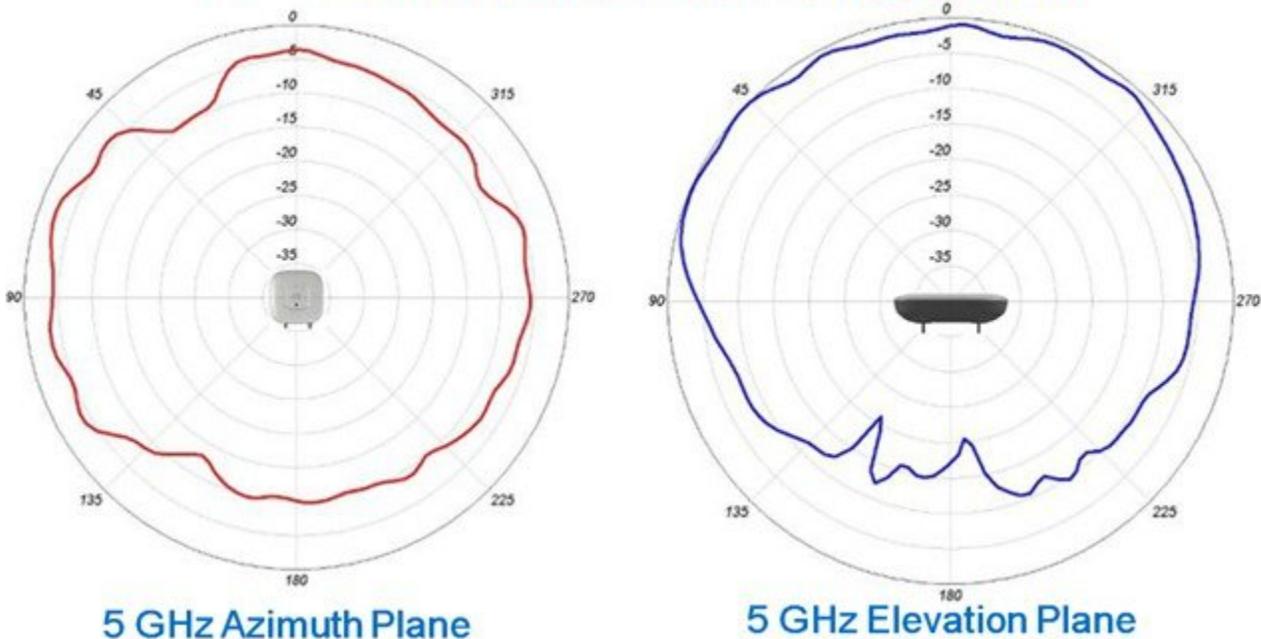


Figure 21: Radiation pattern at 5 GHz

AP-1850i Antenna Patterns @ 5 GHz



Antennas for Outdoor Deployments

The AP 1850 is designed for indoor deployments. However, using a NEMA enclosure or mounting the antenna outdoors may be acceptable (depending upon your location as some countries do not permit this).

In the U.S., installers who need to deploy APs outdoors are recommended to use the “P” series products such as the Cisco Aironet AP 3600P and AP 3700P. For more information, See the [3700 deployment guide](#).

All Cisco antenna connectors are labeled as “A,” “B,” “C,” and so on. “A” has a higher priority than “B” or “C/D”. So, if the AP supports, for example 3 or 4 antennas and you only have 2 antennas, you can use them on ports “A” and “B” for a short period until you install the additional antennas provided you turn off the unused antenna ports on the controller or AP software.

While it is not recommended to use less antennas, the product (in a pinch) supports 802.11a/b/g clients or single spatial stream .11n clients using only one or two antennas. However, there is a significant performance hit and you will also lose ClientLink functionality. If you do this, you will also have to configure the AP in the software to not use the other antenna. Failure to do so could result in performance issues.

The following Dual Radiating Element (Dual-Band) antennas are approved for use with the AP 1850e series access point:

- AIR-ANT2524DB-R= Dipole Black 2dBi @ 2.4 GHz – 4dBi @ 5 GHz
- AIR-ANT2524DG-R= Dipole Gray 2dBi @ 2.4 GHz – 4dBi @ 5 GHz
- AIR-ANT2524DW-R= Dipole White 2dBi @ 2.4 GHz – 4dBi @ 5 GHz
- AIR-ANT2535SDW-R= Short Dipole 3dBi @ 2.4 GHz – 5dBi @ 5 GHz
- AIR-ANT2524V4C-R= MIMO Omni Ceiling 2dBi @ 2.4 GHz – 4dBi @ 5 GHz
- AIR-ANT2566P4W-R= MIMO Patch 6dBi in both bands
- AIR-ANT2544V4M-R= MIMO Wall Mount Omni 4dBi in both bands

- AIR-ANT2566D4M-R= Medium Ceiling / Auditorium Patch 6dBi in both bands

For additional information on Cisco antennas, see [Cisco Aironet Antennas and Accessories Reference Guide](#).

The antenna reference guide has details of all Cisco antennas. You can also find individual data sheets at <http://www.cisco.com/en/US/products/hw/wireless/ps469/index.html>.



Note

Always use Cisco antennas whenever possible. See

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/white_paper_c11-671769.pdf.

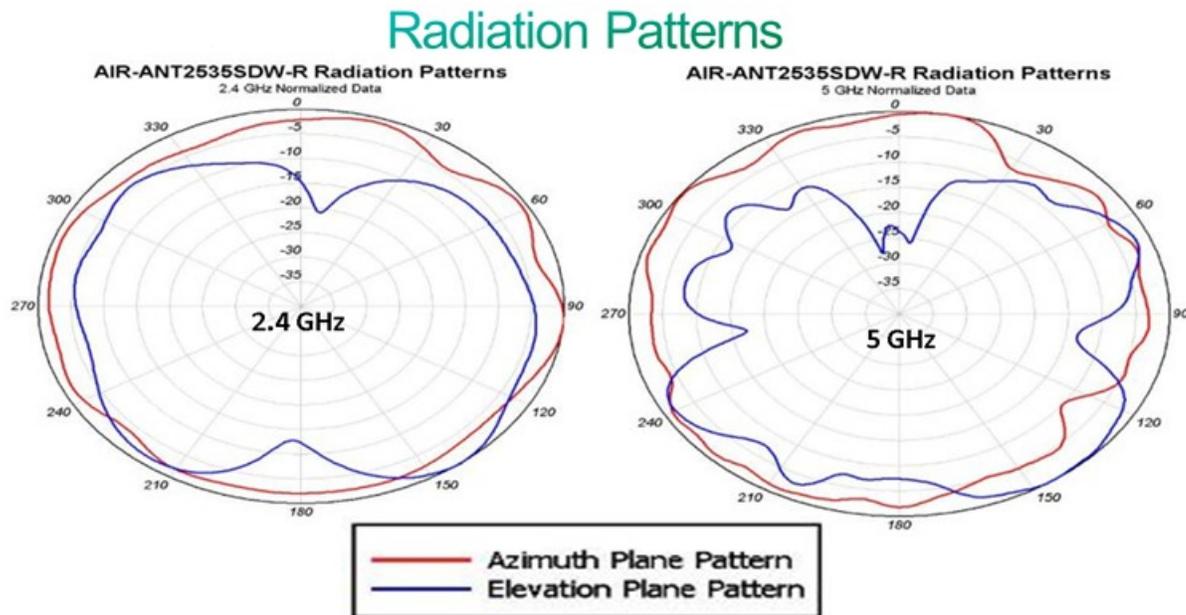
Cisco has also introduced a new smaller size dipole. While this antenna does not have an articulating knuckle, it is much smaller in size and is a good choice when aesthetics is a primary concern. [Figure 22: Standard Dipoles and Short Dipoles \(On Right\)](#), on page 24 shows an AP-3700 with both types of dipoles.

Figure 22: Standard Dipoles and Short Dipoles (On Right)



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Figure 23: Radiation Pattern for the Short Dipole AIR-ANT2535SDW-R



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In addition, the antennas below may also be used with 1600, 1850, 2600, 3600, and 3700 “e” Series APs.

Figure 24: Specifications for the AIR-ANT2524Dx-R Dual-Band Dipole Antenna

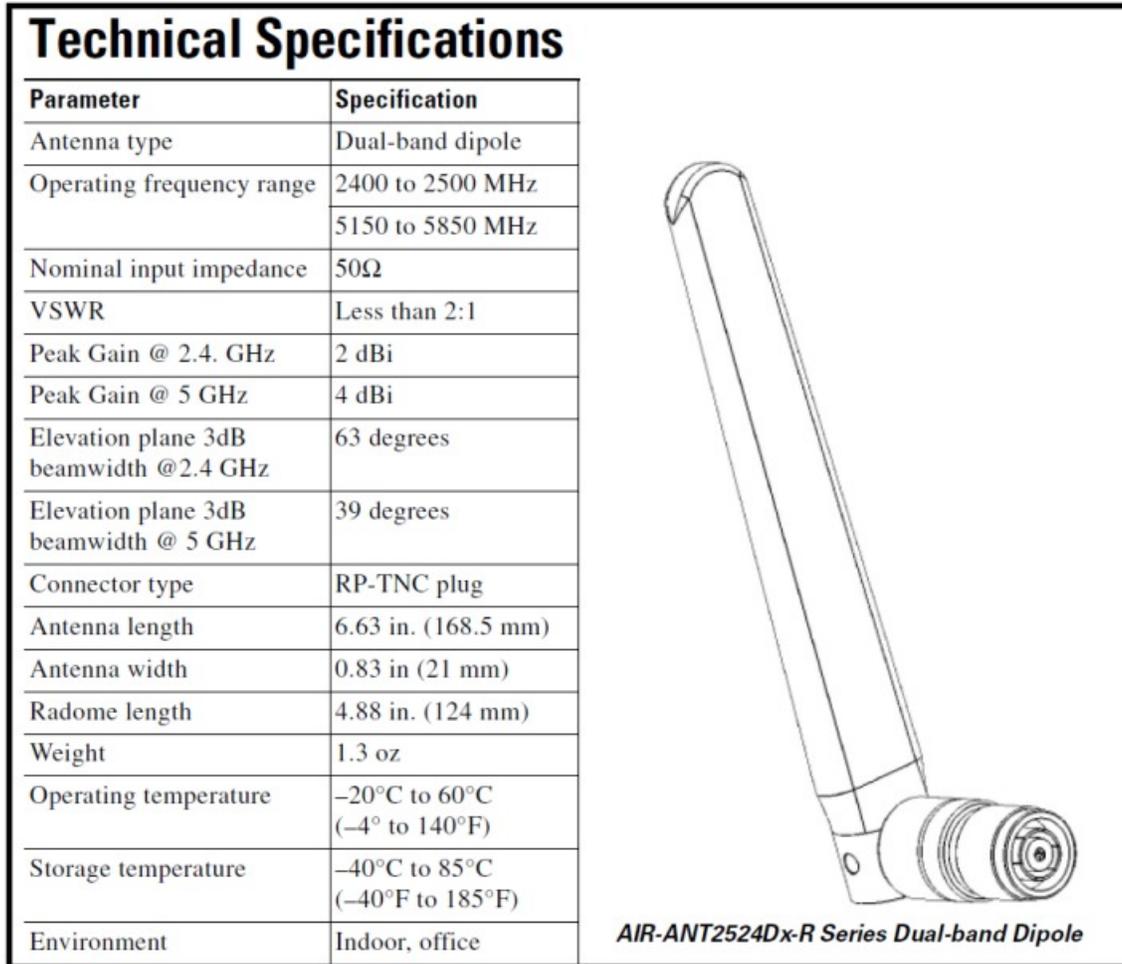
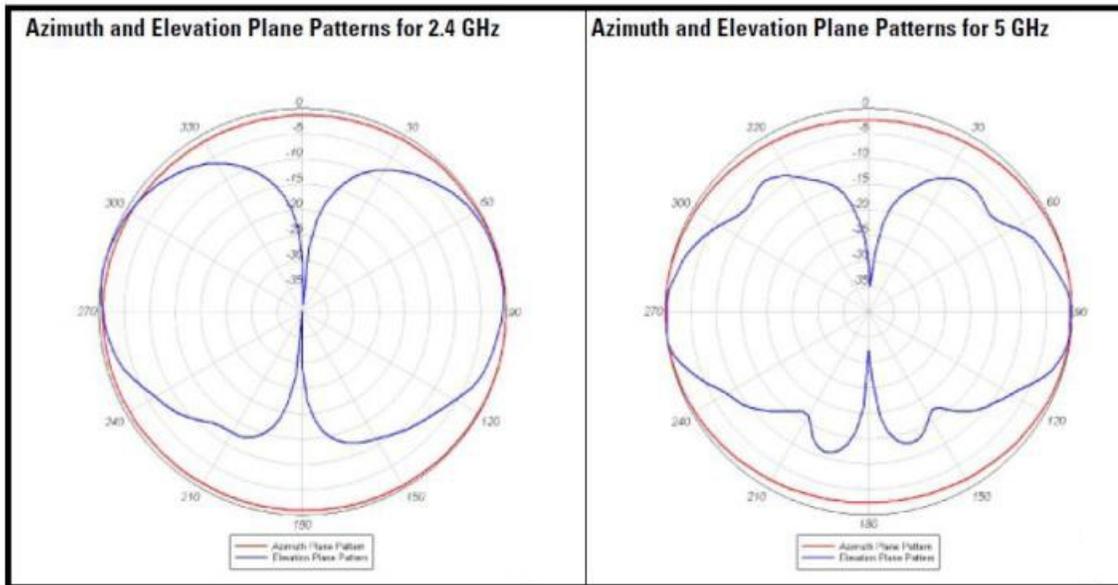
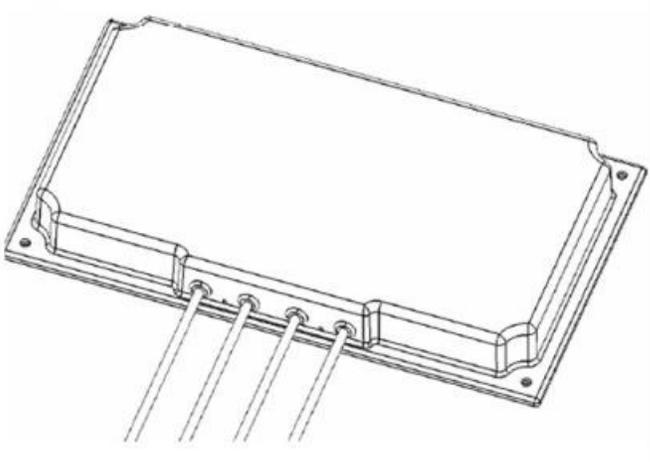


Figure 25: Radiation Pattern for the AIR-ANT2524Dx-R Dual-Band Dipole Antenna



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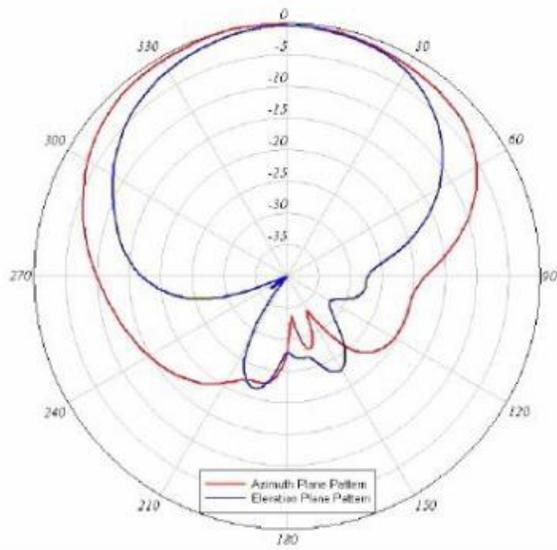
Figure 26: Specifications for the AIR-ANT2566P4W-R Dual-Band Patch Antenna

Antenna type	4-element dual-band MIMO	 <p>AIR-ANT2566P4W-R 4 Element Dual-Band Patch (indoor / outdoor use)</p>
Operating frequency range	2400 to 2484 MHz 5150–5850 MHz	
VSWR	2:1 or less	
Gain	6 dBi in both bands	
Polarization	Linear, vertical	
Azimuth Plane 3-dB Beamwidth	2.4 GHz band: 105° 5 GHz band: 125°	
Elevation Plane 3-dB Beamwidth	2.4 GHz band: 70° 5 GHz band: 60°	
Length	6.3 in. (16 cm)	
Width	11 in. (27.9 cm)	
Depth	1.2 in. (3.05 cm)	
Weight	1.4 lbs	
Cable length and type	3 ft. (91.4 cm) plenum rated	
Connector	RP-TNC	
Environment	Indoor/outdoor	
Operating temperature range	-22° to 158° F -30° to 70° C	

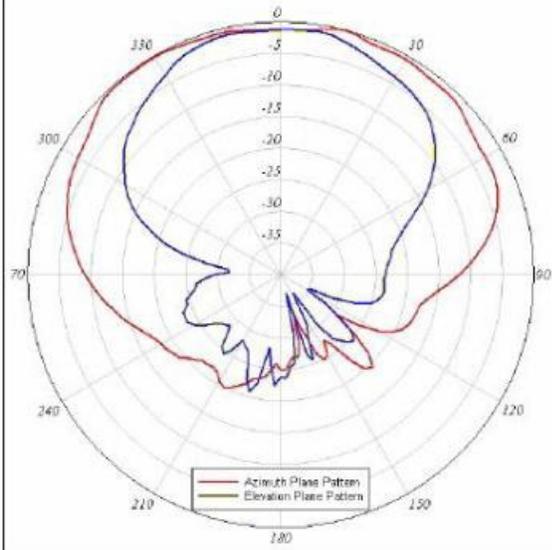
350097

Figure 27: Radiation Pattern for the AIR-ANT2566P4W-R Dual-Band Patch Antenna

**Azimuth and Elevation Radiation Patterns
Left Antenna - 2.4 GHz Band**



**Azimuth and Elevation Radiation Patterns
Left Antenna - 5 GHz Band**



350098

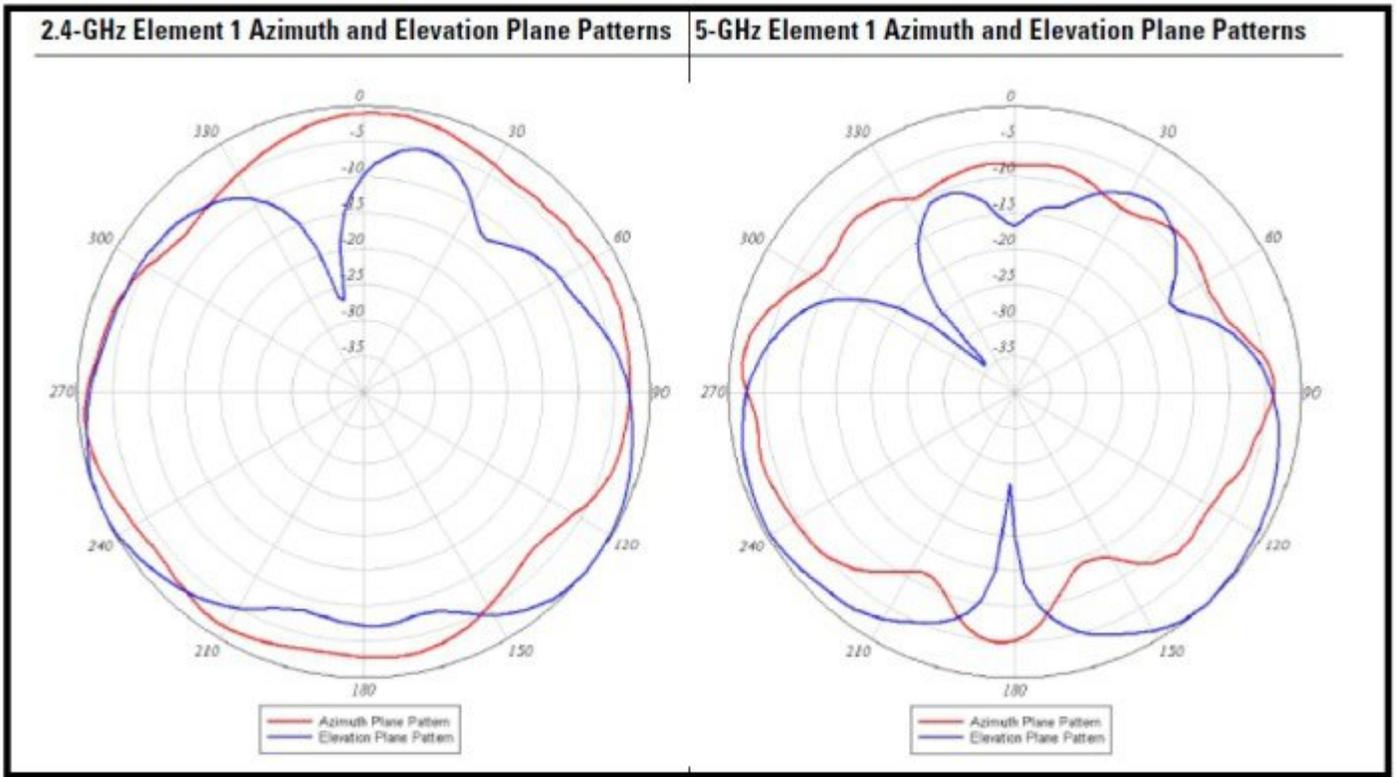
Assuming that the antenna is mounted on a wall, the Azimuth (in Red) is the signal going forward from the antenna. The elevation, in Blue, is the “up/down” pattern.

Figure 28: Specifications for the AIR-ANT2524V4C-R Dual-Band Omni Antenna

Antenna type	4-Element, Dual-band, Low Profile Omni	
Operating frequency ranges	2400–2484 MHz 5150–5850 MHz	
VSWR	2:1 or less in both bands	
Peak gain	2.4-GHz band: 2 dBi 5-GHz band: 4 dBi	
Polarization	Linear	
Azimuth plane 3 dB beamwidth	Omnidirectional	
Elevation plane 3 dB beamwidth	2.4-GHz band: 69° 5-GHz band: 60°	
Length	7.25 in (18.4 cm)	
Width	7.25 in (18.4 cm)	
Depth	1 in (2.5 cm)	
Weight	1.3 lb (0.59 kg)	
Cable	3 ft (91.4 cm) plenum rated, UV stable	
Connector	RP-TNC	
Environment	Indoor	
Temperature range	32°F to 133°F (0°C to 56°C)	

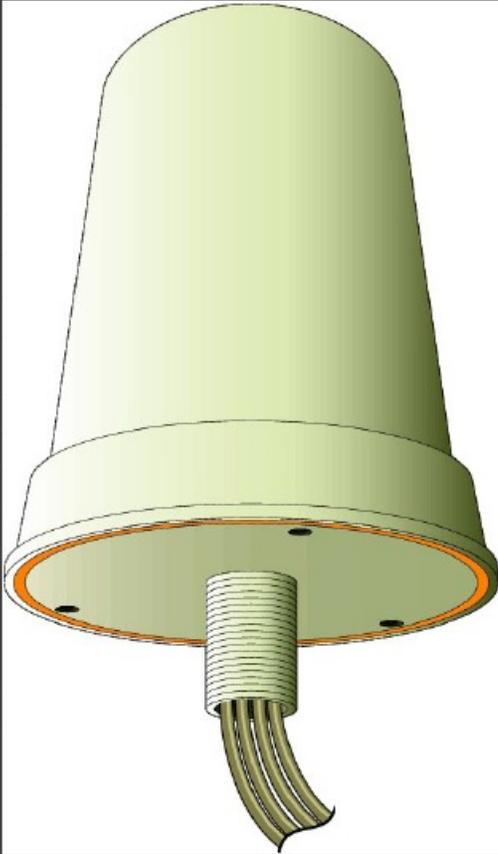
350098

Figure 29: Radiation Pattern for the AIR-ANT2524V4C-R Dual-Band Omni Antenna



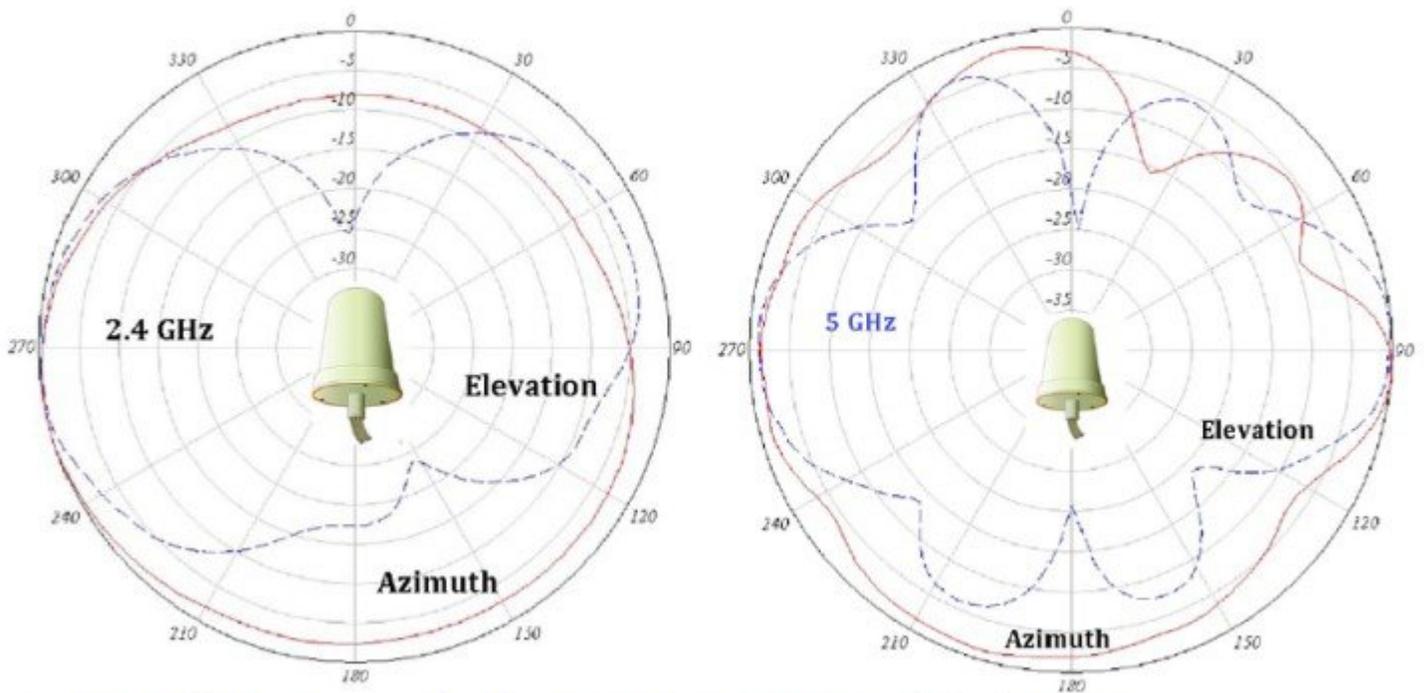
350100

Figure 30: Specifications for the AIR-ANT2544V4M-R Dual-Band Omni Antenna

Antenna type	4-element MIMO omnidirectional	
Operating frequency range	2400-2484 MHz	
	5150-5850 MHz	
Nominal input impedance	50Ω	
VSWR	2:1 or less	
Peak gain	2.4-GHz band: 4 dBi	
	5-GHz band: 4 dBi	
Polarization	Linear, vertical	
Azimuth plane (3 dB beamwidth)	Ominidirectional	
Elevation plane (3 dB beamwidth)	2.4-GHz band: 60°	
	5-GHz band: 33°	
Length	8.6 in (21.8 cm)	
Diameter	6.3 in (16 cm)	
Weight	Antenna: 1.48 lb. (671.5 g);	
Cable	3-ft. (91.4 cm) plenum	
Connector	RP-TNC	
Environment	Indoor/outdoor	
Temperature range	-22° F to 158° F (-30° C to 70° C)	

350242

Figure 31: Radiation Patterns for the AIR-ANT2544V4M-R Dual-Band Omni Antenna



Note For a granular pattern, see the individual specification sheet of the respective antennas.

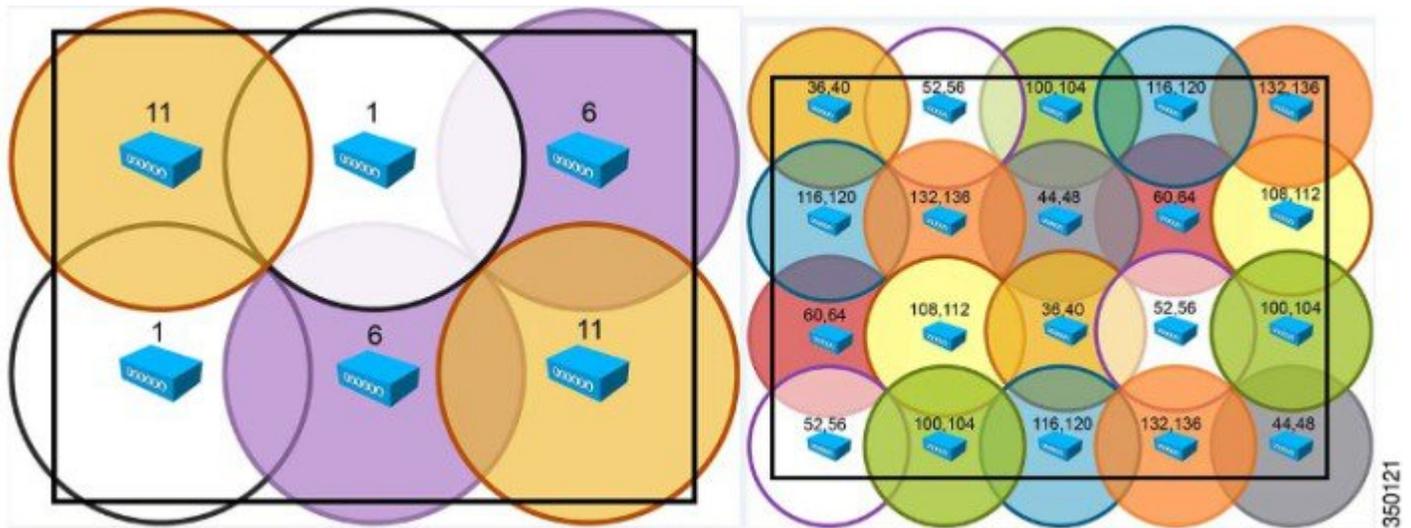
General Considerations – WLAN Best Practice Guidelines

Following are some guidelines to remember regarding AP deployments:

- Always try to mount the AP as close to the users as possible for best performance. Be aware of the environment; for example, hospitals have metal doors and coverage can change when the doors close. Old buildings can have metal grid work in the plaster or asbestos. Avoid mounting the AP or antennas near metal objects, as doing so can change the coverage area.

- When using the 2.4 GHz frequency, the same 1, 6, and 11 channel scheme is used as the 5 GHz channel scheme (Figure 32: Example of Channel Usage in 2.4 and 5 GHz (Two Channels used if 40 MHz), on page 32). Avoid putting all the APs on the same channel, and reuse channels as you can. See other deployment guides for more on this topic.

Figure 32: Example of Channel Usage in 2.4 and 5 GHz (Two Channels used if 40 MHz)



- Try to determine which clients are going to be used and check the coverage using those clients. For example, a PDA or Wi-Fi phone might not have the same range as a notebook or tablet.



Tip Verify coverage using the worst performing clients that you intend to deploy.

- The Cisco AP 1850 series supports standards based transmit beamforming and is positioned for newer Wave-2 MU-MIMO and 4-SS clients. The Cisco 2700 and 3700 series APs with ClientLink 3.0 will perform better than the AP 1850 when using legacy .11g/n and .11ac Wave-1 clients. This is because the performance improvements with the AP 1850 are designed to take advantage of 4-SS and Multi-User MIMO (Wave-2 clients) and does not support Cisco's enhanced Client Link beamforming for legacy clients.
- While site surveys are generally recommended, if the design is done at half power and Cisco RRM is in place, sometimes a limited site survey (coverage check) is adequate for smaller venues. If it is a very challenging environment such as train connectivity, Gas & Oil verticals, large hospitals, and so on, Cisco has an Advanced Services team that can be contracted to help you get up to speed or perform your installation. Contact your Cisco account team for more information.
- The rule of thumb coverage plan is 1 AP per 5,000 square feet for data and 1 per 2,500 square feet for voice and location services, which roughly means 1 AP per 50 feet for best performance.
- Try to leverage 5 GHz for more and cleaner channels / spectrum.
- Try to create 10 – 20% cell overlap for optimized roaming and location calculations / transactions.
- Consider separate SSIDs for Corporate and Guest Access with Guest being Rate Limited.
- Enable band steering, so that the dual band clients are motivated to use 5 GHz to avoid slower 2.4 GHz channels.
- Use Category 5E or better for Gigabit Ethernet or mGig.

- Some clients (especially older ones) do not support the UNII-2 extended client channels 100 – 140. So, if you have lots of older clients, you may need to disable them in the DCA channel list.



Note Clients with later chipsets (especially later 802.11ac clients) should support extended UNII-2 channels.

The following lists the Wi-Fi signal strength guidelines:

- -65 to -67 = Data, Voice, Video, Location, High Density
 - 1 access point per 2,500 square feet / every 50 feet
- -68 to -69 = Data, Voice, Multicast and Unicast Video, Location
- -70 to -71 = Data, Unicast Video
- -72 or greater = Data only

802.11ac Wave-2 primer and the AP 1850

For an overview of 802.11ac, see the technical white paper at the following URL:

http://www.cisco.com/c/en/us/products/collateral/wireless/aironet-3600-series/white_paper_c11-713103.html

Key differences with 802.11ac Wave-2 using the AP 1850 are:

- The ability to use 1, 2, 3 (and now 4) Spatial Streams
- An extra Spatial Stream gives you a bump in data rate @ 80 MHz 1733 versus 1300 Mbps
- Same channel bonding 20, 40, 80 (does not support 160 MHz)
- 11ac Beamforming (was in Wave-1) now implemented, but only 11ac clients participate in 11ac beamforming
- Multi-User MIMO (MU-MIMO) support—supported in Wave-2 for 11ac Wave 2 clients only
- Based on IEEE 802.11ac final standard—ratified Dec'2013

Clients Supporting 3 and 4 Spatial Streams

Clients with 3SS support are starting to become a commonplace with 4SS and MU-MIMO Wave-2 clients on the horizon. As the new 802.11ac specification starts to get traction, many newer client adapters will have more advanced chipsets and support 3SS and 4SS as a subset to 802.11ac. Additionally, the Cisco AP 1850 fully supports all the DFS frequencies for more usable channels in the 5 GHz range. More clients, especially 802.11ac clients, will start supporting these newer channels in legacy 802.11n modes as well.

Currently, the most popular 3SS client is the Apple 2011 MacBook Pro, because it is based upon the Broadcom BCM4331 chipset and a small USB adapter by Trendnet, that is, TEW 684UB, based on the Ralink chipset.

Additionally, the Intel 5300 and 6300 modules have supported 3SS for a long time. Because of the different types of notebooks that these cards are installed in, testers have observed good throughput on many notebooks (+320 Mbps) and reduced throughput on other notebooks such as 240 Mbps. If you experience low throughput using the Intel card, you may try a MacBook Pro or Trendnet adapter. If they perform well, try another notebook with the Intel card or open a case with Intel or the laptop manufacturer for a possible remedy. During the AP 3600 beta trials, Cisco observed differences in performance with different notebooks using the Intel 6300 card.



Note

Sometimes, it can be difficult to reliably maintain a 3SS link because it is easy for the client to rate-shift out of the 3SS mode. The client plays an important role in the ability to maintain a 3SS link, so it can vary with the quality of the client being used and the test environment.

Understanding Channel Plans and Bonded Channels

Currently in the US, there are 25 (20 MHz) channels, 12 (40 MHz) channels, and 6 (80 MHz) channels. 802.11ac (Wave-2) supports 160 MHz channels but currently there are only two channels available. This is likely to get better, because the Federal Communications Commission and other regulatory bodies realize the need for more unlicensed spectrum and are actively working to free up more spectrum.

Let us take a look at the frequencies available and how the channel bonding would work.

Right now in the US, there are only four 80 MHz channels but this is likely to improve.

Figure 33: Current Channel Allocation Plan - US Theater

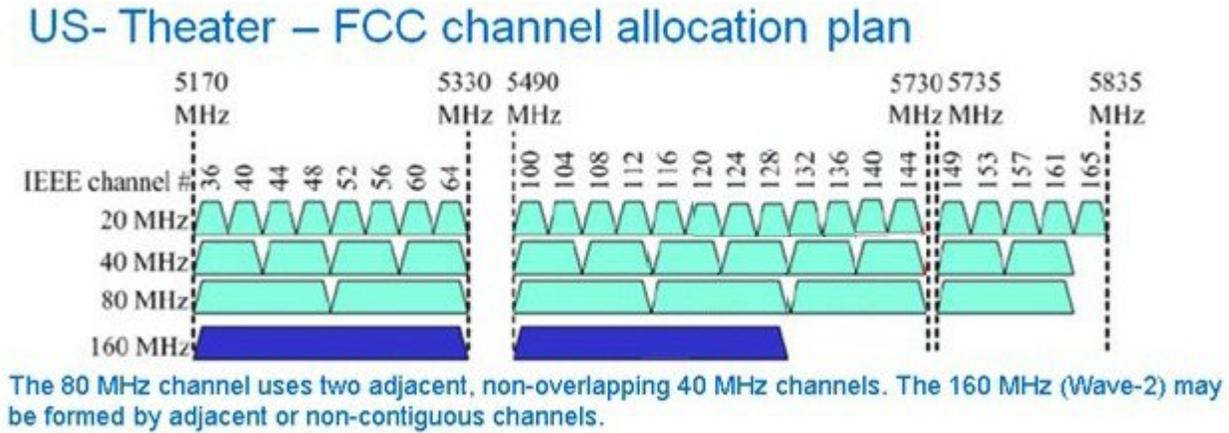
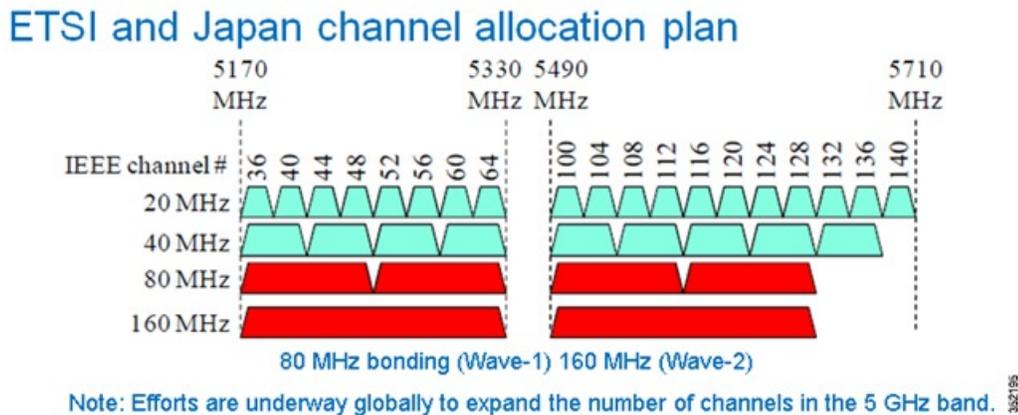


Figure 34: Current Channel Allocation Plan - ETSI Theater



Note: Efforts are underway globally to expand the number of channels in the 5 GHz band.

Future of spectrum allocation?

- In the US, there are currently 25/12/6/2 channels with bandwidth 20/40/80/160 MHz channels.
- With the opening up of 5.35 – 5.47 GHz and 5.85 – 5.925 GHz, the number of channels increases to 34/16/8/3.
- If the industry manages to take back the TDWR channels, the number increases to 37/18/9/4.

So, as time progresses, you should see additional channels becoming available.

Figure 35: Proposed Channel Plan for US Theater (Not Fully Committed as of this Writing)



Summary

- 802.11ac deployments and surveys are not much different than 802.11n deployments.
- 802.11ac supports faster 256 QAM modulation allowing 802.11ac clients the ability to use faster and a wider range of data rates, thus permitting clients to maintain higher connectivity rates.
- When deploying 80 MHz bonded channels, ensure that you have enough spectrum for 80 MHz channels. Note that this can be a major change to your existing spectrum plan.

Understanding Channels and How They Relate to the Client

Most clients (USB) that are emerging are 2 spatial stream, and by using 80 MHz bonding, you can achieve up to 866 Mbps. [Figure 36: Example of a 2-ss Client Bonded at 80 MHz](#), on page 37 shows the Netgear A6200 client card.

Figure 36: Example of a 2-ss Client Bonded at 80 MHz

The screenshot displays the Cisco AnyConnect Secure Mobility Client interface. The main title is "AnyConnect Secure Mobility Client" with the Cisco logo. Below it, the text reads "Network Access Manager Example, using the NETGEAR USB 2 stream (80MHz) is 866 Mbps". There are three tabs: "Configuration", "Statistics", and "Message History".

The "Statistics" tab is active, showing connection information and security details. The "Speed (Mbps)" is circled in red and shows a value of 866.5. Other connection details include: Status: Connected (Secured), Name: 802.11AC1, Local MAC Address: 84:1b:5e:f0:b9:62, Remote MAC Address: 3c:ce:73:38:c9:e6, IP Address: 10.10.210.120, FIPS Mode: Disabled, Media: Wi-Fi, Adapter: NETGEAR A6200 WiFi Adapter.

Security Information includes: Configuration: WPA2 Personal AES, Encryption: AES, EAP Method: None, Server: (blank), Credential Type: N/A.

Wi-Fi Information includes: SSID: 802.11AC1, Signal Strength: Excellent (-27 dBm), Channel: 36.

Bytes statistics: Sent: 3843470, Received: 145412024.

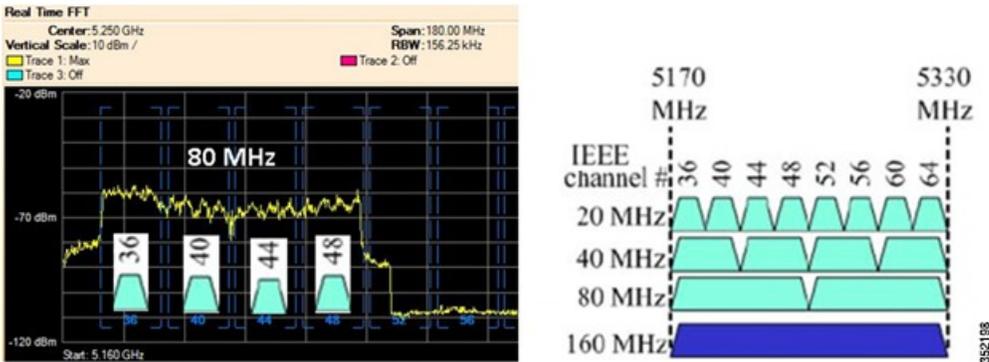
Frames statistics: Sent: 27416, Received: 101269.

An image of the NETGEAR A6200 802.11ac Dual-Band Wi-Fi USB Adapter is shown at the bottom right. A vertical ID number "352197" is visible on the right edge of the screenshot.



Note The software reports channel is 36 (this is where the channel bonding starts). On a spectrum analyzer, you can see that the actual channels in use are 36, 40, 44, and 48.

Figure 37: Example of a Bonded 80 MHz Channel



Note For clients to link at 80 MHz, you have to set the channel width to 80 MHz on the AP.

Figure 38: Setting an AP 1850 to an 80 MHz Channel from the Controller.

MONITOR WLANs CONTROLLER WIRELESS SECURITY MANAGEMENT COMMANDS HELP FEEDBACK

Wireless 802.11a/n Cisco APs > Configure

General

AP Name AP7cad.74ff.33b6
Admin Status Enable
Operational Status DOWN
Slot # 1

11n Parameters

11n Supported Yes

CleanAir

CleanAir Capable Yes
CleanAir Admin Status Enable
* CleanAir enable will take effect only if it is enabled on this band.

Number of Spectrum Expert connections 0

Antenna Parameters

Antenna Type Internal
Antenna A B C D

RF Channel Assignment

Current Channel (36,40,44,48)
Channel Width * 80 MHz
* Channel width can be configured only when channel configuration is in custom mode
Assignment Method Global Custom
Choose "Custom"

Tx Power Level Assignment

Current Tx Power Level 1
Assignment Method Global Custom

Performance Profile

View and edit Performance Profile for this AP
Performance Profile

Note: Changing any of the parameters causes the Radio to be temporarily disabled and thus may result in loss of connectivity for some clients.

352109

802.11ac and Legacy Client Recommendations

Devices such as Samsung Galaxy S4, ZTE's Grand Memo, HTC One, and new notebooks such as the Apple 2013 Macbook Pro are the first to market 802.11ac devices. It is expected that integrated notebooks and tablets (those devices often supporting 2 and 3 spatial streams) will start to become a commonplace.

Currently, Cisco's test bed for interoperability has the following configuration types.

Table 2: Interoperability Matrix

Hardware/Software Parameter	Hardware/Software Configurations Type
Release	8.1
Controller	Cisco 5500 Series Controller
Access Points	1131, 1142, 1242, 1252, 1850, 3500e, 3500i, 3600, 3702
Radio	802.11ac, 802.11a, 802.11g, 802.11n2, 802.11n5
Security	Open, WEP, PSK (WPA and WPA2), 802.1X (WPA-TKIP and WPA2-AES) (LEAP, PEAP, EAP-FAST, EAP-TLS)
RADIUS	ACS 4.2, ACS 5.2
Types of tests	Connectivity, traffic, and roaming between two access points

Interoperability matrix for APs, Clients and security types tested with the below clients.

Table 3: Laptops and Clients Tested for Interoperability

Client Type and Name	Version
Laptop	
Intel 3945/4965	11.5.1.15 or 12.4.4.5, v13.4
Intel 5100/5300/6200/6300	—
Intel 1000/1030/6205	v14.3.0.6
Intel 7260(11AC)	v14.3.0.6
Broadcom 4360(11AC)	16.1.5.2
Dell 1395/1397/Broadcom 4312HMG(L)	XP/Vista: 5.60.18.8 Win7: 5.30.21.0
Dell 1501 (Broadcom BCM4313)	v5.60.48.35/v5.60.350.11

Client Type and Name	Version
Dell 1505/1510/Broadcom 4321MCAG/4322HM	5.60.18.8
Dell 1515 (Atheros)	8.0.0.239
Dell 1520/Broadcom 43224HMS	5.60.48.18
Dell 1530/Broadcom BCM4359	v5.100.235.12
Cisco CB21	v1.3.0.532
Atheros HB92/HB97	8.0.0.320
Atheros HB95	7.7.0.358
MacBook Pro (Broadcom)	5.10.91.26
MacBook Air	OSX 10.8.5, BCM43xx 1.0 (6.30.223.154.45)

Table 4: Hand Held Devices Tested for Interoperability

Handheld Devices	Version
Apple iPad	iOS 5.0.1
Apple iPad2	iOS 7.0.3 (11B511)
Apple iPad3	iOS 7.0.3 (11B511)
Asus Transformer	Android 4.0.3
Sony Tablet S	Android 3.2.1
Toshiba Thrive	Android 3.2.1
Samsung Galaxy Tab	Android 3.2
Motorola Xoom	Android 3.1
Intermec CK70	Windows Mobile 6.5 / 2.01.06.0355
Intermec CN50	Windows Mobile 6.1 / 2.01.06.0333
Symbol MC5590	Windows Mobile 6.5 / 3.00.0.0.051R
Symbol MC75	Windows Mobile 6.5 / 3.00.2.0.006R

Table 5: Phones and Printers Tested for Interoperability

Phones and Printers	Version
Cisco 7921G	—
Cisco 7925G	1.4.2.LOADS
Ascom i75	1.8.0
Spectralink 8030	119.081/131.030/132.030
Vocera B1000A	4.1.0.2817
Vocera B2000	4.0.0.345
Apple iPhone 4	iOS 7.0.3 (11B511)
Apple iPhone 4S	iOS 7.0.3 (11B511)
Apple iPhone 5	iOS 7.0.3 (11B511)
Apple iPhone 5S	iOS 7.0.3 (11B511)
Ascom i62	2.5.7
HTC One (11AC)	Android 4.2.2
Samsung Galaxy S4 - GT-19500 (11AC)	Android 4.3
HTC Sensation	Android 2.3.3
RIM Blackberry Pearl 9100	WLAN version 4.0
RIM Blackberry Pearl 9700	WLAN version 2.7

802.11ac Devices on the Market

- Integrated Devices – Shipping
 - Apple - Macbook Air
 - Intel Dual Band Wireless - AC 7260
 - Samsung S4
 - HTC ONE
 - ZTE Grand Memo

- USB Clients - Shipping
 - LinkSys AE6000 1x1
 - Asus – USB-AC53 2x2
 - NetGear – A6200 2x2
 - Belkin P-F9L1106 - 2x2
 - D-Link DWA-182 – 2x2
 - Buffalo ac866 – 2x2
 - Edimax EW-7822AC– 2x2

- Ethernet to 802.11ac Bridges - Shipping
 - LinkSys (Belkin) WUMC710
 - Buffalo WLI-H4-D1300

- List for identifying new 802.11ac hardware:
http://wikidevi.com/wiki/List_of_802.11ac_Hardware

Variables Impacting Performance

Some early observations show that USB clients can appear to be a bit slow in performance depending on drivers, USB port versions, and so on. Also, it is observed that some clients have trouble in maintaining an 80 MHz bandwidth in the Dynamic Frequency Selection (DFS) bands. [Table 6: List of 802.11ac Clients and Driver Versions, on page 42](#) lists the clients that had reasonable success during testing.

Table 6: List of 802.11ac Clients and Driver Versions

	Spatial Streams	Interface	DFS	Driver
Samsung Galaxy S4	1ss	Integrated	Yes	4.1.2
HTC One	1ss	Integrated	Yes	4.1.2
Linksys AE6000	1ss	USB 2.0	Yes	5.0.7.0
MacBook Air	2ss	Integrated	Yes	10.8.4
Intel 7260	2ss	Mini PCIe	Yes	16.1.5
Edimax EW-7822UAC	2ss	USB 3.0	Yes	1024.2.618.2103
Linksys WUMC710	3ss	Bridge	No	1.00
MacBook Pro	3ss	Integrated	Yes	10.9

Wi-Fi is a highly variable technology and there are many factors that could impact performance. Few examples are: environment, client, channel, AP placement, and client distance from the AP.

Is the spectrum clean?

If you are not seeing the results you expect, you need to first check the coexistence with other Wi-Fi networks. Also, you need to ensure the entire 80 MHz wide channel or whatever you have bonded together is clear. The easiest way to confirm this is to put your 3600/3700 into SE Connect mode and have a look on Spectrum Expert or Metageek Chanalyzer Pro. This will allow you to see Wi-Fi and non-Wi-Fi interference on all channels.

What client are you using?

The client will have a big impact on performance. First, you need to check if the client is 1, 2, or 3 spatial stream? Then, check the interface used? A USB 3.0 client performs much better than a USB 2.0 client. Integrated radios are the best of all, because they can take advantage of a fast bus speed as well as the built-in antennas of the device. So, it is recommended to use devices such as the Samsung Galaxy s4 (1x1) or the Apple MacBook Air (2x2) over USB clients. We certainly recommend USB 3.0 products over USB 2.0 products.

What channel are you using?

If you are doing a Rate versus Range demo, it is important to choose your channel carefully. Obviously, you need to ensure that the channel is clear. However, not all channels are created equal. Some channels have total output power restrictions. So, Cisco recommends UNII-3 or UNII-2, over UNII-1 for best performance.

How far is the client from the access point?

Check how far is the client from the AP. 802.11ac introduces 256 QAM, which is a more complex modulation. So, the modulation is harder to maintain over distance. If you want to consistently show 256 QAM, which equates to m8 and m9, it is recommended to keep the client within 25'. Beyond 25', you will still see m8/m9, but not consistently.

Keep in mind, m7 is the same for 11n and 11ac, the difference being, 11ac allows for 80 MHz channels. Under ideal conditions, you can expect 11ac to have an almost 3x gain over 11n at m9 and a 2x gain at m7.

How is the AP mounted?

AP placement needs to be considered. For close-in tests, less than 10', placement is not so important. Just make sure that the AP is not obstructed. For other tests, you must take care to mount the AP in a proper location (ceiling or high on a wall in the right orientation). Try to follow these best practices: avoid mounting the AP near metal, mount it horizontally on a ceiling, and so on.

What data rate is the AP transmitting to the client at?

It is often useful to monitor the data rate of the client. The data rate has a direct impact on performance. There are several ways to monitor the data rate. The easiest method is to check on the GUI.

A Quick Look at a Few Non-Optimal Installations

This section lists some examples of installations that are not recommended. It is very difficult to provide good Wi-Fi service with a poor installation. Always try to avoid metal and clutter.

Figure 39: Example of an AP Installation Near Metal and Clutter (Try to Avoid Metal and Clutter)

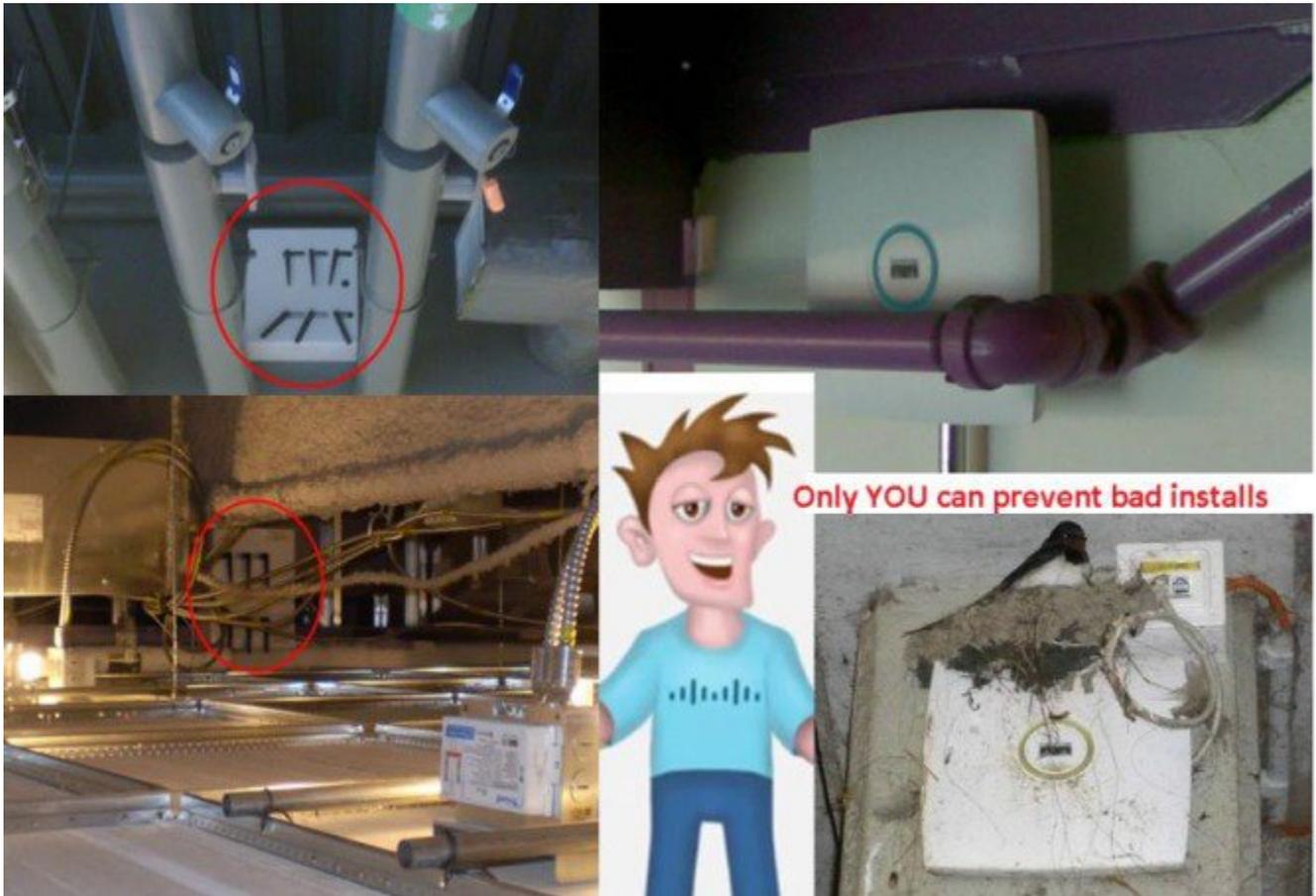


Figure 40: Patch Antenna Against a Metal Fence



Installations that went wrong

Patch antenna shooting across a metal fence

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Figure 41: Example of an AP Installation Near Metal and Clutter (Try to Avoid Metal and Clutter)

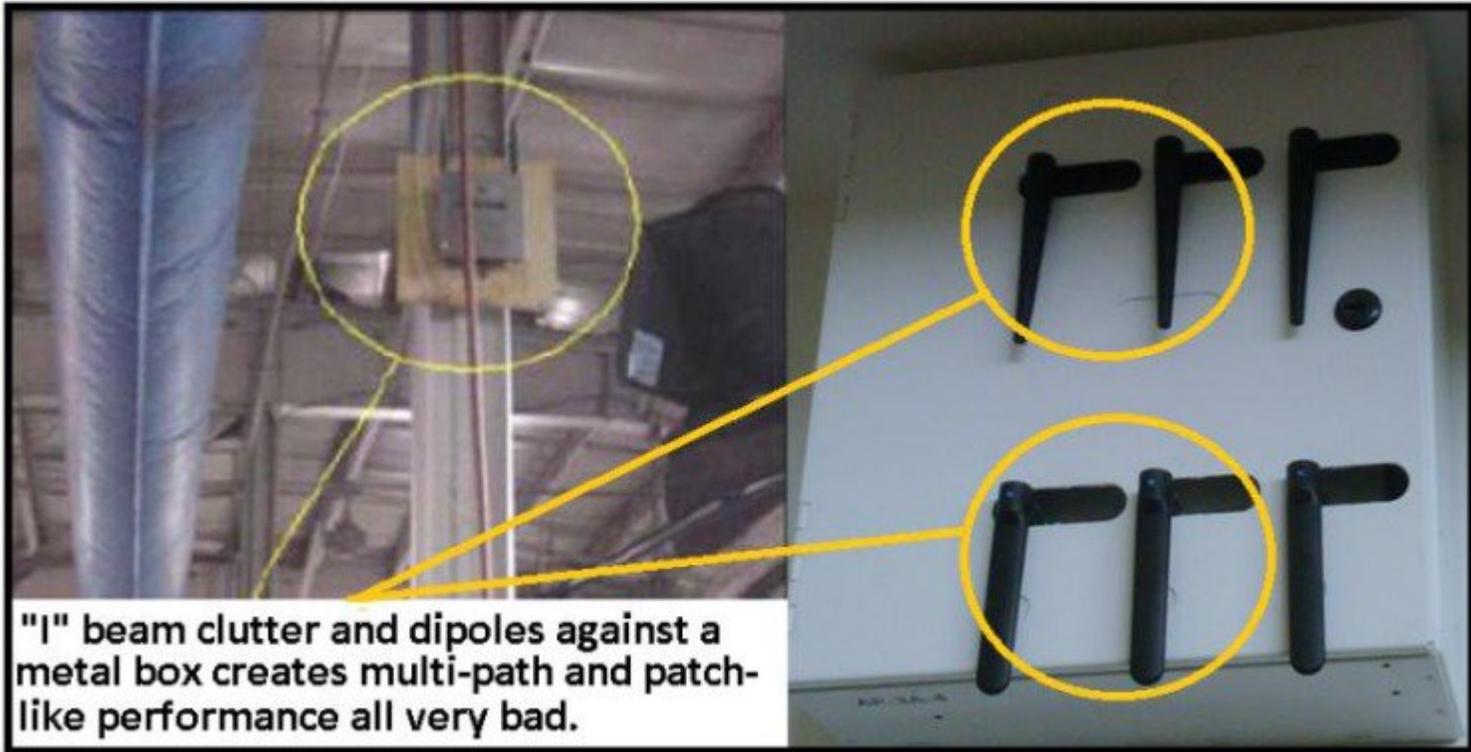
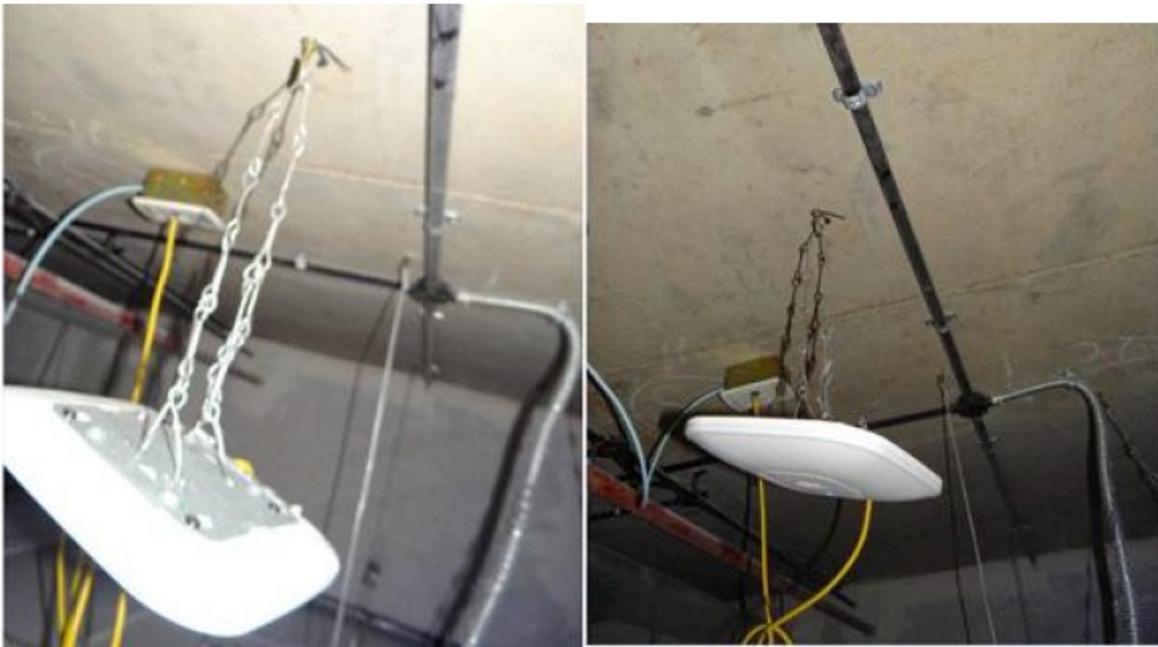


Figure 42: Example of a Poor Installation - Access Point Needs to be Level and Not Swing or Move About



When mounting devices, the AP should be level and secured so that it does not sway or move. Keep the AP away from metal objects and try to place it as close to the users as possible.

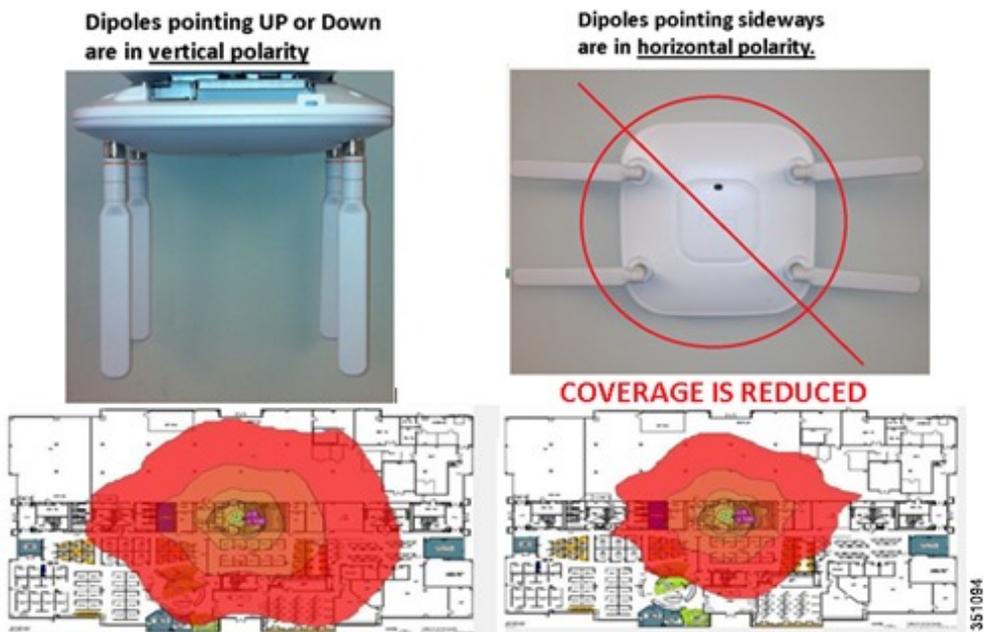
Figure 43: Example of a Poor Installation – Access Point is too High and Buried in Conductive Foil



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Remember, the best place for an AP is as close to the users as possible. Avoid metal or conductive objects in the near field (they cause the radio waves to become directional and increases nulls (dead spots)). If you must mount the AP in a high ceiling, look at directional antennas to direct (angle down) the signal to the intended target area and always mount dipoles in the correct orientation.

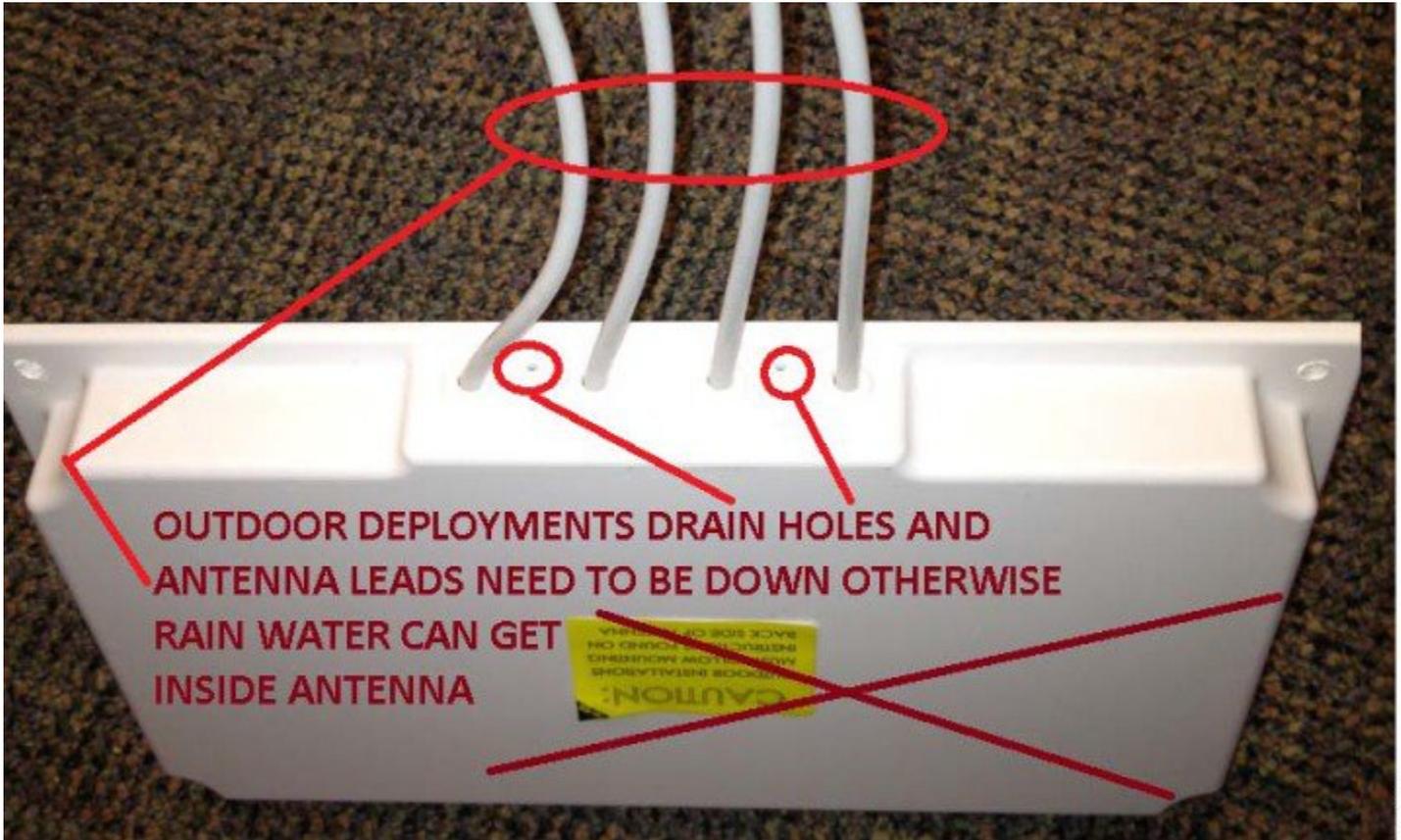
Figure 44: When Using Dipole Antennas Observe the Correct Orientation (Vertical Polarity)





Tip When mounting antennas outdoors, always mount with the WIRES DOWN and never obstruct or put weather proofing material over the drain holes.

Figure 45: Always Mount Antennas Outdoors with Leads DOWN (Indoors Does not Matter)



350126

Figure 46: If Antenna Connectors are Exposed to Weather – Coax-Seal Should be Used but if Present, Do Not Cover Antenna Drain Holes



COAX-SEAL®
The Original Connector Sealant!

Seals connections from moisture & corrosion

A must for Wi-Fi – satellite dishes – microwave work – radar and HAM radio • Forms and seals around odd-shaped and difficult fittings • Stays flexible for years • Adheres to polyvinyl and vinyl outer coax jackets • Allows for quick disconnection of fittings • Effective at temperatures from -30° to +180°F (-35° to +82°C)



WRAP

MOLD

To apply - diagonally wrap a strip of Coax-Seal over a clean, dry connection making sure to overlap as you apply. Mold to form a smooth surface and to force out air.

**EFFECTIVE
LONG LASTING
INEXPENSIVE**

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Email: sales@CoaxSeal.com
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For larger quantities visit us at: **www.CoaxSeal.com**

350127

New features

Auxiliary Ethernet Port

AP 1850 has an additional Ethernet port labeled "AUX", that is, Auxiliary port used for LAG connection to the Ethernet switch supporting LAGB or for downstream traffic. The Ethernet uplink port to the controller on the AP 1850 is labeled "PoE".

Link Aggregation for the AP 1850

Many Ethernet switches support links up to 1 Gbps throughput. However, with newer Wave-2 access points such as the AP 1850, it is possible (or at least the potential exists) that the AP traffic could exceed 1 Gbps. It is not likely to occur until MU-MIMO and 4 spatial stream Wave-2 clients become more commonplace.

To address this potential issue, we have implemented Link Aggregation into the Cisco AP 1850.

Link Aggregation is the only method to gain higher throughput on AP 1850 as it does not support multi-gigabit technologies such as NBase-T.

For more on multigigabit technology, see the following URL:

<http://www.cisco.com/c/dam/en/us/solutions/collateral/enterprise-networks/catalyst-multigigabit-switching/multigigabit-ethernet-technology.pdf>



Note It is expected that future Wave-2 access points may support multigigabit functionality.

Cisco Switches Supporting Link Aggregation

The following Cisco switching series support LAG with the AP 1850:

- Catalyst 3850 / all models (non-CA mode)
- Catalyst 3650 / all models (non-CA mode)
- Catalyst 4500/Sub-8E

Enabling link aggregation on the AP 1850

Procedure

Step 1 Enable the controller to support LAG for all APs using the command:
config ap lag-mode support enable

This will NOT result in a reset and reboot of the APs that support LAG.

To disable the LAG on all APs, use the command:

config ap lag-mode support disable

This will result in a reset and reboot of all the APs that support LAG.

Step 2 Enable LAG mode on the individual AP 1850 using the command:
config ap lag-mode support <ap-name> enable

To disable the LAG on the AP, use the command:

config ap lag-mode support <ap-name> disable

Note APs that support LAG will reset and will reboot only if the LAG state is toggled between enable and disable.

Step 3 For optimal traffic load balancing on the LAG ports to the AP and the controller, it is important that the switch support balancing is based purely on the L4 source and destination ports.
A sample configuration on the Cisco 3850 switch is shown below, where the AP 1850 is connected to G6/0/13 and G6/0/3 on the wired0(plink) and wired1 (Aux port) respectively.

```
conf t
port-channel load-balance src-dst-port
interface Port-channel1
description To AP-1850
switchport access vlan 192
switchport mode access
interface GigabitEthernet6/0/3
switchport access vlan 192
switchport mode access
channel-group 1 mode active
interface GigabitEthernet6/0/13
switchport access vlan 192
switchport mode access
channel-group 1 mode active
end
```

Step 4 The state of the LAG configuration on the controller and AP can be seen using the following commands on the controller:
show ap lag-mode

show ap config general <ap-name>

The successful formation of LAG between AP and the switch can be seen using the following commands on the switch:

show lacp neighbors

show lacp internal

Downstream Device connection for the AP 1850

The AUX port is designed to function as a downstream port. The AUX port is ideal for devices such as video cameras, projectors, IP Phones, Point of Sale terminals, and other end point devices. Also, it is designed to perform port Link Aggregation (LAG).

Additionally, this AUX port will be disabled if the AP is powered by a limited 15.4 W .3af PoE source because it requires PoE+, .3at, or local power (wall brick type power supply) to properly function.



Note The AUX port is not manageable and is simply bridged back to the controller. Avoid connecting another AP to this port or devices such as switches/hubs or the same switch or uplink as the PoE port because it can create spanning tree loop issues.

For example, if you configure the switch port (to AP 1850) as access in VLAN 5, then the traffic comes from the AUX port.

If you configure the switch port to trunk, the AP 1850 will be in the native VLAN and the AUX port will also be in native by default. Traffic from the AUX port will not be sent to the WLC, and the AP 1850's built-in switch will drop the traffic in the native VLAN.



Note This feature will not be implemented on the initial release of the code. The initial release will only support LAG.

USB Port

The USB port is not enabled in the first release of this software. This will be enabled in the later release.

Understanding Multi-User MIMO

With 802.11n, a device can transmit multiple spatial streams at once, but only directed to a single address. For individually addressed frames, only a single device (or user) gets data at a time. This is referred to as Single-User MIMO (SU-MIMO). With the advent of

802.11ac Wave-2, a new technology is defined, called Multi-User MIMO (MU-MIMO). Using this technology, an AP can use its antennas and radio systems to transmit to different clients, all at the same time over the same frequency spectrum.

Figure 47: Example of SU-MIMO



Figure 48: Example of MU-MIMO

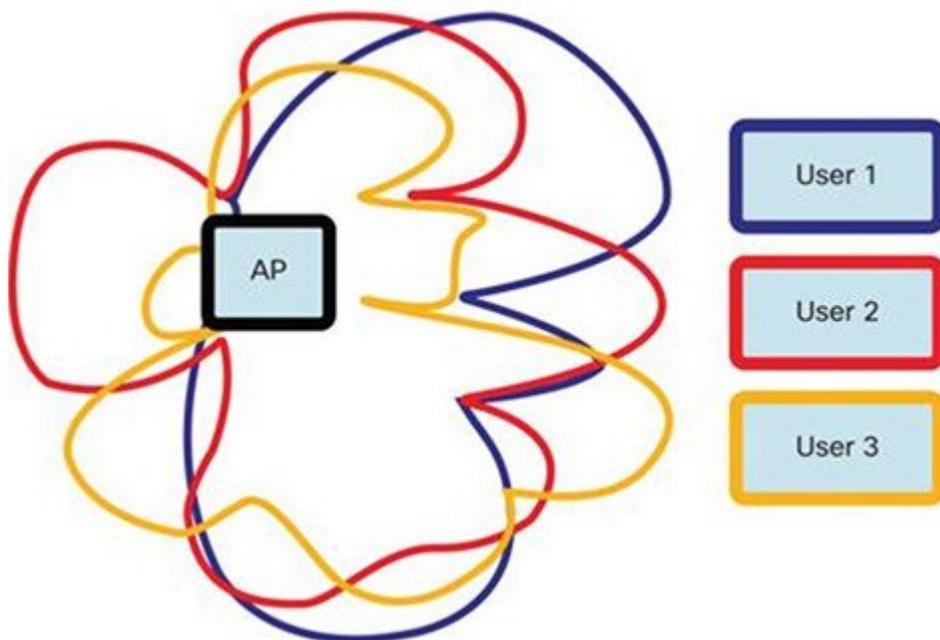


MU-MIMO with the AP 1850 is limited to a maximum of 3 spatial streams simultaneously.

To send data to user 1, the AP forms a strong beam towards user 1, shown as the top right lobe of the blue curve (Figure 49: MU-MIMO Using a Combination of Beamforming and Null Steering to Multiple Clients in Parallel, on page 53). At the same time the AP minimizes the energy for user 1 in the direction of user 2 and user 3. This is called “null steering” and is shown as the blue notches. In addition, when the AP sends data to user 2, it forms a beam towards user 2, and forms notches (nulls) towards users 1 and 3, as

shown by the red curve. The yellow curve shows a similar beam towards user 3 and nulls towards users 1 and 2. In this way, each of users 1, 2, and 3 receives a strong copy of the desired data that is only slightly degraded by interference from data for the other users.

Figure 49: MU- MIMO Using a Combination of Beamforming and Null Steering to Multiple Clients in Parallel



For all this to work properly, especially the deep nulls, the AP has to know the wireless channel from itself to all of the users very accurately. Because the channel changes over time, the AP has to keep measuring the channel, which adds overhead.

Meanwhile, the client receives its desired signal distorted by some interference from the signals intended for other users. This interference makes the highest constellations such as 256QAM infeasible within an MU-MIMO transmission.

In summary, MU-MIMO allows an AP to deliver appreciably more data to its associated clients, especially for small form-factor clients (often BYOD clients) that are limited to a single antenna. If the AP transmits to two or three clients, the effective speed increase varies from a factor of unity (no speed increase) up to a factor of two or three times, according to wireless channel conditions.

You cannot configure to use MU-MIMO, the clients will advertise this capability and the AP will put them into groups.

Elements of Multi-User MIMO

- 802.11ac MU-MIMO is similar to traditional 802.11n MIMO, except instead of one client at a time, it supports up to several clients that can all receive different data simultaneously.
- AP does pre-coding for all the clients; basically aggregating clients that advertise MU-MIMO capability into groups that participate in MU-MIMO process.
- It is an elaborate process. In MU pre-coding, when the AP is beamforming the signal, for example at 1SS or 2SS rate to a particular client, the space-time streams have to be constructed so that it also simultaneously null-steers to those space-time streams being sent to the other clients.
- All users' MPDUs are padded to the same number of OFDM symbols. The AP seeks out opportunities to send similar size packets out to the MU-MIMO clients to optimize on air time increasing throughput by sending data out to 2 – 4 clients per

transmission. The number of clients depends on the type of stream, for example one client can receive 1SS while another is receiving 2SS.

- Wi-Fi alliance certification for Wave-2 includes MU-MIMO.
- Take-away: MU-MIMO is designed to maximize downlink capacity by overlapping clients in space (multiplexing). Best performance occurs with high client counts and high AP densities.

Challenges of Multi-User MIMO

- Requires precise (CSI) channel state information to maintain deep nulls so that each MU-MIMO client can properly decode its data without too much interference from the other clients.
- MU-MIMO CSI, pre-coding group data adds overhead as does their acknowledgments and so on.
- Rate adaptation is slow – Wave-2 clients to be integrated into new laptops, tablets, and phones but this moves slowly.
- MU-MIMO is a new technology and needs to develop and mature. So, issues such as lower end clients may be sensitive to MU grouping overhead and client driver version issues.

Figure 50: Example of a MU-MIMO protocol advertisement

Looking at MU-MIMO Protocol Advertisement

You can see some of this in the VHT Capabilities Element (191)

You can check the Beacons/Probe Responses to see that the SU Beamformer and MU Beamformer bits are enabled. Also, the number of sounding dimensions needs to be non-zero and then you can check for same in the association responses.

```
VHT Capabilities element
  Element ID: 191 VHT Capabilities element [146]
  Length: 12 [147]
  VHT Capabilities Info: 000001111100000110111100110110010 [148-151]
  xx..... Reserved
  ..0..... Tx Antenna Pattern Consistency: Tx antenna pattern does not change
  ...0..... Rx Antenna Pattern Consistency: Rx antenna pattern does not change
  ....11... VHT Link Adaptation Capable: Both
  .....11 1..... Maximum AMPDU Length Exponent: 1048575
  ....0..... +HTC-VHT Capable: Not Supported
  ....0..... VHT TXOP PS: Not Supported
  ....0..... MU Beamformee Capable: Not Supported
  ....0..... MU Beamformer Capable: Not Supported
  ....011..... Number of Sounding Dimensions: 4
  ....011..... Compressed Steering Number of Beamformer Antennas Supported: 4
  ....1..... SU Beamformee Capable: Supported
  ....1..... SU Beam-former Capable: Supported
```

Checking the Access Point LEDs

Access Point Status LEDs



Note Regarding LED status colors, it is expected that there will be small variations in color intensity and hue from unit to unit. This is within the normal range of the LED manufacturer’s specifications and is not a defect.

The access point status LED indicates various conditions and are described in [Table 7: LED Status Indications](#), on page 55.

Table 7: LED Status Indications

Message Type	Status LED	Message Meaning
Boot loader status sequence	Blinking green	DRAM memory test in progress
		DRAM memory test OK
		Board initialization in progress
		Initializing FLASH file system
		FLASH memory test OK
		Initializing Ethernet
		Ethernet OK
		Starting operating system
Association status	Chirping Green	Normal operating condition, but no wireless client associated
	Green	Normal operating condition, at least one wireless client association
Operating status	Blinking amber	Software upgrade in progress
	Cycling through green, red, and amber	Discovery/join process in progress
	Rapidly cycling through red, green, amber, and off.	Access point location command invoked
	Blinking red	Ethernet link not operational

Message Type	Status LED	Message Meaning
Boot loader warnings	Blinking amber	Configuration recovery in progress (MODE button pushed for 2 to 3 seconds)
	Red	Ethernet failure or image recovery (MODE button pushed for 20 to 30 seconds)
	Blinking green	Image recovery in progress (MODE button released)
Boot loader errors	Red	DRAM memory test failure
	Blinking red and amber	FLASH file system failure
	Blinking red and off	Environment variable failure
		Bad MAC address
		Ethernet failure during image recovery
		Boot environment failure
		No Cisco image file
Boot failure		
Cisco IOS errors	Red	Software failure; try disconnecting and reconnecting unit power
	Cycling through red, green, amber, and off	General warning; insufficient inline power

Ethernet Port LEDs

Each Ethernet port has two LEDs for showing Link (Green) and Activity (Amber) statuses. They are integrated on the RJ45 connector. For a description of the statuses they indicate, see the following table.

LED	10M Link	10M Active	100M Link	100M Active	1000M Link	1000M Active
Link (Green)	Off	Off	Off	Off	On	On
Activity (Amber)	On	Blinking	On	Blinking	On	Blinking

Cisco – Addendum Differences between AP1850 and AP1830

The AP1830 is designed for cost sensitive customers who wish to deploy 802.11ac but do not require the higher client scale, throughput and advanced enterprise features found in the higher end AP1850 yet would still like to take advantage of the newer 802.11ac Wave 2 features.

Cisco Aironet 1850 & 1830 Comparison Chart	1830	1850
Number of Radios	3x3	4x4
Spatial Streams	2	4
Dual Radio	Yes	Yes
Max Data Rate (5GHz)	870 Mbps	1.7 Gbps
Max Data Rate (5GHz + 2.4GHz)	1.17 Gbps	2.22 Gbps
SU-MIMO – For Non 802.11ac Wave 2 Devices	2 Spatial Streams	4 Spatial Streams
MU-MIMO – For 802.11ac Wave 2 Devices	2 Spatial Streams	3 Spatial Streams
Gigabit Ethernet Ports (GbE)	1	2
Universal Serial Bus (USB)	1	1
Mobility Express Deployment Mode Support	Yes	Yes
Centralized Deployment Mode Support	Yes	Yes
FlexConnect Deployment Mode Support	Future	Future
Converged Access Deployment Mode Support	Future	Future
Spectrum Analysis	Future	Future
Internal Antenna Models Available	Yes	Yes
External Antenna Models Available	No	Yes

One of the advantages of the AP1830 is its low power consumption. Since it has one less Ethernet port and less radios than the AP1850 it is able to function at (15.4 Watts) IEEE 802.3af specification so it is ideal for customers who are running older switches that cannot produce higher power.

1830 Power Requirements

* This is the power required at the PSE, which is a switch or injector.

		Description	AP Functionality	PoE Budget* (Watts)	802.3af	E-PoE	802.3at PoE+ PWRINJ4
1830	PoE+ 802.3at	1850 – Out of the Box	3x3:2 on 5G & 3x3:2 on 2.4G	13.4	✓	✓	✓
	PoE 802.3af	1850 – Out of the box	3x3:2 on 5G & 3x3:2 on 2.4G	13.4	✓	n/a	n/a

The antenna patterns and physical mounting of the AP1830 are identical to the AP1850 as is most of the features such as Mobility Express, MU-MIMO (although the 1830 is limited to 2-SS) and so on.

Q & A

Q: Cisco has a newer Power Injector (AIR-PWR-INJ5). Can I use this with the AP 1850?

A: The newer AIR-PWR-INJ5 is a low cost injector for use with the AP 1600 and AP 2600 series products. It is an 802.3af (15.4 W injector) and will power the AP 1850 at reduced functionality. It is recommended to use AIR-PWR-INJ4, which is a 30 W injector, as the AP 1850 draws roughly 20 W for full functionality.

Q: Can industrial wireless motion or smoke detectors cause WLAN interference?

A: Yes, some products such as United Technologies DD475 and Optex MX-50 operate in the 2.4 GHz band as do other wireless chimes, cameras, and other industrial equipment from other manufacturers.

Q: What if I am in a country where the regulatory agency may not approve the AP to be used outdoors because of UNII-1 band restrictions or if I wish to use higher gain antennas?

A: Consider deploying the Cisco Mesh products (1570, 1550, and 1530 series) or look for access points ending in "P" for professional install, such as the 3602P and 3702P series.

Q: Any other thoughts when installing wireless APs?

A: When installing wireless APs, consider the following:

- Place the APs as reasonably close to the actual users as possible.
- Make sure that you have coverage (to a known requirement) and compensate for nulls or dead spots regardless of what product you choose to deploy. This is called a site survey.
- Installations should be done based on lessons learned from the site survey. The better the survey the less likely any connectivity problems will occur.
- Cisco has an advanced services team that can perform WLAN surveys or help with the wireless design if a partner is not available or able to do the same.
- When possible, use Cisco brand antennas listed in this document (with the orange band).
- Do not mount antennas against metal objects. Similar to a light bulb, antennas work best when there are no obstructions in the path.
- AP 1600, 1700, 1850, 2600, 2700, 3600, and 3700 are not weatherproof and have an IP rating of 40.

References

AP 1850 Product Page and Datasheet

<http://www.cisco.com/go/ap1850>

AP 3700 Datasheet

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps13367/data_sheet_c78-729421.html

AP and Controller Datasheets

<http://www.cisco.com/en/US/products/hw/wireless/index.html>

Cisco Antenna Reference Guide

http://www.cisco.com/c/en/us/products/collateral/wireless/aironet-antennas-accessories/product_data_sheet09186a008008883b.html

Why Buy Cisco Brand Antennas

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/white_paper_c11-671769.pdf

Understanding Antenna Patterns and their Meaning

http://www.cisco.com/en/US/prod/collateral/wireless/ps7183/ps469/prod_white_paper0900aecd806a1a3e.html

Cisco Guest Access Deployment Guide

http://www.cisco.com/en/US/docs/wireless/technology/guest_access/technical/reference/4.1/GAccess_41.html

Cisco Schools WLAN Deployment Guide

http://www.cisco.com/en/US/docs/solutions/Verticals/Education/SRA_Schools/schoolSRA_wlan_sba.pdf

The Apple Bonjour/Apple TV Deployment Guide

http://www.cisco.com/en/US/partner/products/hw/wireless/ps4570/products_tech_note09186a0080bb1d7c.shtml

Optimizing Enterprise Video over Wireless LAN

http://www.cisco.com/en/US/prod/collateral/wireless/ps6302/ps8322/ps10315/ps10325/white_paper_c11-577721.html

Cisco 7925 IP Phone Deployment Guide

http://www.cisco.com/en/US/docs/voice_ip_comm/cuipph/7925g/7_0/english/deployment/guide/7925dply.pdf

Cisco Mobility Services Engine – WLAN Location Deployment Guide

http://www.cisco.com/en/US/products/ps9742/products_tech_note09186a00809d1529.shtml

WLAN Design Guide for High Density Client Environments in Higher Education

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/design_guide_c07-693245.pdf

Mobility Design Guides

http://www.cisco.com/en/US/netsol/ns820/networking_solutions_program_home.html

Software Support and Downloads

<http://www.cisco.com/tac>

New Generation of Cisco Aironet Access Points

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/at_a_glance_c45-636090.pdf

802.11ac Customer Use Cases

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps13367/at_a_glance_c45-729588.pdf

Adaptive Radio Modules

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps11983/at_a_glance_c45-727334.pdf

New Generation of Cisco Aironet Access Points

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/at_a_glance_c45-636090.pdf

802.11ac Wave-1 Module Datasheet

http://www.cisco.com/en/US/prod/collateral/modules/ps12859/ps13128/data_sheet_c78-727794.html

802.11ac – The Fifth Generation Wi-Fi Technical Whitepaper

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps11983/white_paper_c11-713103_ps12859_Products_White_Paper.html

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