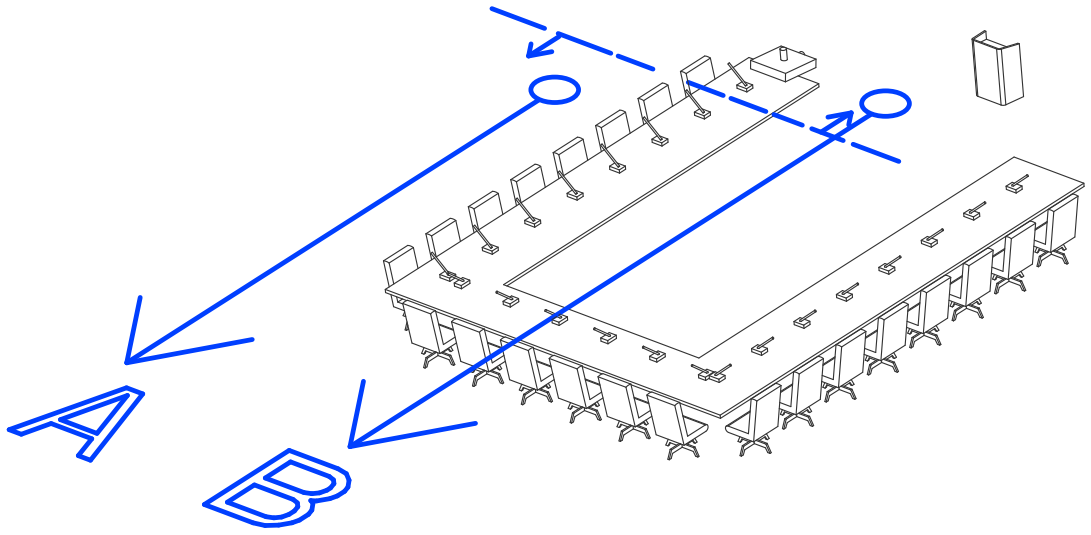
SACOM™

Mission-Critical Audio™

Wireless Microphone

Antenna Application Guide



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DIGITAL SPECTRUM SERIES
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SACOM™ Extension Antennas Application Guide

SACOM's digital technology supports much larger microphone systems than is possible with analog technology. It should be noted that marginal antenna designs may work well with smaller systems, but they can cause hits and dropout as the channel counts go up. On the other hand, a well designed antenna system delivers excellent performance with both big and small systems. SACOM™ engineers are on hand to share their expertise by offering free antenna system designs for both your large and small systems. Contact CustomerService@SacomUSA. com for details (4).

SACOM™ engineers rely on following these design criteria:

Design Goal: Keep the power level of all the microphones between -40 and -60 dBm all of the time to prevent hits and dropouts.

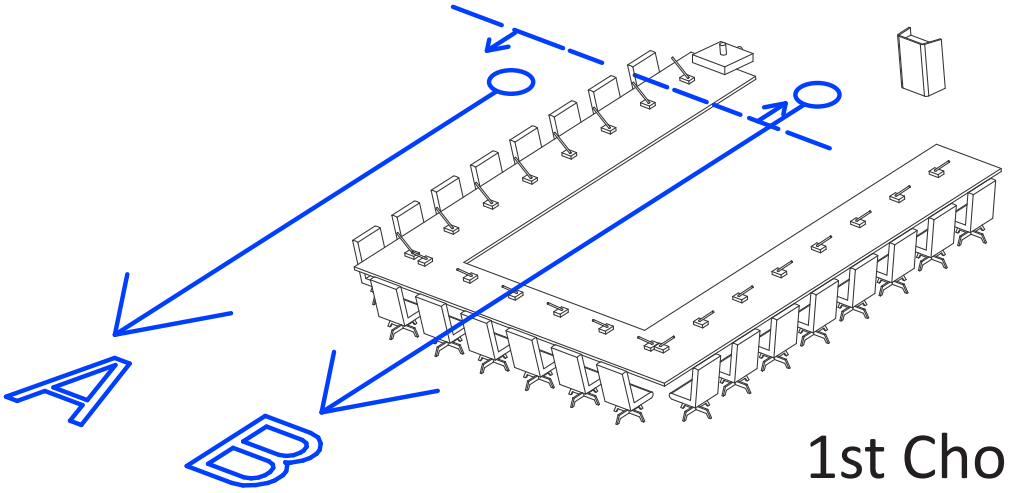
Design Rules:

- **Rule 1: Intermodulation Distortion(1)** The distance to the most distant transmitter should not be more than double the distance to the closest transmitter.
- **Rule 2: Diversity(2)** The antennas should be separated so that the ends of the transmitter antenna (the null) cannot be aimed at both antennas at the same time. The antennas should be co-located with the optimal separation distance of 12ft apart. (The recommended minimum separation distance is 6ft and the maximum separation distance is 30ft).
- **Rule 3: Line of Sight** All transmitters should remain in the line of sight of both antennas. Line of sight means all transmitters are not blocked by metal, concrete, and similar radio opaque objects, and there is minimal signal absorption through people's bodies.
- **Rule 4: Cable Loss** The total antenna cable loss should be less than 15 dB.
- **Rule 5: Range Loss** Doubling the distance between a transmitter and an antenna cuts the signal strength by a factor of 4 (inverse square law). Keep the antennas as close to the performance space as practical without violating Rule 1.
- **Rule 6: Transmitter Power(5)** Adjust the transmitter power to meet the -40 to -60 dBm rating.

The following case studies show how these rules may be applied in several common configurations:

Case I:
Flexible Configurations Conference Room

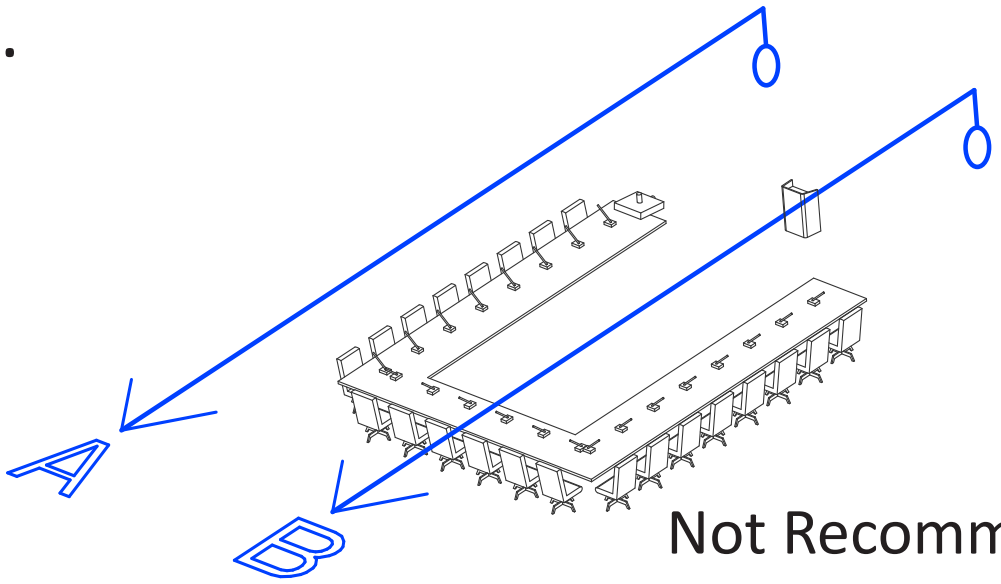
A.



1st Choice

Factor	Antennas In Drop Ceiling
IMD	All of the transmitters are about the same distance to the closest antenna. The IMD product is small compared to the transmitter signal. It meets the design rule.
Diversity	The antennas are separated so at least one antenna is always out of the null. This meets the design rule.
Line of Sight	All transmitters are in the line of sight of both antennas. This meets the design rule.
Cable Loss	This configuration requires a shorter antenna run to the rack. It meets the design rule.
Range Loss	All transmitters are close to at least one antenna and have about the same gain. It meets the design rule.
Transmitter Power	The setup is ideal, so set the power to 1mW for extended battery life and minimal interference with systems in near-by rooms.
Rating	**Expect excellent performance in all room configurations.**

B.

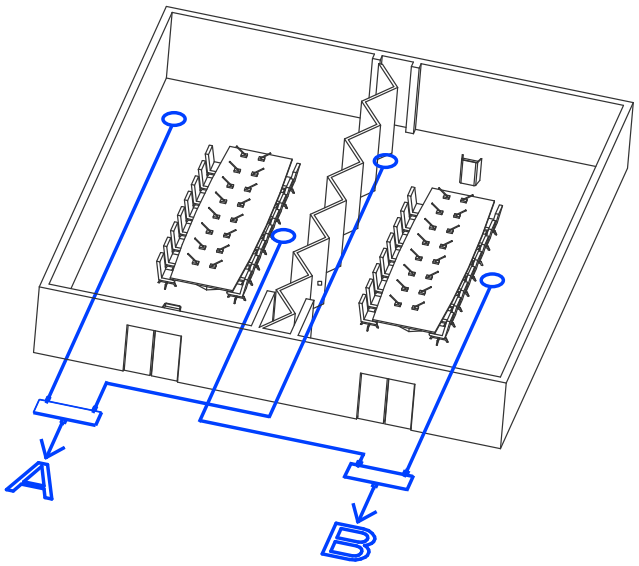


Not Recommended

Factor	Antennas On Back (or Front) Wall
IMD	**The IMD from the transmitters close to the antennas can interfere with transmitters away from the antennas. Expect dropout and hits with large numbers of transmitters.**
Diversity	The antennas are separated so at least one antenna is always out of the null. This meets the design rule.
Line of Sight	All transmitters are in the line of sight of both antennas, provided the antennas are high on the wall and not blocked by bodies. This meets the design rule.
Cable Loss	Long cable runs require expensive RG8 low-loss cable but it will meet the design rule.
Range Loss	Transmitters away from the antennas have approximate 3 dB less gain than the close transmitters, but it meets the design rule.
Transmitter Power	Use 10 mW output power to assure pick-up of the far transmitters.
Rating	**This design is prone to dropouts and hits with large numbers or transmitters.**

Case II:
Split Flexible Configurations Conference Room

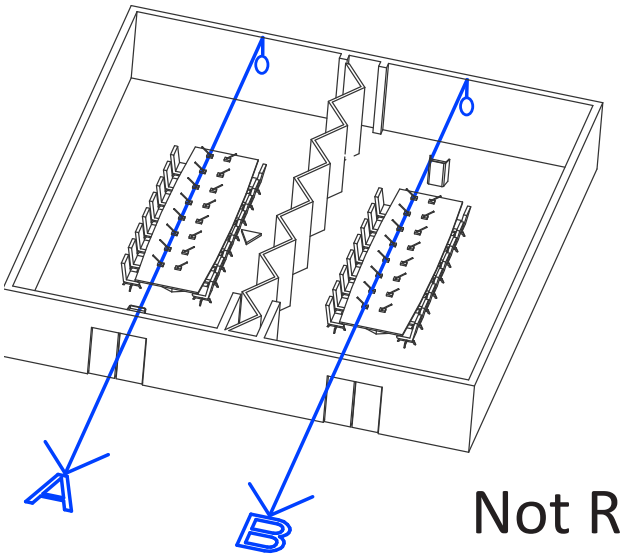
A.



1st Choice

Factor	4 Antennas In Drop Ceiling
IMD	All of the transmitters are about the same distance to the closest antenna. The IMD product is small compared to the transmitter signal. It meets the design rule.
Diversity	The antennas are separated so at least one antenna is always out of the null. This meets the design rule.
Line of Sight	All transmitters are in the line of sight of both antennas. It meets the design rule.
Cable Loss	Antenna combiners add 3 dB loss. Make sure the total loss in each run is less than 15 dB to meet the design rule.
Range Loss	All transmitters are close to at least one antenna and have about the same gain. This meets the design rule.
Transmit Power	The setup is ideal, so set the power to 1mW for extended battery life and minimal interference with systems in near-by rooms.
Rating	**Expect excellent performance open or closed.**

B.

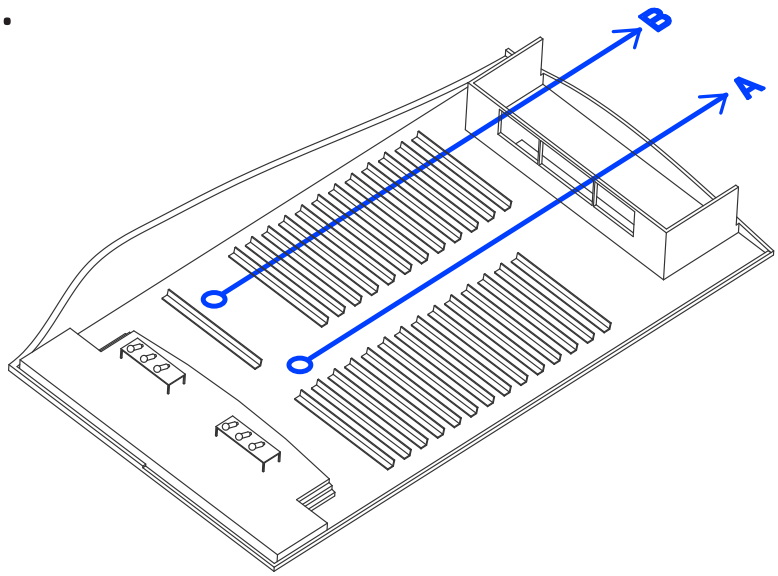


Not Recommended

Factor	2 Antennas On Back (or Front) Wall
IMD	**The IMD from the transmitters close to the antennas can interfere with transmitters away from the antennas. Expect dropout and hits.**
Diversity	**Dividers often have metal cores which are radio opaque. Diversity is defeated when there is only one antenna in a room. Expect dropout and hits when the room is divided.**
Line of Sight	No transmitter is in the line of sight of both antennas when the room is divided. It does not meet the design criterion.
Cable Loss	Long cable runs require expensive RG8 low-loss cable. Make sure the loss on each side is less than 15 dB.
Range Loss	Use low-loss cable for long runs. Make sure the loss on each side is less than 15 dB.
Transmit Power	Use 10 mW output power to assure pick-up of the far transmitters.
Rating	**This system is prone to dropouts and hits open or closed.**

Case III:
Small Auditorium or Church

A.

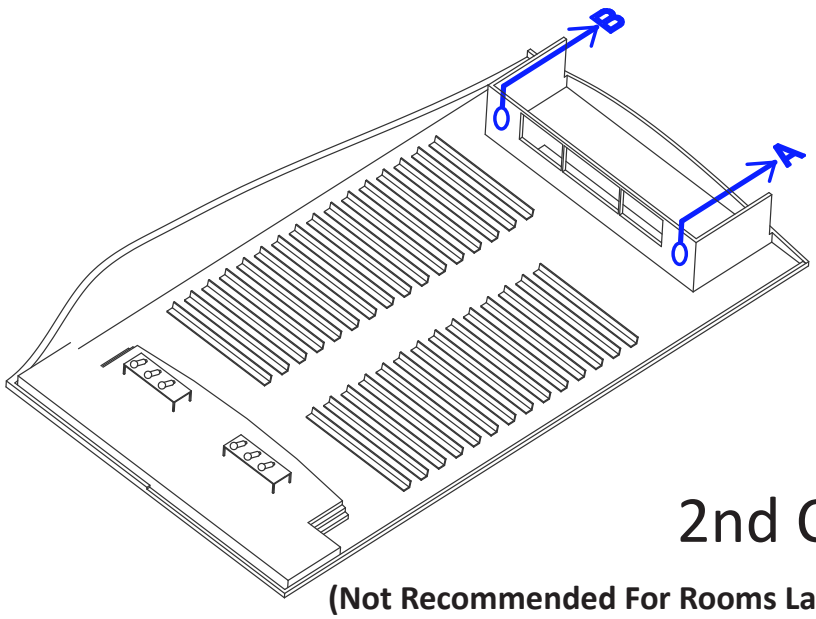


1st Choice

Factor	2 Antennas In Drop Ceiling
IMD	All of the transmitters are about the same distance to the closest antenna. The IMD product is small compared to the transmitter signal. This meets the design rule.
Diversity	The antennas are separated so at least one antenna is always out of the null. This meets the design rule..
Line of Sight	All transmitters are in the line of sight of both antennas. This meets the design rule.
Cable Loss	Use low loss cable to assure total loss in each run is less than 15 dB to meet the design rule.
Range Loss	All transmitters are close to at least one antenna and have about the same gain to meet the design rule.
Transmit Power	The setup is ideal, so set the power to 1mW for extended battery life and minimal interference with systems in near-by rooms.
Rating	**Expect excellent performance with small and large channel counts.**

Case III: (continued)
Small Auditorium or Church

B.

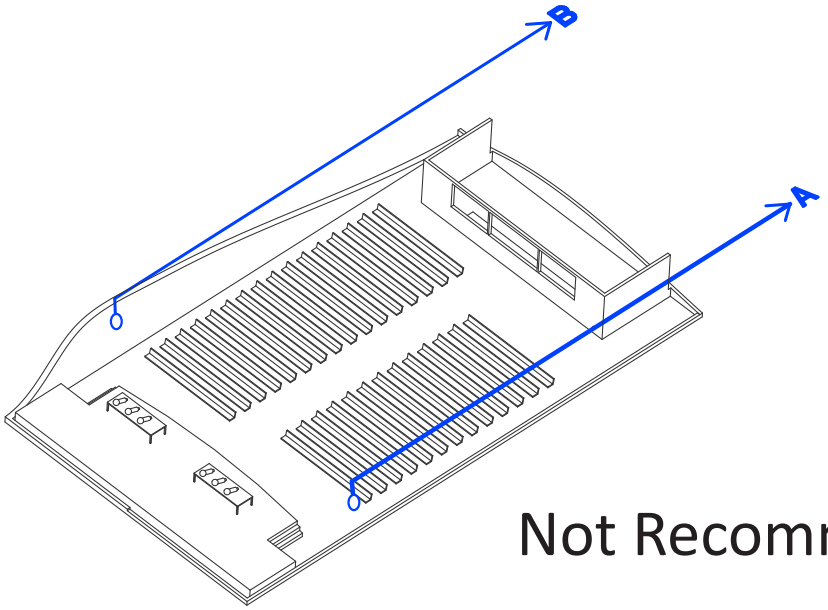


2nd Choice

(Not Recommended For Rooms Larger Than 50'x50')

Factor	2 Antennas On Back Wall
IMD	All of the transmitters are about the same distance to the closest antenna. The IMD product is small compared to the transmitter signal. This meets the design rule.
Diversity	The antennas are separated so at least one antenna is always out of the null. This meets the design rule.
Line of Sight	Place the antennas over the audience to keep the line of sight for both antennas. This meets the design rule.
Cable Loss	Short antenna lengths reduce loss and cost. Use low loss cable to assure total loss in each run is less than 15 dB.
Range Loss	All transmitters are far from the antennas, but within range. It meets the design rule.
Transmit Power	Use 25 mW to overcome range loss.
Rating	**Expect excellent performance with small and large channel counts.**

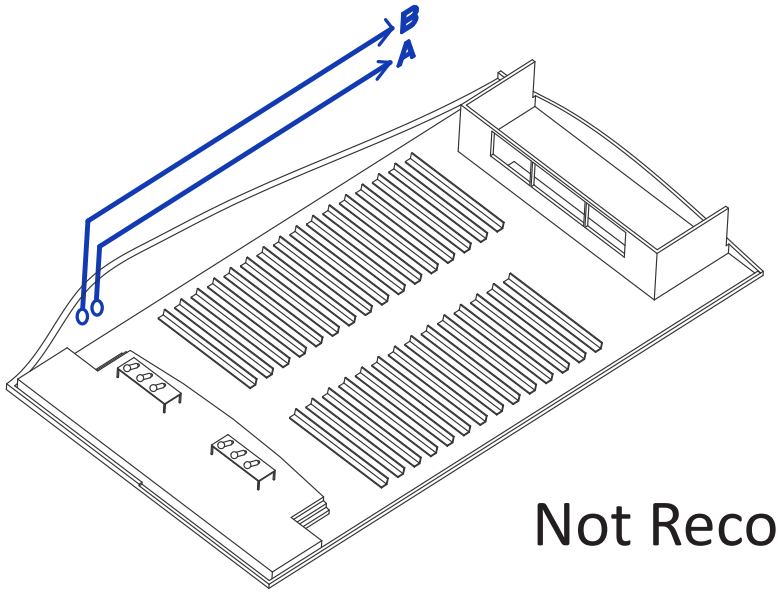
C.



Not Recommended

Factor	2 Antennas On Opposing Walls
IMD	All of the transmitters are about the same distance to the closest antenna. The IMD product is small compared to the transmitter signal.
Diversity	**Antenna separation is greater than 30ft. The antennas are too far apart to maintain a good RF signal on both antennas simultaneously. Antennas are not co-located. Does not meet the design rule.**
Line of Sight	All transmitters are in the line of sight of both antennas, provided the antennas are high on the wall and not blocked by bodies.
Cable Loss	Use low-loss cable to assure total loss in each run is less than 15 dB.
Range Loss	All transmitters are close to the antennas.
Transmit Power	Use 10 mW (or 25 mW) output power to assure pick-up through Presenter's bodies and stage obstacles.
Rating	**Dropouts can occur because there is no transition time for antenna "A" to take over for antenna "B" when a multipath null hits .**

D.



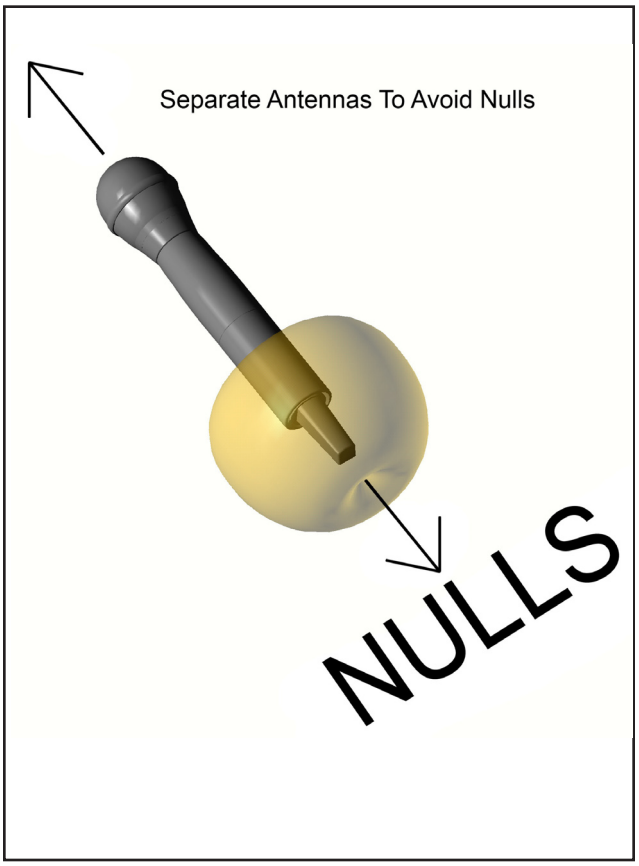
Not Recommended

Factor	2 Antennas On Side Wall (or Rack Mounted w/ Dipoles)
IMD	**The IMD from the transmitters close to the antennas can interfere with transmitters away from the antennas. Expect dropout and hits.**
Diversity	**Diversity is defeated when the antennas are too close together. Expect dropouts when the transmitter antenna null points at the antennas.**
Line of Sight	All transmitters are in the line of sight of both antennas but blocked by bodies.
Cable Loss	Use low-loss cable to assure total loss in each run is less than 15 dB.
Range Loss	The far transmitters have less gain than close transmitters.
Transmit Power	Use 10 - 25 mW output power to assure pick-up of the far transmitters.
Rating	**This system is prone to dropouts and hits with large numbers of transmitters.**

Appendix

(1) Intermodulation Distortion Interference (IMD)

Two or more transmitters operating in close proximity produce low-level, side-band frequencies called IMD. These sideband frequencies can interfere with other microphones that normally operate on the same side-band frequencies, but only when the IMD signal strength is comparable to the transmitter's signal strength. This can happen when the interfering transmitters are in close proximity to the antennas while the interfered transmitter is far away.



Case III - D above is a typical example. Microphones four feet away from the antennas on stage left will have a signal (and corresponding IMD) that is 64 times greater than the signal from a transmitter that is 32 feet away on stage right by the inverse-square law. In this case, the IMD signal will cause dropouts and hits.

The science of IMD control is to arrange the antennas so that all of the transmitters are about the same distance away from an extension antenna. A good rule of thumb is to divide the distance between the transmitters located closest to an antenna and farthest from an antenna. The result should be a number between 1 and 2. It may seem counter-intuitive to move the antennas away from the performance area to reduce dropouts, but Case III C will have less IMD interference than Case III D.

In addition, SACOM's digital wireless transmission method uses numerical techniques that make them far less prone to IMD interference than is possible with analog systems. That is one reason SACOM™ arrays can be much larger than is possible with analog systems.

(2) Diversity

Transmitter antennas radiate power in a toroid-shaped (donut) pattern. Very little energy radiates out the ends of the transmitters. Separate the antennas sufficiently so at least one receives a strong signal The antennas should be co-located with the optimal separation distance of 12ft apart. (The recommended minimum separation distance is 6ft and the maximum separation distance is 30ft).

(3) Dipole Antennas:

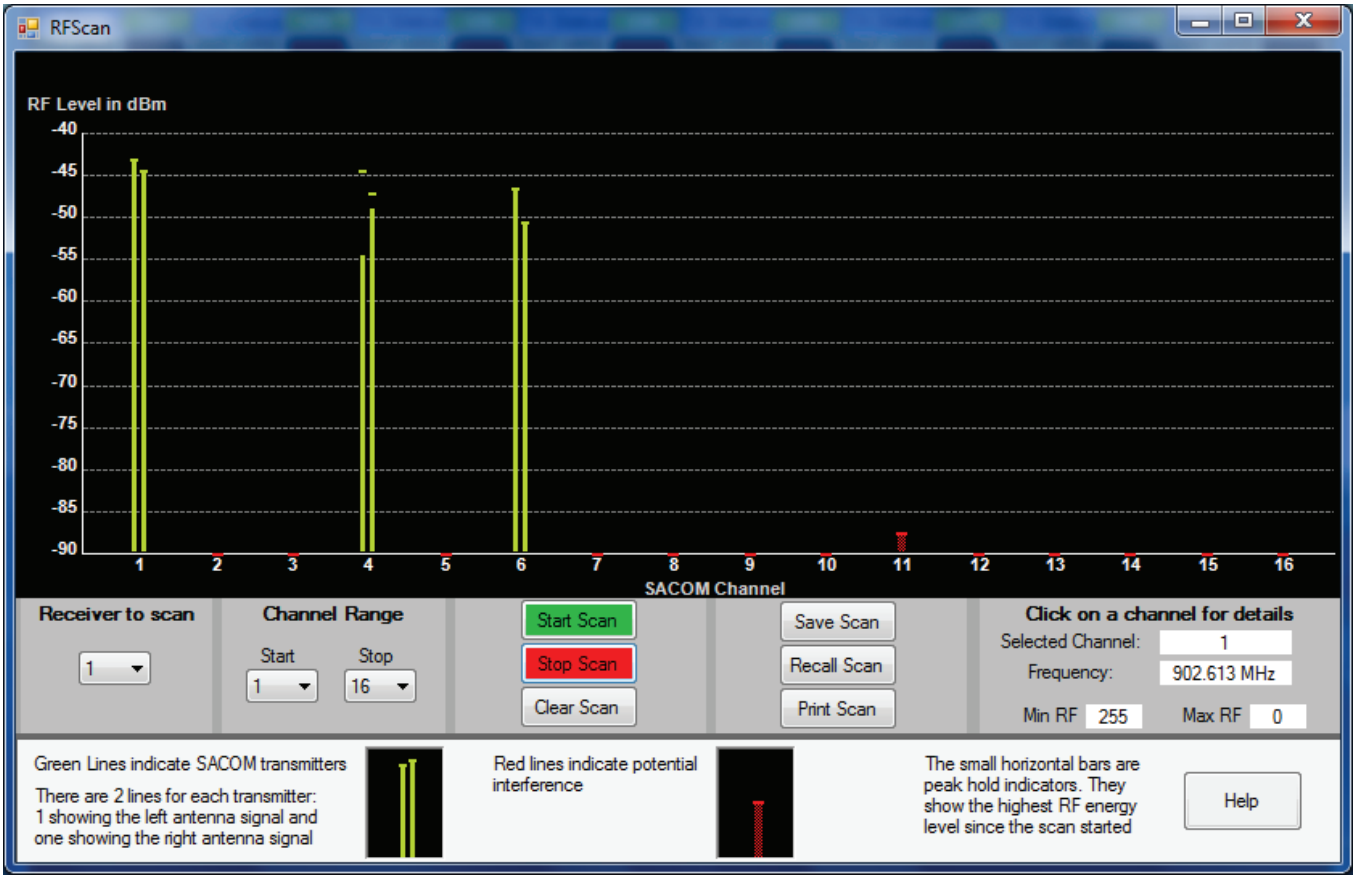
SACOM™ systems are shipped with dipole (rabbit ear) antennas, but they are only recommended with small systems and only when they are in the line of sight. They provide only a minimal diversity. SACOM™ recommends extension antennas whenever possible.

(4) Free Antenna Design:

SACOM™ offers free extension antenna design and offers complete antenna hardware kits custom made for your project. The kits include extension antennas, tested antenna cables with proper terminations, and antenna combiners if required. Your marked up shop drawings are included that show where the antennas should be located for optimal performance. The goal of extension antenna kits is to take all of the guesswork out of one of the most challenging and critical aspects of a wireless microphone installation so your job is completed on time and within budget.

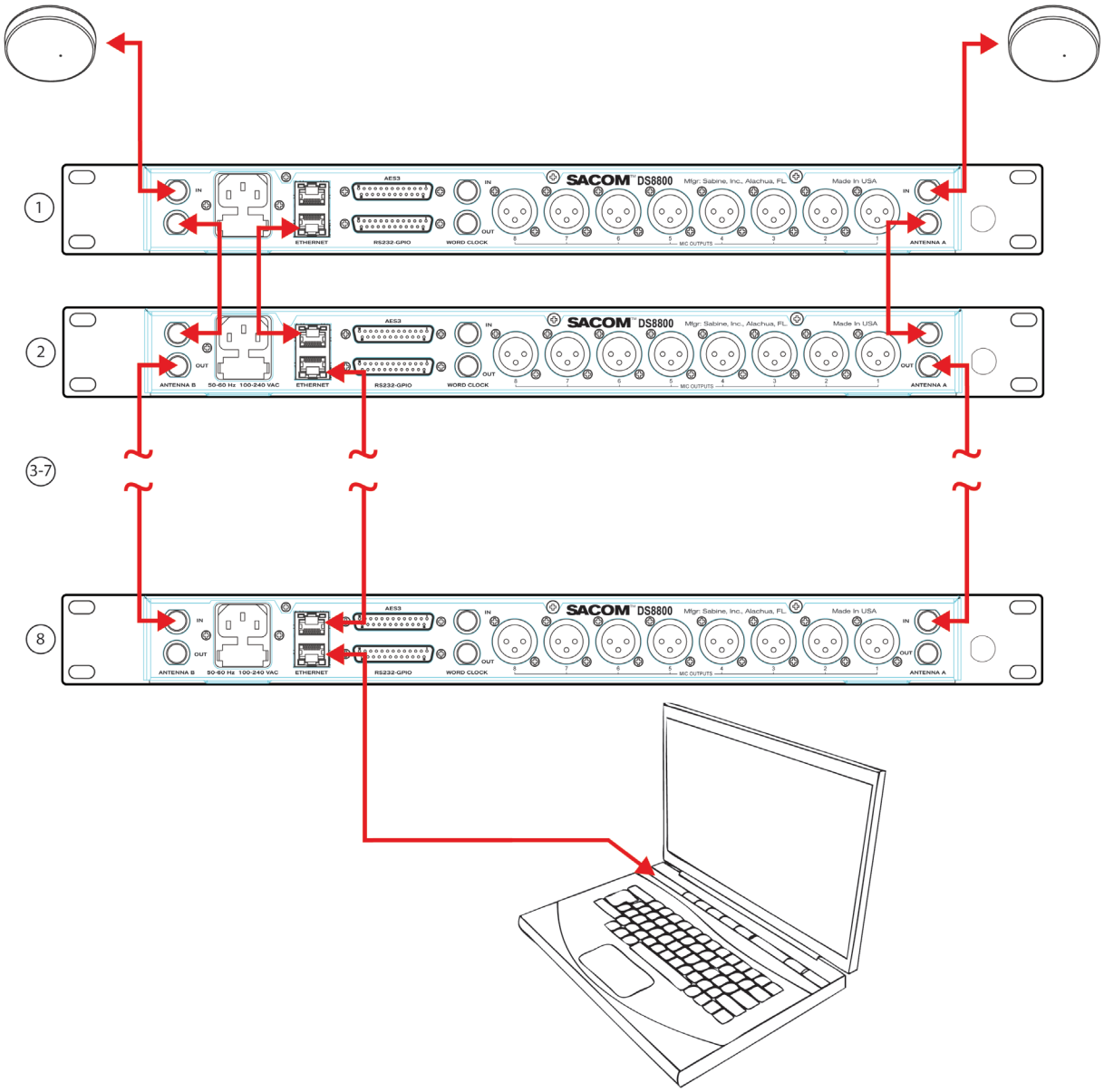
(5) RF Scan: Antenna Power Measument

Run the SACOM™ Remote software RF Scanner to verify the antennas and cables are working correctly. Each transmitter is represented by two green lines, one for each antenna. The received power from at least one antenna should always be between -40 and -60 dBm.

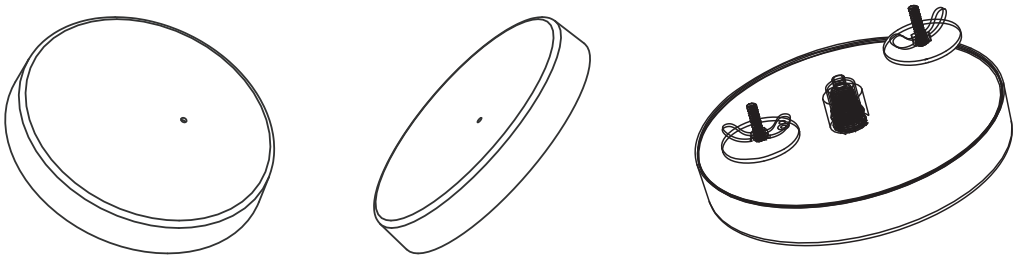


(6) Built-in antenna distribution

Daisy-chain up to 32 channels and connect to a pair of extension antennas



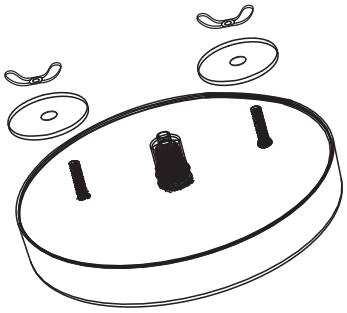
Antenna Mounting Instructions:



Ceiling-tile Mounting

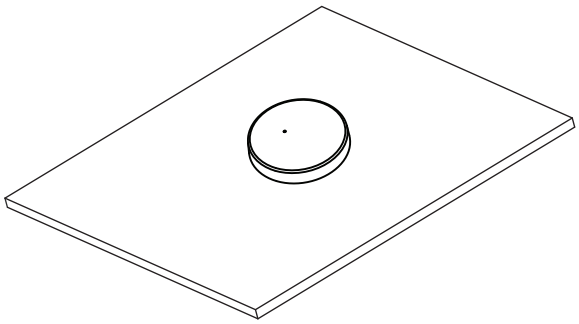
Tools needed:

1) Drill
2) 1/8” drill bit
3) 9/16” drill bit

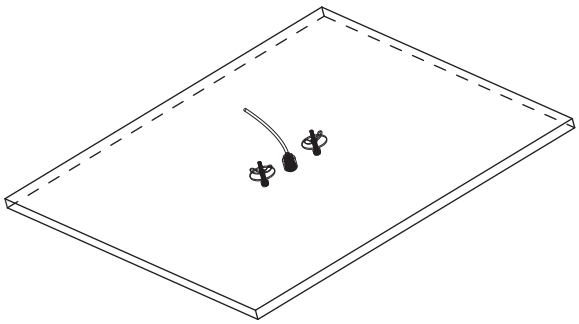


1 Unscrew the two wing-nuts on the underside of the antenna assembly and remove the washers.

2 Center the antenna on the room-facing-side of the ceiling tile and press down slightly to mark the holes. Drill holes using 1/8” bit. Place the antenna on the tile again and press to mark the center, antenna cable hole. Drill using a 9/16” bit.

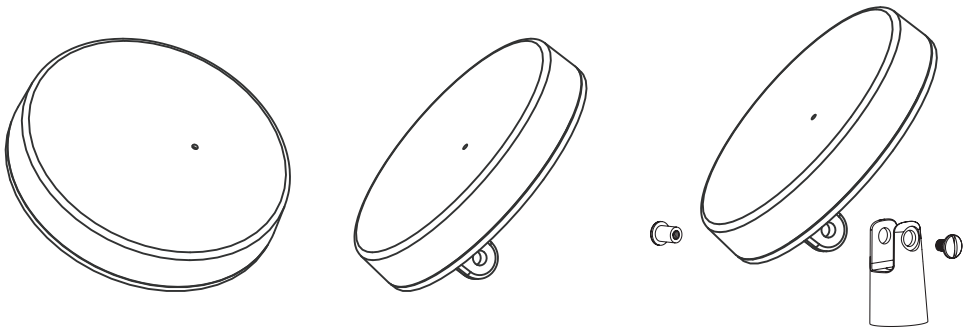


3 Push the antenna cable through the back of the tile and screw it into the antenna. Install the antenna on the room-facing-side of the ceiling tile. Turn the ceiling tile over and attach the washers and wing-nuts. Tighten gently until the antenna is securely fastened to the tile.



4 Replace the ceiling tile in the ceiling.

Mounting Instructions For Mic Stands

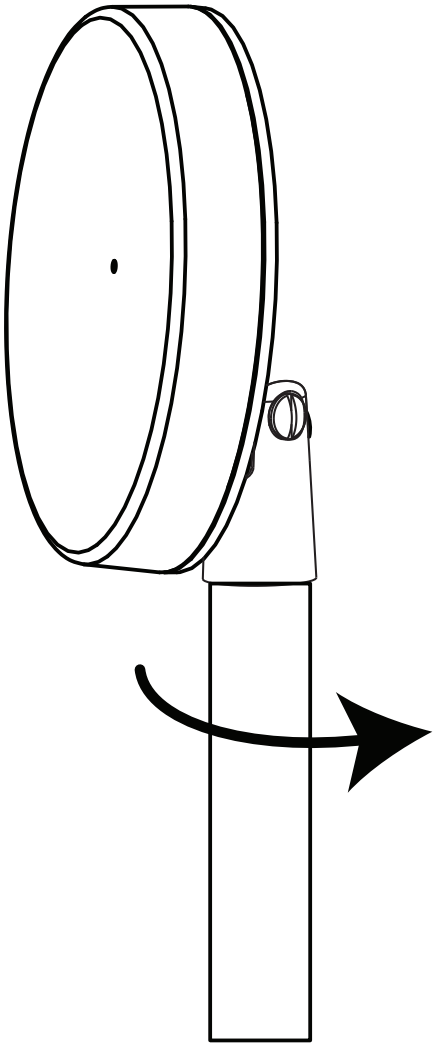


Microphone Stand Mounting

No tools needed.

1 Screw the antenna assembly, with the mic stand connector, onto the mic stand.

2 Position antennas according to the rules in the case studies in this application guide. Do not daisy-chain extension antennas together in series.



Extension Antenna Cables

Government regulations severely limit the output power of wireless microphones. For a comparison, mobile phones connect to towers miles away, but wireless microphones barely reach 300 feet line-of-sight. A mobile phone is similar to a lighthouse that shines to the horizon, while a wireless microphone is like a penlight that barely casts a shadow on the far side of a dark auditorium. Microphone power limitations make extension antennas systems a critical component of every mission-critical wireless microphone system, and coax cables are a critical part of every antenna system. There is no room for error.

SACOM provides antenna kits that includes the extension antennas and the cables. The cables are cut to length, properly terminated, and individually tested at SACOM operating frequencies. SACOM also provides extension antennas without cables, but it should be noted that we have found serious errors in the spec sheets published by two of the industry's largest and best know cable suppliers. Had our clients purchased and installed these cables, their microphone systems would have never worked properly, and the antenna cables may have never been identified as the cause. This is why SACOM cannot guarantee our systems unless we make the cables or unless our clients install approved cables. Contact CustomerService@SacomUSA.com for details.

Plenum Rated Cables have a special coating (usually Teflon) that does not give off toxic gasses and smoke when it burns. Some building codes require plenum-rated cables, but longer plenum cables are considerably more expensive than standard cables. Kits with longer cables are available with plenum or standard cables.

SACOM Systems requires 50 Ohm Coax Cable with a total line loss less than 15 dB at 900 MHz.

SACOM Part Number	Length (Ft)	Fire Rating	Diameter (in)	Flex Min. Radius	Exposure	loss at 900 MHz (dB)
Antenna Ext Kit - RG58 - Plenum						
DSA-EXT-C-KIT(25)-RG58P-M915	25	Plenum	0.108	2.0”	Indoor	5
DSA-EXT-C-KIT(50)-RG58P-M915	50	Plenum	0.108	2.0”	Indoor	9
DSA-EXT-C-KIT(75)-RG58P-M915	75	Plenum	0.108	2.0”	Indoor	13
Antenna Ext Kit - RG8 - Plenum						
DSA-EXT-C-KIT(25)-RG8P-M915	25	Plenum	0.28	3.5”	Indoor	3
DSA-EXT-C-KIT(50)-RG8P-M915	50	Plenum	0.28	3.5”	Indoor	4
DSA-EXT-C-KIT(75)-RG8P-M915	75	Plenum	0.28	3.5”	Indoor	6
DSA-EXT-C-KIT(100)-RG8P-M915	100	Plenum	0.28	3.5”	Indoor	7
DSA-EXT-C-KIT(125)-RG8P-M915	125	Plenum	0.28	3.5”	Indoor	9
DSA-EXT-C-KIT(150)-RG8P-M915	150	Plenum	0.28	3.5”	Indoor	10
DSA-EXT-C-KIT(175)-RG8P-M915	175	Plenum	0.28	3.5”	Indoor	12
Antennas Without Cables						
DSA-EXT-C-M915	Pair of ceiling mount antennas without cables					
DSA-EXT-M-M915	Pair of mic-stand mount antennas without cables					

Contact CustomerService@SacomUSA.com for longer lengths or outdoor-rated cables.

Cables Continued

SACOM Part Number	Length (Ft)	Fire Rating	Diameter (in)	Flex Min. Radius	Exposure	loss at 900 MHz (dB)
Antenna Ext Kit - LMR400 - Non-Plenum						
DSA-EXT-C-KIT(25)-LMR400NP-M915	25	Non Plenum	.405	1.0”	Indoor/outdoor	1
DSA-EXT-C-KIT(50)-LMR400NP-M915	50	Non Plenum	.405	1.0”	Indoor/outdoor	2
DSA-EXT-C-KIT(75)-LMR400NP-M915	75	Non Plenum	.405	1.0”	Indoor/outdoor	3
DSA-EXT-C-KIT(100)-LMR400NP-M915	100	Non Plenum	.405	1.0”	Indoor/outdoor	4
DSA-EXT-C-KIT(125)-LMR400NP-M915	125	Non Plenum	.405	1.0”	Indoor/outdoor	5
DSA-EXT-C-KIT(150)-LMR400NP-M915	150	Non Plenum	.405	1.0”	Indoor/outdoor	6
DSA-EXT-C-KIT(175)-LMR400NP-M915	175	Non Plenum	.405	1.0”	Indoor/outdoor	7
DSA-EXT-C-KIT(200)-LMR400NP-M915	200	Non Plenum	.405	1.0”	Indoor/outdoor	8
DSA-EXT-C-KIT(225)-LMR400NP-M915	225	Non Plenum	.405	1.0”	Indoor/outdoor	9
DSA-EXT-C-KIT(250)-LMR400NP-M915	250	Non Plenum	.405	1.0”	Indoor/outdoor	10
DSA-EXT-C-KIT(275)-LMR400NP-M915	275	Non Plenum	.405	1.0”	Indoor/outdoor	11
DSA-EXT-C-KIT(300)-LMR400NP-M915	300	Non Plenum	.405	1.0”	Indoor/outdoor	12
Cable w/ TNC Connectors - RG58-Plenum						
DSA-Cable(10)-RG58P	10	Plenum	0.108	2.0”	Indoor	1
DSA-Cable(25)-RG58P	25	Plenum	0.108	2.0”	Indoor	5
DSA-Cable(50)-RG58P	50	Plenum	0.108	2.0”	Indoor	9
DSA-Cable(75)-RG58P	75	Plenum	0.108	2.0”	Indoor	13
Cable w/ TNC Connectors - RG8-Plenum						
DSA-Cable(10)-RG8P	10	Plenum	0.28	3.5”	Indoor	1
DSA-Cable(25)-RG8P	25	Plenum	0.28	3.5”	Indoor	2
DSA-Cable(50)-RG8P	50	Plenum	0.28	3.5”	Indoor	4
DSA-Cable(75)-RG8P	75	Plenum	0.28	3.5”	Indoor	6
DSA-Cable(100)-RG8P	100	Plenum	0.28	3.5”	Indoor	7
Cable w/ TNC Connectors - LMR400-Non-Plenum						
DSA-Cable(10)-LMR400NP	10	Non Plenum	.405	1.0”	Indoor/outdoor	.5
DSA-Cable(25)-LMR400NP	25	Non Plenum	.405	1.0”	Indoor/outdoor	1
DSA-Cable(50)-LMR400NP	50	Non Plenum	.405	1.0”	Indoor/outdoor	2
DSA-Cable(75)-LMR400NP	75	Non Plenum	.405	1.0”	Indoor/outdoor	3
DSA-Cable(100)-LMR400NP	100	Non Plenum	.405	1.0”	Indoor/outdoor	4
DSA-Cable(125)-LMR400NP	125	Non Plenum	.405	1.0”	Indoor/outdoor	5
DSA-Cable(150)-LMR400NP	150	Non Plenum	.405	1.0”	Indoor/outdoor	6
DSA-Cable(175)-LMR400NP	175	Non Plenum	.405	1.0”	Indoor/outdoor	7
DSA-Cable(200)-LMR400NP	200	Non Plenum	.405	1.0”	Indoor/outdoor	8
DSA-Cable(225)-LMR400NP	225	Non Plenum	.405	1.0”	Indoor/outdoor	9
DSA-Cable(250)-LMR400NP	250	Non Plenum	.405	1.0”	Indoor/outdoor	10
DSA-Cable(275)-LMR400NP	275	Non Plenum	.405	1.0”	Indoor/outdoor	11
DSA-Cable(300)-LMR400NP	300	Non Plenum	.405	1.0”	Indoor/outdoor	12

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