

4x4 MIMO External Antennas

by **WAVEFORM**

PLEASE READ THIS FIRST:

We know, reading manuals isn't always fun. But we promise it's worth it.

We've helped thousands of customers improve signal to their cellular routers. We've compiled everything we've learned in this manual.

Give it a read before you start: it'll save you time and help you get the best performance out of your 4x4 MIMO External Antenna.

About Waveform

Your 4x4 MIMO External Antenna Kit is designed, sold, and supported by Waveform and our team of Signal Specialists.

We've helped over 20,000 customers improve their signal since our company was founded in 2007. We've installed and configured thousands of devices in buildings across the country, and **we're here to help**. If you have any issues at all, please don't hesitate to reach out.



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Santa Ana, CA 92704



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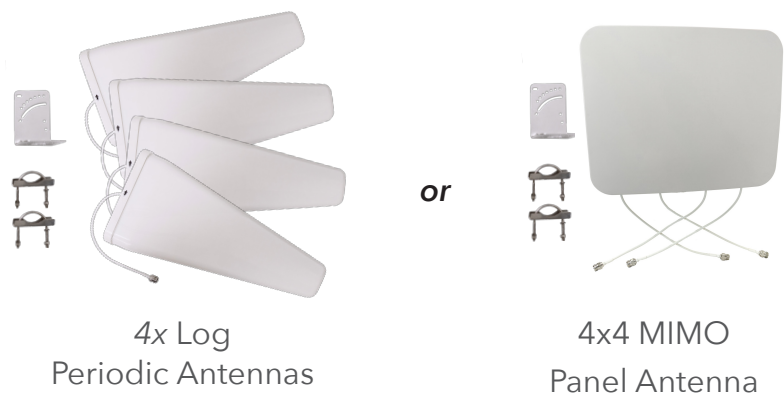


www.waveform.com
help@waveform.com

What's in the Box

Antennas

Depending on what you purchased, your package will contain either a *single 4x4 MIMO Panel Antenna* or *four Log Periodic Antennas*. We recommend using the Log Periodic Antennas if you have line-of-sight to your nearest cell towers. Our 4x4 MIMO Panel Antenna may perform slightly better if you're surrounded by trees, buildings, or hills.



Cables and Adapters (optional, only included with complete kit)

If you purchased a complete antenna kit, the parts listed below will also come included.



Optional: 4x Lightning Protector Kits

Clear bag



J-Mount Bracket and Hardware

Red bag



J-Mount Antenna Mount
(2x For Log Periodic Kit)



2x Twin-RS240 N-Male to SMA-Male Cables



4x N-Male to SMA-Male Adapters

Clear bag



Pigtail Adapters
(4x U.FL & 4x TS9)

Install Manuals, Who Needs 'Em?

Heads up: Using MIMO antennas to improve your signal can take a bit of patience.

We'd be surprised if you saw better data rates immediately upon connecting the antennas.

Be prepared to spend an hour or two to find the right location and direction for your antennas.

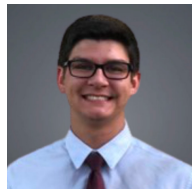
This manual is based on feedback from hundreds of customers like you. We've revised it dozens of times to make it as helpful as possible and make the process of getting better data rates as easy as we can.

We promise you'll be glad if you read it from start to finish before you get started. It'll help you save time, avoid the most common pitfalls, and ensure your system works as well as possible.

Who We Are

Hi! We're Waveform. We've been around since 2007, and while we've grown a bunch since then, we're still a small team. There's just a handful of us answering texts, and picking up calls.

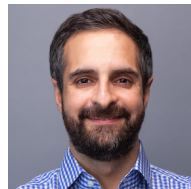
The four of us pictured below lead support and product development. Feel free to reach out to us at any time; our emails are all just our first names @waveform.com



Ian (Support)



Marcus (Product)



Sina (CEO)



Harry (Support)

Stuck? Have Questions? *Please*: Contact Us!

We're a small team, but we *really* care about helping you get the best results.

If you're having issues, please contact us. Sometimes a small tweak we suggest can make all the difference.

Even if everything goes smoothly, please let us know how your system is performing. We love getting feedback: Is there any way we could make the install process or this manual better?

Call us at **(800) 761-3041**, email **help@waveform.com**, or book a meeting with our dedicated support team at waveform.com/meet. We're available from 9am-5pm PT, Monday to Friday.

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It's important that there's at least some 4G LTE or 5G signal outside or on the roof of the building where you're installing your 4x4 MIMO antennas, and ideally it should be "usable." If you don't have usable signal outside, proceed with caution, and consider giving us a call.

What Do We Mean by "Usable"?

When you take your cellular router or hotspot outdoors, you should have a reliable data connection even without connecting your new 4x4 MIMO external antenna(s). When running a speed test, you should have at least 0.1 Mbps download and upload speed.

MIMO antennas will help condition the outdoor signal and get you better data rates. But if the signal outside your building isn't usable to begin with, MIMO antennas might not help.

You can certainly still give the MIMO antenna a shot, but you may still be unable to connect.

Compatibility

First, a quick reminder: Our 4x4 MIMO Panel and Log Periodic Antennas support almost every 3G, 4G LTE, and low/mid-band 5G service in use in the US and across the world. Here are the bands that each antenna covers:



 **AT&T** B2/n2, B4, B5/n5, B12, B17, B29, B30, B46, B66/n66, n77



verizon B2/n2, B4, B5/n5, B13, B46, B48/n48, B66/n66, n77



T-Mobile B2, B4, B5, B12, B25, B26, B41/n41, B46, B66, B71/n71, n77

CBRS, B48/n48

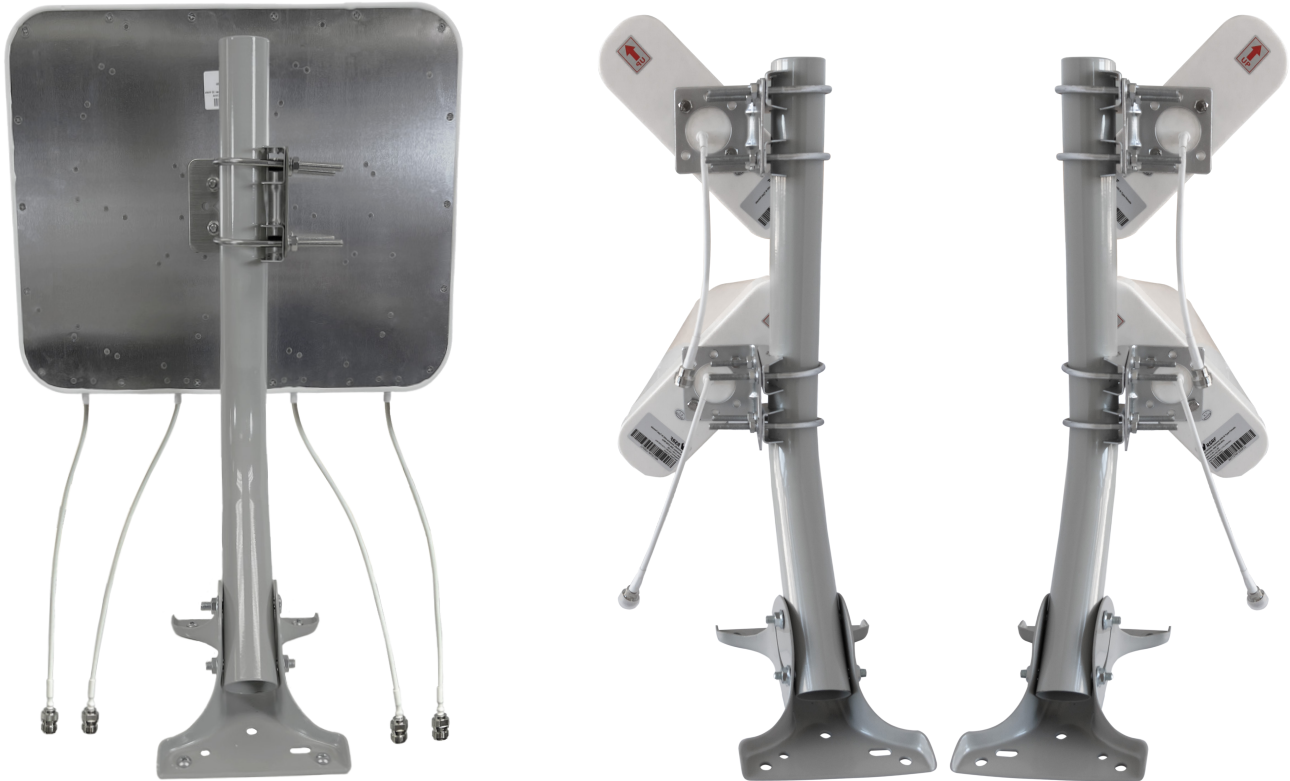
All supported LTE Bands: B1, B2, B3, B4, B5, B7, B8, B11, B12, B13, B14, B17, B18, B19, B20, B21, B22, B25, B26, B28, B29, B30, B32, B34, B37, B38, B39, B40, B41, B42, B43, B46, B47, B48, B50, B51, B53, B65, B66, B67, B69, B70, B71, B74, B75, B76, B85, B103, B106

All supported 5G Bands: n1, n2, n3, n5, n7, n8, n12, n13, n14, n18, n20, n25, n26, n28, n29, n30, n34, n38, n39, n40, n41, n46, n47, n48, n50, n51, n53, n65, n66, n67, n70, n71, n74, n75, n76, n77, n78, n79, n80, n81, n82, n83, n84, n85, n86, n89, n90, n91, n92, n93, n94, n95, n96, n97, n98, n99, n100, n101, n102, n105

**Your router's supported bands may vary from this list.*

02 Assembling the Antenna(s)

The pictures below show how your antenna(s) should be secured to your mount. It's helpful to have your antenna(s) attached to your mount for the next steps in section 3, so take some time to get the antenna(s) set up before moving on.



For the best results and to ensure their drainage holes work properly, **mount the antennas in the orientation shown above**. For the Log Periodic Antennas in particular, **ensure their arrows are pointed upwards**. You can find more detailed instructions on how to attach your antenna(s) to your J-Mount at waveform.com/polemount-instructions

Cross-Polarizing the Log Periodic Antennas (if purchased)

If you have four Log Periodic Antennas, angle each pair of antennas 45 degrees in opposite directions to achieve “cross-polarization”, as shown above. Cross-polarizing each pair of antennas and aiming all four of them in the same direction is **crucial for successful 4x4 MIMO connections**.

When mounting the antennas, **spread the pair of antennas about 3-4 ft apart or as far apart as your cables allow**. Treat all four antennas as a single antenna moving forward.

03 Positioning and Aiming the Antenna(s)

Finding the right antenna position for your 4x4 MIMO antenna(s) is the most important part of the install. In this section, we explain the best and simplest method for positioning and aiming. Section 7 covers some more advanced tips that we don't recommend for most users.

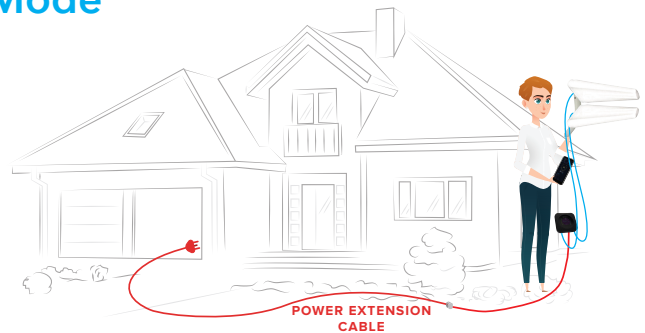
The Goal

Your goal is to find the **best location and direction** for your antenna(s). This location should **maximize the data rates** from your cellular router. It can take a little patience, but spending some extra time here can have a huge impact on performance - it's worth the extra effort.

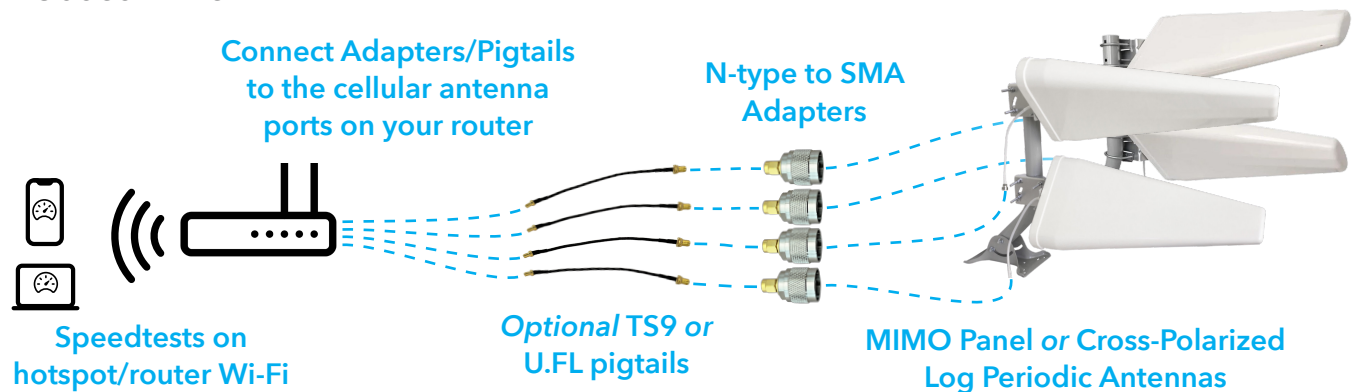
Set up Your MIMO Antenna in "Test Mode"

Is your cellular router battery-powered or do you have a power extension cord?

If so, connect your MIMO antenna(s) directly to your router and take them both outside to start testing different locations and directions.



Here's how to set up your router and antenna(s) in Test Mode if you're using the adapters included in the kit:



Can't take your router with you outdoors? No problem. Just keep your router powered on indoors and use the included coax cables instead of the N-type to SMA adapters to take your MIMO antenna(s) outside.

If you're leaving your router indoors, your speed tests may be limited by the router's Wi-Fi range rather than its cellular connection. We recommend asking someone to stay near the router so they can run speed tests as you try different positions with the antenna(s) outside.

Not sure which ports to connect to? Some devices have both Wi-Fi and Cellular external antenna ports. Make sure to attach your antenna(s) to your router’s cellular ports and not it’s Wi-Fi ports. To help you identify which ports to connect to, refer to your router’s manual, our device-specific guides at waveform.com/hotspot-guides, or feel free to reach out to us.

Is holding all four Log Periodic Antennas difficult? Have someone assist you with moving and aiming all four antennas at the same time. If that isn’t possible, but you know your router’s primary cellular antenna port, connect just one of the antennas to that port for this process.

Running Speed Tests

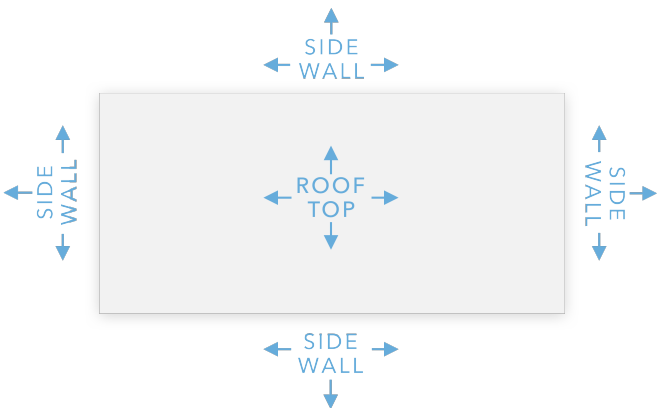
Since the goal is improved data rates, it makes sense to **use a speed test app to measure your data rates** through your cellular router’s Wi-Fi.

If you’re **testing with a phone**, download our favorite speed test app (“Speedtest by Ookla”) by visiting this URL: waveform.com/speedtest. For **testing with a laptop**, visit speedtest.net. Go ahead and run a couple of speed tests from a device connected to your router’s Wi-Fi. You’ll notice your results fluctuate a between tests – that’s normal.

Head outside and run 1-2 speed tests for each position and direction you try, then write down each of your results in the next page.

How to Position & Aim

Finding the right antenna location and direction takes some patience, but spending time to get it right can have a big impact on your system’s performance. Here are all the locations and directions where we recommend testing your MIMO antenna(s):



Don’t just go to the highest point of the roof! While signal is generally stronger the higher you go, there’s also often more interference. We’ve found it’s often better to mount the antenna(s) on the side of the building where the structure can shield the antennas from interference.

Once you’ve found the best antenna location and direction, move on to section 5 below to get ready for your final installation.

04 Your Data Rate Measurements

Use the table below to make notes of your data rate measurements while you're positioning and aiming your antenna(s).

Position and Direction	Download Speed	Upload Speed

05 Assembling Your System

Once you've identified the best location for your antenna(s), it's time to set up a provisional install. You'll keep your antenna(s) outside at the location you've selected, but run the cables and test your router/gateway indoors.

Don't drill any holes in your walls yet! Start with a temporary install and test performance first.

If you purchased the complete kit with your 4x4 MIMO antenna(s), follow the steps below to assemble and install your 4x4 MIMO External Antenna kit. If you just purchased just the antenna, your assembly may look a little different.

Getting the Complete Kit Set Up

Refer to the diagram to the right as needed.

- 1 Secure your 4x4 MIMO Panel Antenna or Log Periodic Antennas to your mount if you haven't already.** *If your kit includes four Log Periodic Antennas, be sure to cross-polarize them during this step, see section 2 for more information.*
- 2 Mount the antenna(s) outdoors** in the location and direction where you found the fastest data rates using the method described in section 3.
- 3 Connect your two Twin-RS240 coax cables** to your Panel or Log Periodic Antennas.
OR, if you purchased lightning surge protectors, connect your antenna(s) to the included 5 ft jumper cables, lightning surge protectors, and Twin-RS240 coax cables.
Instructions on grounding are in the next section of the manual.
- 4 Connect the SMA ends** of each Twin-RS240 cables to the antenna ports on your router and hand-tighten the connections.
OR, if your cellular router has TS9 or U.FL ports, install the included pigtail adapters between each Twin-RS240 cable and your router, and then hand-tighten the connections.

Install Tips

- **Before attempting to route the cables through your building,** lay each Twin-RS240 cable out flat to straighten it. This will make it easier to work with.
- **A finger-tight connection is sufficient** to secure the connectors. Tools are not required to tighten them and may cause damage.
- **Unsure how your pigtail adapters should connect to on your router?** Refer to the information on page 8 to help you identify which ports to connect to.

Depending on which kit you purchased. Shown with the included J-Mount(s).

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Only included in our complete
4x4 MIMO with Lightning Surge
Protectors Kit.

Connect each Lightning Surge Protector to the building's ground with 10 AWG or thicker grounding cable.

Only included in our complete
4x4 MIMO kit.

Only included in our complete
4x4 MIMO kit.

If your router uses TS9 or U.FL connectors for it's cellular antenna ports, install the relevant pigtail here.

If your router uses SMA connectors instead, connect your Twin-RS240 cables directly to the router.



Connect the cables or pigtails to the cellular antenna ports.

If you are unsure which ports to connect to, refer to page 8 for further guidance.

06 Test & Install Permanently

Before drilling holes in your walls, we recommend running cables temporarily through a window or door and testing to make sure that everything still works well.

If you're happy with your data rates, you can start drilling holes and moving to a permanent install.

If you're having issues with your temporary setup, or aren't happy with the performance, don't panic! We can help you figure it out. **Call us at (800) 761-3041, email help@waveform.com, or book a meeting with our dedicated support team at waveform.com/meet.** We're available from 9am-5pm PT, Monday to Friday.

A Quick Note on Surge Protection & Grounding

We highly recommend picking up four Lightning Surge Protector Kits from [waveform.com/surge-protector](https://www.waveform.com/surge-protector) to ground your outdoor antenna. They'd be installed just before the coaxial cable enters your building to protect your router from lightning and prevent high-voltage power from entering your building.

Both the surge protectors *AND* your mount itself should be grounded. We recommend using at least 10 AWG cable. Keep in mind the numbers increase as the cable gets thinner so 6 AWG and 8 AWG are both okay, but 12 AWG and 14 AWG are too thin.

If you have a satellite or HDTV antenna on your roof already, it's likely grounded. You can simply ground the mast and lightning surge protectors to the satellite dish. Alternatively, you can ground your mast and antenna(s) directly to a grounding rod. Most homes should have a grounding rod, but if yours doesn't you can purchase one at a local hardware store.

Even if you don't purchase a lightning surge protector, it's critical to ground your antenna **mount**, since its metal frame makes it a prime target for lightning strikes.

You can find more detailed instructions on how to properly ground your antenna(s) at [waveform.com/grounding](https://www.waveform.com/grounding)

Weatherproofing Outdoor Connections

N-Type connectors are outdoor rated, but water can still sometimes get in and cause issues. We strongly recommend that you **wrap all outdoor N-type connections** with stretch-and-seal self-fusing silicone rubber tape (available from most hardware stores).

07 Advanced Optimization

By this point, you should have a really solid understanding of how to aim your MIMO antenna(s) and get great performance. In fact, **we're convinced that for 95% of people, the instructions provided in this manual so far are more than enough.**

If, however, you'd like to go a little deeper and get technical to optimize your system even further, here are some general guidelines.

- 1 Look up your nearby towers** on cellmapper.net by performing a "Tower search" with the "eNB-ID" that your cellular router is connecting to. An eNB-ID is a unique cell tower identifier that can often be found in your cellular router's admin interface.
- 2 Aim your antenna(s) at each nearby tower.** Run speed tests for each tower to find the fastest bands, and compare speed tests. **If your cellular router also supports bandlocking**, band lock it to every band that the tower transmits, and run speed tests for each tower on each band to find your fastest band(s) and tower.
- 3 Try enabling multiple bands** and using carrier aggregation to find the fastest band combination. Carrier aggregation is supported by most cellular routers and allows them to connect to two or more bands simultaneously. However, it doesn't always result in an faster data speeds so stick to a single band if that gets you the best results.

Unfortunately, many devices don't support band locking or carrier aggregation, and some don't list eNB-IDs or any other tower identifiers, making these steps impossible. Every cellular router is so different that we could never cover them all with just one set of instructions.

However, **we've written up guides for some of the most common devices**, you can find them online at waveform.com/hotspot-guides. We suggest reading our guide for your router, or referring to your user manual.

We're Here to Help!

We know, there's a lot of information out there and this can get very technical. Don't be afraid!

If you're having difficulty, aren't happy with the performance of your system, or you'd just like a hand, we'd love to help! **Call us at (800) 761-3041, email help@waveform.com, or book a meeting with our dedicated support team at waveform.com/meet.** We're available from 9am-5pm PT, Monday to Friday.

08

Need Help with your Pigtail Adapters?

- Having difficulties connecting your U.FL pigtails? Since U.FL connectors are very small and can be difficult to install on the first try, we suggest that you **use a locking or reverse-action tweezer to hold the cable in place** and a **pencil eraser to push the U.FL connector down**.

- **Are your TS9 pigtails a bit loose?** Lightly **squeeze the end of the TS9 connector with your fingers** to improve it's grip. We know its not ideal, but TS9 connectors aren't threaded or standardized, so TS9 ports vary in depth between routers and they may not initially stay in place. While our adapter has been thoroughly tested, it's not always perfect for every device.

09

Some Final Tips

- If you have extra cable, don't coil it tightly.

If you have extra cable, make sure to keep any cable loops as large as possible to minimize any negative side-effects (4 ft or wider loops are best).

- If data rates decrease over time, consider re-optimizing your system.

Occasionally carriers will change their towers to broadcast different bands, light up new towers, or simply turn off existing towers altogether. If your data rates suddenly get worse, try re-aiming your antenna(s) to get the best results.

- If you have the Log Periodic Antenna Kit, try alternative antenna mounting configurations.

For an additional performance boost with the log periodic antennas, other antenna configurations can be tried *depending on your local terrain*.

- » **For obstructed terrain** (i.e. locations surrounded by large buildings/hills/mountains etc.), try mounting the antennas horizontally side-by-side.
- » **For open terrain** (i.e. locations in large fields/plains/etc.), try mounting the antennas vertically top-to-bottom.

10 Tell Us How It Works

Did your installation go great? Are you having trouble aiming your antenna(s)? Do you think our manual could be improved? Are your data rates not quite what you were hoping?

Please tell us: Give us a call at (800) 761-3041, email help@waveform.com, or book a meeting with our fantastical support team at waveform.com/meet. We're available from 9am-5pm PT, Monday to Friday.

We're a small team who loves hearing how our products perform, and helping folks get the absolute best data rates in any given situation. **So please, reach out!**

Excited about your 4x4 MIMO antenna?

Get 5% for each friend, family, or neighbor you refer.

Hopefully by the time you've finished installing and tuning your MIMO antenna, you're as excited about this product as we are.

One of our biggest challenges is spreading the word. Most people don't know that products like our 4x4 MIMO External Antenna Kit exist.

Help us get the word out: Everyone you refer gets 5% off their kit, and we'll also give you 5% of whatever they spend in cash (via PayPal).

Simply visit waveform.com/referrals to get started.



Need help? We're ready and waiting.

MIMO Antennas aren't always easy to install. In fact, getting everything up and running can sometimes be a pain. But the end result is worth it.

One of the benefits of buying from Waveform is our **lifetime technical support** on every system we sell. We've installed hundreds of these devices ourselves, and can walk you through troubleshooting and fine-tuning your installation for best results.

Simply give us a call at +1 (800) 761-3041, email us at help@waveform.com, or book a meeting with our fantastical support team at [waveform.com/meet](https://www.waveform.com/meet). We're available from 9am-5pm PT, Monday to Friday.

We love helping solve tricky install problems.



v3.1



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www.waveform.com
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