2x2 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 hundreds 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 2x2 MIMO External Antenna.

About Waveform

Your 2x2 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.

3411 W. Lake Center Dr.,
Santa Ana, CA 92704

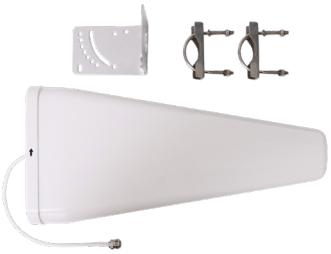
+1 (800) 761-3041

www.waveform.com
help@waveform.com

What's in the Box

Antennas

Depending on what you purchased, your package will contain either a *single* 2x2 MIMO Panel Antenna or *two* Log Periodic Antennas. We recommend using the Log Periodic Antennas if you have line-of-sight to your nearest cell towers. Our 2x2 MIMO Panel Antenna may perform slightly better if you're surrounded by trees, buildings, or hills.



2x Log
Periodic Antennas

or

2x2 MIMO
Panel Antenna

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: *2x* Lightning
Protector Kits

Clear bag

J-Mount Bracket
and Hardware

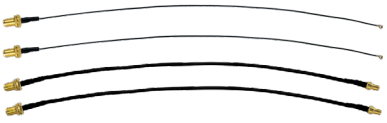
Red bag

J-Mount Antenna
Mount

Twin-RS240 N-Male
to SMA-Male Cables

2x N-Male to SMA-Male
Adapters

Clear bag



Pigtail Adapters
(*2x* U.FL & *2x* 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.

00 Before You Start

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 2x2 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 2x2 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 2x2 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*:

Our **2x2 MIMO Panel Antenna** supports all 4G LTE and 5G bands between 600 MHz and 2.7 GHz, including:

AT&T	B2/n2, B4, B5/n5, B12, B17, B29, B30, B66/n66
verizon	B2/n2, B4, B5/n5, B13, n40, B66/n66
T-Mobile	B2, B4, B5, B12, B25, B26, B41/n41, B66, B71/n71

Our **Log Periodic Antennas** support all 4G LTE and 5G bands between 600 MHz and 6 GHz, including:

AT&T	B2/n2, B4, B5/n5, B12, B17, B29, B30, B46, B66/n66, n77
verizon	B2/n2, B4, B5/n5, B13, n40, B46, B48/n48, B66/n66, n77
T-Mobile	B2, B4, B5, B12, B25, B26, B41/n41, B46, B66, B71/n71, n77 CBRS, B48/n48

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

How Much Improvement Should You Expect?

In short: It's hard to say. Many people see an increase in data rates of between 50% and 200%, but some people may only see 10%. Our CEO often says that despite all the science, wireless signals often work in "strange and magical" ways.

One thing is for sure, **the more locations and directions you try the more likely you are to see a big increase in data rates**. If you've gone through this manual and aimed the antenna(s) as we suggest, but you're still not seeing much improvement, **please reach out to us for help**.

What tools do I need?

The mounting hardware of your J-Mount and MIMO Antenna(s) will require a **size-10mm wrench** to be assembled and **additional fasteners and tools** will be required to secure the J-Mount against your building.

If you are unsure which specific fasteners and tools to use for your building, **we recommend reaching out to a local contractor for guidance**.

01 Install Process Overview

This is the process that we suggest using for installing your 2x2 MIMO Antenna(s):

1. **Read this manual,** ideally from start to finish, so that you understand the whole installation process before you begin.
2. **Assemble your antenna(s) to your mount *(Page 6).*** Start by assembling your mount and attaching your 2x2 MIMO Panel Antenna or cross-polarized Log Periodic Antennas.
3. **Find the best antenna location and direction *(Pages 7-9).*** This step is the most time-consuming, but it's worth the effort. Getting it right has a huge impact on your system's performance. Make notes of your readings in the table on page 9.
4. **Verify performance and hard-wire everything *(Pages 10-12).*** Without making any holes in your roof or walls, temporarily run the cable indoors to your cellular router and run speed tests. If everything looks good, finalize the cable runs and hard-wire everything.
5. **Tell us how your system is doing.** We really love hearing how our customers' systems are performing. Send an email or give us a call and let us know how things look.

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 two Log Periodic Antennas, angle each antenna 45 degrees in opposite directions to achieve "cross-polarization", as shown above. Cross-polarizing the antennas and aiming them in the same direction is **crucial to achieving a successful 2x2 MIMO connection**. Treat the two antennas as a single antenna moving forward.

03 Positioning and Aiming the Antenna(s)

Finding the right antenna position for your 2x2 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.

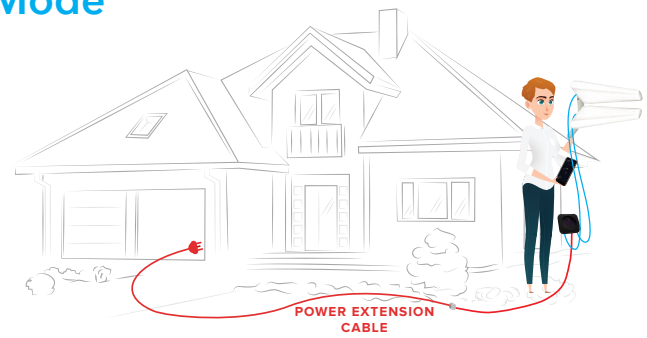
The Goal

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.

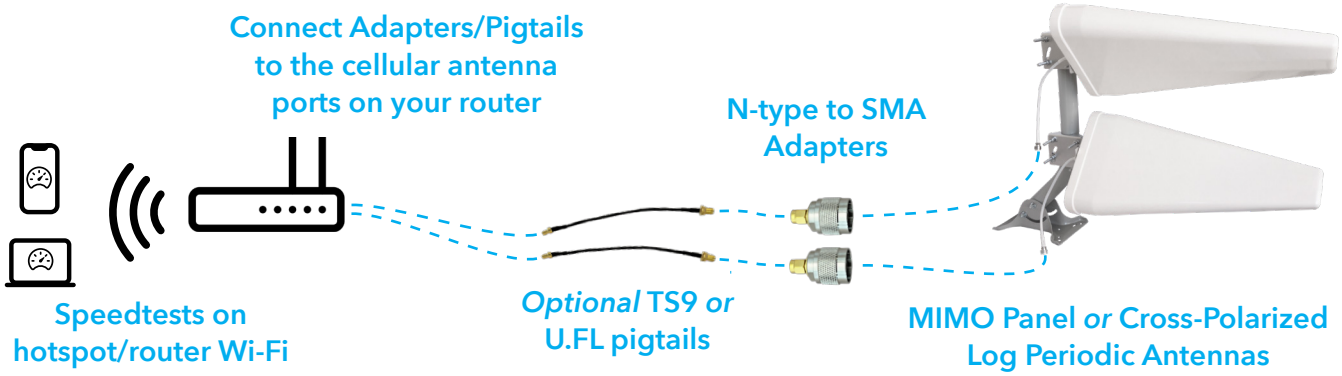
Set up Your MIMO Antenna in "Test Mode"

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*. If your device has **two cellular ports**, it doesn't matter which cable is connected to which port. If your device has **four cellular ports**, test which ports give you the best results.

Refer to your router's manual, our device-specific guides at **waveform.com/hotspot-guides**, or feel free to reach our team so we can help you identify which ports to connect to.

Running Speed Tests

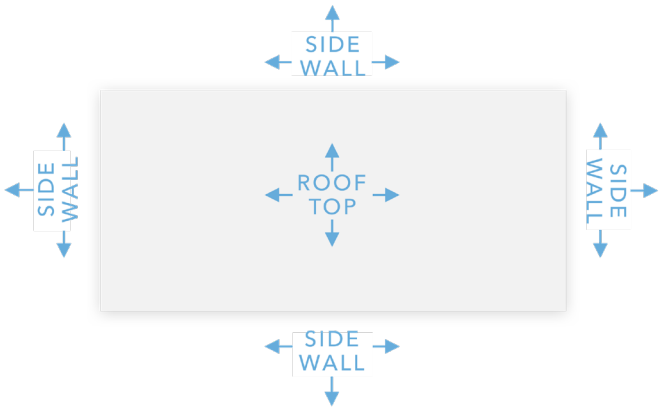
Since the goal is improved data rates, it makes sense to **use a speed test app to measure your data rates** through your cellular router's Wi-Fi.

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 cellular 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 2x2 MIMO antenna(s), follow the steps below to assemble and install your 2x2 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 2x2 MIMO Panel Antenna or Log Periodic Antennas to your mount if you haven't already**. *If your kit includes two Log Periodic Antennas*, be sure to cross-polarize them during this step, see section 2 for more information.
2. **Mount your 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 Twin-RS240 coax cables** to your MIMO Panel or Log Periodic Antennas.

   OR, If you purchased lightning surge protectors, connect your MIMO Antenna(s) to the included 5 ft jumper cables, Lightning Surge Protectors, and Twin-RS240 coax cable. *Instructions on grounding are in the next section of the manual*.
4. **Connect the SMA ends** of your Twin-RS240 cable to the antenna ports on your router and hand-tighten the connections.

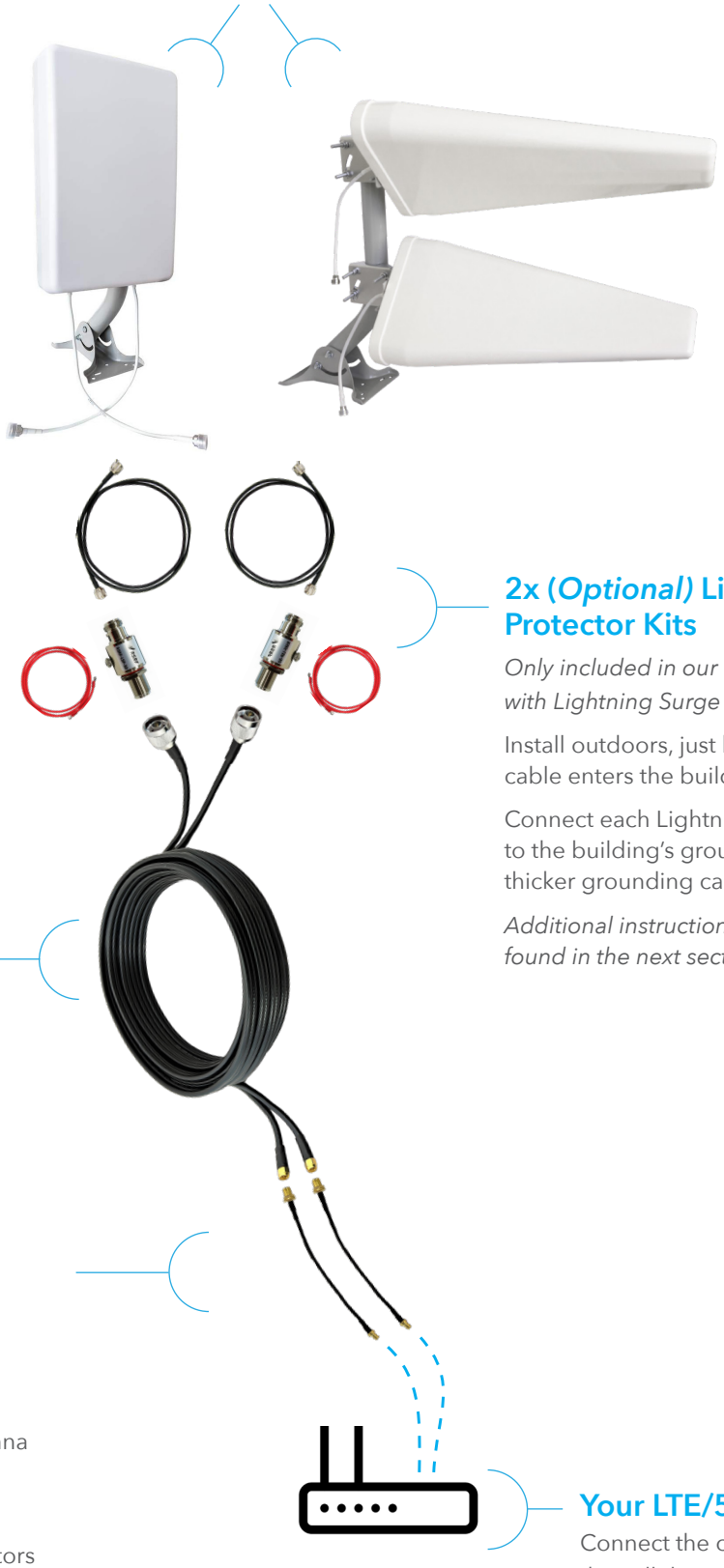
   OR, If your cellular router has TS9 or U.FL ports, install the included pigtail adapters between the Twin-RS240 cable and your router, and then hand-tighten the connections.

Install Tips

- **Before attempting to route the cables through your building**, lay the 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.

2x2 MIMO Panel Antenna *or* cross-polarized Log Periodic Antennas

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



2x (*Optional*) Lightning Surge Protector Kits

Only included in our complete 2x2 MIMO with Lightning Surge Protectors Kit.

Install outdoors, just before Twin-RS240 cable enters the building.

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

Additional instructions on grounding are found in the next section of the manual.

Twin-RS240 N-Male to SMA-Male Cable

Only included in our complete 2x2 MIMO kit. Length varies by kit.

2x TS9 or U.FL Pigtail Adapters

Only included in our complete 2x2 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 the Twin-RS240 cable directly to the router.

Your LTE/5G 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 a pair of Lightning Surge Protector Kits from **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 it's 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**

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.

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 2x2 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 2x2 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.

WAVEFORM

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.** We're available from 9am-5pm PT, Monday to Friday.

We love helping solve tricky install problems.

v8.1

3411 W. Lake Center Dr.,
Santa Ana, CA 92704

+1 (800) 761-3041

www.waveform.com
help@waveform.com