Factors affecting Iris range

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1 Introduction

This document explains the factors that affect the wireless communication range between Iris transmitters and receivers. Its purpose is to help readers plan fixed installations, select suitable antennas and cables, and understand how installation conditions influence connection reliability.

Chapter 2 explains the main factors affecting range, including obstacles, antenna placement, Fresnel-zone clearance, transmit power, receiver sensitivity, and cable losses. It introduces link-budget calculations and fade margin to show how these factors combine to determine whether a connection has sufficient signal reserve. It also discusses antenna diversity, DECT region settings, audio modes, and signal strength.

Chapter 3 applies these principles to Iris and Iris Pro products using antennas supplied by Streamit. The calculations compare expected received signal levels for internal antennas, standard external antennas, and outdoor omnidirectional and directional antennas, including the effects of antenna cables.

These calculations provide a basis for comparing configurations and estimating performance under ideal conditions. Actual usable range depends on the installation environment, so the results should support installation planning and be confirmed by testing at the intended location.

2 Key Parameters That Determine Iris Range

2.1 Introduction

Many parameters determine the range of wireless devices. This document is not intended as a theoretical reference; it provides practical guidelines for understanding the usable range of Iris products.

Iris operates at about 1.9 GHz and transmits at about 20 dBm. At this frequency, the wavelength is approximately 16 cm. Concrete walls strongly attenuate the signal. A signal may instead reach the

receiver through openings, such as doors and windows, or along reflected paths. This reduces range and can create multipath fading, with strong reception in some locations and poor reception in others.

For long-distance links, clear line of sight between the transmitter and receiver antennas is therefore important.

Iris can operate in two antenna modes:

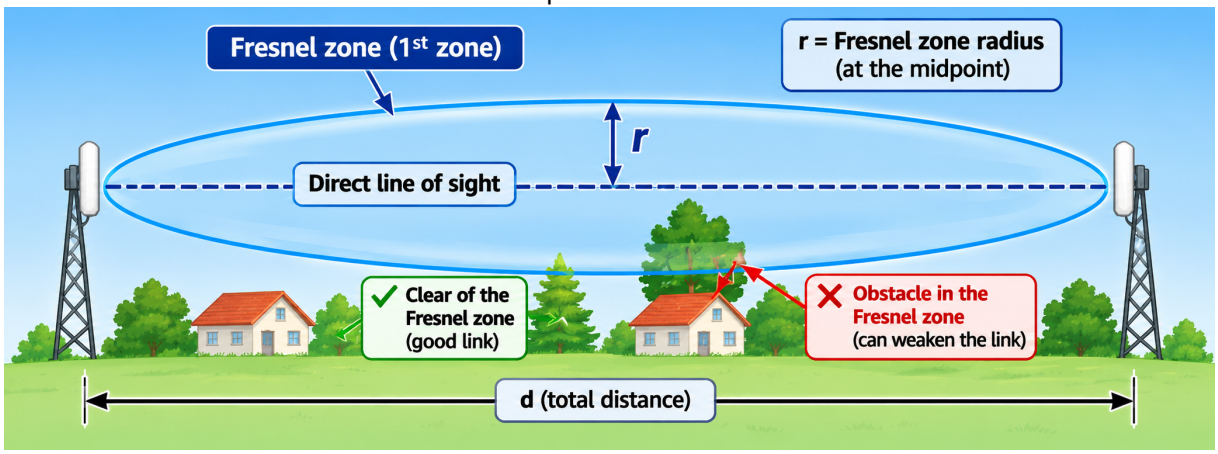
- Single-antenna mode, using either the internal antenna (when available) or an external antenna
- Diversity mode.

Iris products are designed for fixed installations rather than moving applications. During range testing, it can take up to 10 seconds for the transmitter and receiver to establish a lock. Re-establishing a lost lock may take longer. Keep both products stationary during this process. Holding the products during a range test often produces disappointing results.

An external antenna does not automatically provide greater range; performance depends on antenna gain, cable loss, placement, and the enclosure. The internal antenna in Iris Pro and some AMP products performs poorly because of the metal enclosure. Diversity is therefore useful only when both antenna paths are effective, as in an Iris Transmitter and Iris Receiver setup.

2.2 Keep the Radio Path Clear

To reduce obstruction loss, maintain sufficient clearance around the direct line-of-sight path. This clearance area is called the Fresnel zone. See picture below.



A common engineering guideline is to keep at least 60% of the first Fresnel zone clear.
The radius of the first Fresnel zone at any point is:

$$r_1 = \sqrt{\frac{\lambda d_1 d_2}{d_1 + d_2}}$$

or, using practical units:

$$r_1(m) = 17.32 \sqrt{\frac{d_1(km) d_2(km)}{f(GHz)[d_1 + d_2](km)}}$$

Here d_1 and d_2 are the distances from the obstruction to the two antennas.

The maximum value of r_1 is reached at the center, so when $d_1 = d_2$.

At the midpoint of a link of total length D:

$$r_{1,mid} = 8.66\sqrt{\frac{D_{km}}{f_{GHz}}}$$

Signals from consecutive Fresnel zones tend to alternate between reinforcing and cancelling one another because of their phase differences. The first zone has the greatest practical effect, so link planning normally aims to keep at least 60% of the first Fresnel zone unobstructed:

This gives the required clearance C:

$$C \approx 5.2\sqrt{\frac{D_{km}}{f_{GHz}}}$$

The following examples use a frequency of 1.9 GHz:

At a distance of 25 m, C is approximately 0.6 m.
At a distance of 100 m, C is approximately 1.2 m.
At a distance of 1 km, C is approximately 3.8 m.
At a distance of 10 km, C is approximately 11.9 m.

These examples indicate how high the transmit and receive antennas may need to be above obstacles.

Note the following relationships:

- **Frequency: a higher frequency produces a smaller Fresnel zone**
- **Distance: a longer link produces a larger Fresnel zone**

2.3 Iris Range Calculation Theory

The practical range between two Iris devices depends on the following parameters:

P_{TX} (dBm) is the Iris transmitter output power relative to 1 mW.
L_{TXC} (dB) is the loss in the transmitter cable and connectors.
G_{TXA} (dBi) is the transmitter antenna gain relative to an ideal isotropic antenna.

EIRP (dBm) is the effective isotropic radiated power in the antenna's strongest direction.

The relationship is: $EIRP = P_{TX} - L_{TXC} + G_{TXA}$

For example:

- *Transmitter output P_{TX}: 22 dBm*
- *Cable and connector loss L_{TXC}: 2 dB*
- *Antenna gain: 0 dBi*

$$EIRP = 22 - 2 + 0 = 20\,dBm$$

P_{RX} (dBm) is the received power relative to 1 mW.
L_{RXC} (dB) is the loss in the receiver cable and connectors.
L_{path} (dB) is the loss along the path between the transmitter and receiver antennas.
G_{RXA} (dBi) is the receiver antenna gain relative to an ideal isotropic antenna.

The relationship is:

$$P_{RX} = EIRP - L_{path} + G_{RXA} - L_{RXC}$$

S_{RX} (dBm) is the receiver sensitivity.

A link works when: $P_{RX} \geq S_{RX}$ + required fade margin.

Lpath = FSPL + $L_{obstructions}$ + $L_{environment}$ + L_{fading}

FSPL is the ideal free-space propagation loss in decibels. With distance in kilometers and frequency in gigahertz, the standard formula is:

$$FSPL = 92.45 + 20log_{10}(d_{km}) + 20log_{10}(f_{GHz})$$

Where:
d_{km} = distance in kilometers
f_{GHz} = frequency in gigahertz

Real-world link calculations must also account for:

- Walls and floors
- Trees and terrain
- Buildings and vehicles
- Antenna polarization mismatch
- Multipath and shadowing

These losses are included in $L_{environment}$.

Environmental loss is often difficult to calculate accurately. For this reason, link calculations usually focus on the remaining fade margin after all known gains and losses have been included.

Fade margin = P_{RX} - S_{RX}

Typical design targets are:

- 5-10 dB: stable, clear line-of-sight link with limited reliability reserve
- 10-20 dB: typical indoor or outdoor installation
- 20-30 dB: difficult indoor conditions or a high-reliability requirement

For example:

- *Frequency: 1.9 GHz*
- *Distance: 1 km*

FSPL = 98.03 dB

- *Receive antenna gain: 0 dBi*
- *Cable loss: 0 dB*
- *Receiver sensitivity SRX: -83 dBm*

PRX = 20 - 98.03 + 0 - 0 = -78.03 dBm

The theoretical fade margin is -78.03 - (-83) = 4.97 dB.

The following parameters are important in a link-budget calculation:

- **FSPL: assumes free-space propagation; sufficient Fresnel-zone clearance helps make this assumption reasonable**
- **Antenna gain: does not change the Fresnel-zone dimensions**
- **Transmit power: does not change the Fresnel-zone dimensions, but additional power increases the margin available for obstruction loss**
- **Receiver sensitivity: does not change the Fresnel zone; it determines how much total loss the link can tolerate**
- **Fade margin: provides a reserve for varying Fresnel-zone obstruction, multipath, moving vehicles, vegetation, and weather-related changes**

2.4 DECT Region

Select the DECT region for the country in which the product will be used. The app defaults to the EU region. Contact Streamit if this setting must be changed.

2.5 Audio Mode

The following audio modes are available:

- Mono 128 kbps
- Stereo 128 kbps
- Mono 256 kbps
- Stereo 256 kbps

It is important to realize that with 128 kbps GFSK modulation (1 bit per symbol) is used and with 256 kbps DQPSK modulation (2 bits per symbol). Theoretically using GFSK should lead to a little larger range, but in practical situations we have not experienced major differences.

2.6 Signal Strength

The strength of the DECT signal at the receiver indicates the connection quality.

Signal strength	Color	Connection quality
≥ -45 dBm		Perfect connection
-65 dBm to < -45 dBm		Good connection
-85 dBm to < -65 dBm		Fair connection
< -85 dBm		Poor connection

3 Practical Iris Range Calculations

The previous section explained the theory behind Iris antenna range. This section applies that theory to Iris products and the antennas supplied by Streamit.

Use the values in the following table for the calculations. The audio modes produce only slight differences, which are difficult to measure without specialized equipment.

Please also don't forget to take into consideration the Fresnel zones, so the areas around the antenna path to keep clear of obstacles. I have summarized these here for several distances:

At a distance of 25 m, the radius is approximately 0.6 m.
At a distance of 50 m, the radius is approximately 0.84 m.
At a distance of 100 m, the radius is approximately 1.2 m.
At a distance of 500 m, the radius is approximately 2.7 m.
At a distance of 1 km, the radius is approximately 3.8 m.
At a distance of 10 km, the radius is approximately 11.9 m.

Iris devices	TX power (dBm)	RX sensitivity (dBm)
Internal antenna		
EIRP (dBm) - 128 kbps audio	22.46	-97
EIRP (dBm) - 256 kbps audio	22.29	-97
External antenna connector		
Power (dBm) - 128 kbps audio	18.35	-93
Power (dBm) - 256 kbps audio	17.42	-93

All products are supplied with standard omnidirectional antennas with a maximum gain of approximately 1 dBi.
An outdoor version is also available. Its maximum gain is approximately 5 dBi.

A Yagi antenna with a maximum gain of 10 dBi is also available.
A 5 m Aircell 7 cable is available for this antenna. The cable introduces a loss of 2.5 dB.

The following setups are evaluated:

1. Iris TX and Iris RX with internal antennas at ranges of 50, 100, and 500 m
2. Iris TX and Iris RX with external antennas at ranges of 50, 100, and 500 m
3. Iris Pro TX and Iris Pro RX with standard external antennas at ranges of 50, 100, and 500 m
4. Iris Pro TX and Iris Pro RX with outdoor omnidirectional antennas and 5 m Aircell 7 cables at ranges of 50, 100, and 500 m
5. Iris Pro TX and Iris Pro RX with one outdoor omnidirectional antenna, one outdoor Yagi antenna, and two 5 m Aircell 7 cables at ranges of 50, 100, and 500 m

The calculations were performed in a spreadsheet using the formulas in the previous section.
The results are discussed for each setup.

1. Iris TX and Iris RX with internal antennas

Audio (kbps)	EIRP (dBm)	Range (m)	RX antenna gain (dBi)	FSPL (dB)	RX power (dBm)
128	22.46	25	3.96	66.0	-39.6
128	22.46	50	3.96	72.0	-45.6
128	22.46	100	3.96	78.0	-51.6
128	22.46	500	3.96	92.0	-65.6
256	22.29	25	4.58	66.0	-39.1
256	22.29	50	4.58	72.0	-45.1
256	22.29	100	4.58	78.0	-51.2
256	22.29	500	4.58	92.0	-65.1

These values require optimal orientation of the transmitter and receiver because the internal antennas are not fully omnidirectional. Clear line of sight must also be maintained.

2. Iris TX and Iris RX with external antennas

Audio (kbps)	TX power (dBm)	Range (m)	TX antenna gain (dBi)	RX antenna gain (dBi)	FSPL (dB)	RX power (dBm)
128	18.35	25	1	1	66.0	-45.6
128	18.35	50	1	1	72.0	-51.7
128	18.35	100	1	1	78.0	-57.7
128	18.35	500	1	1	92.0	-71.7
256	17.42	25	1	1	66.0	-46.6
256	17.42	50	1	1	72.0	-52.6
256	17.42	100	1	1	78.0	-58.6
256	17.42	500	1	1	92.0	-72.6

The results are slightly lower than those obtained with the internal antennas. However, these external antennas are omnidirectional, so their relative orientation is less critical when there is clear line of sight.

Iris TX and Iris RX can use antenna diversity effectively in non-line-of-sight conditions. Both antennas can transmit and receive audio signals, and the devices manage antenna selection automatically.

3. Iris Pro TX and Iris Pro RX with standard external antennas

The achievable values are the same as those for Iris devices with external antenna connectors.

The metal enclosure of Iris Pro prevents the use of its internal antenna for effective diversity. For a more nearly omnidirectional pattern, use a short antenna cable to separate the antenna from the metal enclosure and reduce unwanted reflections.

4. Iris Pro TX and Iris Pro RX with outdoor omnidirectional antennas and 5 m Aircell 7 cables

Audio (kbps)	TX power (dBm)	Range (m)	TX gain (dBi)	RX gain (dBi)	FSPL (dB)	RX power (dBm)
128	18,35	25	2,5	2,5	66,0	-42,6
128	18,35	50	2,5	2,5	72,0	-48,7
128	18,35	100	2,5	2,5	78,0	-54,7
128	18,35	500	2,5	2,5	92,0	-68,7
128	18,35	1000	2,5	2,5	98,0	-74,7
256	17,42	25	2,5	2,5	66,0	-43,6
256	17,42	50	2,5	2,5	72,0	-49,6
256	17,42	100	2,5	2,5	78,0	-55,6
256	17,42	500	2,5	2,5	92,0	-69,6
256	17,42	1000	2,5	2,5	98,0	-75,6

Some customers use Iris Pro or Iris with outdoor antennas. The following table shows the received-power values when both the transmitter and receiver use a good-quality 5 m cable. The results show that this setup does not outperform the internal antennas of Iris.
Theoretically in this setup we can achieve ranges of more than 500m. But due to technical limitations in the DECT receivers (mainly jitter), we do not recommend to use these products above about 550 meter.

5. Iris Pro TX and Iris Pro RX with one outdoor omnidirectional antenna, one outdoor Yagi antenna, and two 5 m Aircell 7 cables

Audio (kbps)	TX power (dBm)	Range (m)	TX gain (dBi)	RX gain (dBi)	FSPL (dB)	RX power (dBm)
128	18,35	25	2,5	7,5	66,0	-37,6
128	18,35	50	2,5	7,5	72,0	-43,7
128	18,35	100	2,5	7,5	78,0	-49,7
128	18,35	500	2,5	7,5	92,0	-63,7
128	18,35	1000	2,5	7,5	98,0	-69,7
128	18,35	5000	2,5	7,5	112,0	-83,7
256	17,42	25	2,5	7,5	66,0	-38,6
256	17,42	50	2,5	7,5	72,0	-44,6
256	17,42	100	2,5	7,5	78,0	-50,6
256	17,42	500	2,5	7,5	92,0	-64,6
256	17,42	1000	2,5	7,5	98,0	-70,6
256	17,42	5000	2,5	7,5	112,0	-84,6

As above table shows, using a directional antenna the received signal power increases about 5 dB and the highest values also remain above -65 dBm. We have no experience yet whether this makes really sense.