Making Wireless Work: Antenna & Cable Selection

When designing an antenna system, there are several items to consider

Factors that affect the performance of antennas include: Radio Output Power, Radio Receive Sensitivity, Transmit/Receive Distance, Cable Impedance, Antenna Type, Cable Type, and Obstacles. Keeping these factors in mind, one of the most important components in an antenna system is the transmission cable. This article summarizes the choices a system designer needs to consider when designing a wireless system utilizing the maximum potential of the correct antenna and cabling system.

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a. **Radio Output Power.** RF power is rated in Watts or milli-watts. Zlinx products are rated in 1mW, 10mW, 100mW, 500mW and 1W outputs. As the RF power increases, so will the current demand on the system power supply. If a battery or solar system is used to power a Zlinx product, use the minimum RF power required to ensure reliable communication and keep the polling rate as low as possible.

b. **Radio Receive Sensitivity**. Receive Sensitivity is a measure of the ability to detect and decode a radio signal. Typically this is given in dBm, the lower the better. Typical B&B Zlinx products are rated at -114dBm receive sensitivity.

c. **Transmit/Receive Distance.** Transmit power and receive sensitivity must be considered when evaluating communication link distance. Link symmetry must be maintained or bi-directional communication will be problematic. Poor receive sensitivity must be compensated with higher effective transmit power. The type of cable and antenna used will affect the receive sensitivity and the effective radiated RF output power.

d. **Antenna Deployment and Type.** Ideally, the system antennas should be deployed in an unobstructed line-ofsight arrangement; the antennas should be able to "see" each other. Since this is not always possible, it is critical to select the proper antenna and cable components to minimize signal loss and preserve receive sensitivity. Also consider future obstructions such as a new building or vegetation growth. If obstacles are unavoidable, consider a higher gain antenna, or a repeater arrangement. Regardless of the antenna type, the antennas in a system should be deployed using matching polarization. Polarization refers to the orientation of the radiating E-field with respect to the Earth, and is either vertical or horizontal. Simply put, if an antenna is pointed vertically towards the sky, it is said to be vertically polarized. If it is oriented parallel to the Earth, it is said to be horizontally polarized. Mismatched polarization results a signal loss of 10 dB or more.

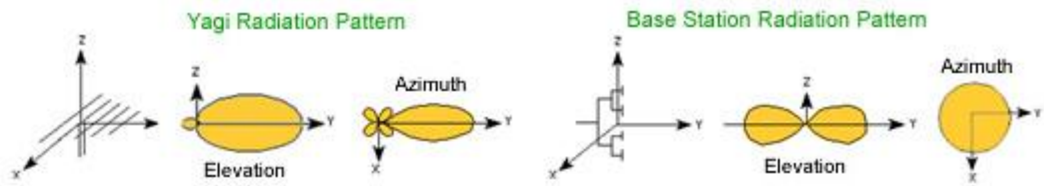
e. **Cable Type.** Select a cable that matches the radio antenna port impedance, typically 50 Ohms. An impedance mismatch will introduce inefficiency resulting in degraded transmit output power and receive sensitivity. In high power applications, impedance mismatches may cause damage to the radio. This damage is very unlikely using Zlinx radios. As seen in the chart below, cable loss is also an important consideration. 3dB of cable loss represents a loss of one half the transmit output power. Here is and example of how dramatic this affect can be: 25 feet of RG-58 cable has a loss of 3.6 dB at 900 MHz. The power applied to the antenna from a 100 mW radio would be reduced to 43 mW. If 100 feet of cable were to be used, the cable loss alone would reduce the transmit power to 3.5 mW. Cable loss also degrades receive sensitivity. Keep cable runs as short as possible and avoid connector losses by using a continuous length of cable instead of connecting several short lengths together. Lower loss cable is more expensive, but is usually worth the extra expense.

f. **Peer-to-Peer vs. Peer-to-Multi-Peer.** System architecture largely dictates the types of antennas required. Peer-to-Peer systems can be easily designed using Yagi antennas at both ends of the link. In multi-peer system, such as a modbus master to several slave devices, the master typically communicates to all the slave devices. This can be accomplished by using an omni-directional antenna on the master and Yagi antennas on the slave devices pointing at the master antenna.

Antenna Gain

For a comprehensive treatment on antennas, refer to Antennas, the classic work by John Krause, or The ARRL Antenna Handbook. When referring to antennas, gain is always directional gain. An antenna does not add energy to a signal, rather it directs radiated energy in some directions at the expense of other directions. Since this occurs in 3 dimensions, antenna radiation pattern graphs are very useful. Typical radiation patterns are depicted in the figures below.

Typical Radiation Patterns of Yagi and Dipole type antennas



Antenna gain improves transmission distance, not only by increasing effective radiated power, but also because receive sensitivity is also improved by way of a phenomenon known as antenna reciprocity (an antenna receives as well as it transmits). Link performance is also improved because reception of noise and interfering signals from other directions is reduced, improving the signal-to-noise ratio. Antenna power gain is given in units of dBd or dBi. dBd is the gain of the antenna over a standard half-wave dipole antenna in free space. Although suppliers use both units, dBi is a unit usually reserved for theoretical discussions because it refers to gain over a theoretical isotropic radiator that radiates energy equally well in all directions. Such an antenna is not physically realizable, making the dBd unit favorable for most discussions, since the dipole is a realiable, well known antenna. Be sure to understand which unit is being quoted.

A Dipole exhibits 2.15 dB of gain over the isotropic radiator, so to convert dBi to dBd simply subtract 2.15 from the dBi figure. For every 3 dBi of gain, the effective radiated power is doubled in the favored direction. An antenna with gain of 8.1dBi increases the effective isotropic radiated power (EIRP) of a 100 mW radio to approximately 640 mW of output power, neglecting other losses. High gain antennas such as the Yagi are directional; the antenna must be pointed directly towards the other antenna. Higher gain antennas exhibit a tighter beamwidth, which makes aiming the antenna more critical since the directional gain will drop off quickly in the unfavored directions. Be sure to not exceed FCC rules regarding EIRP.

Antenna Selection Guide

High-Gain Antenna Type	Gain (dBi)	Frequency Range (MHz)	Feed Connector	Length	Part No.
Yagi 4 Element	8.1	902-928	N Female	12"	Part no: A09-Y8NF
Yagi 6 Element	11.1	902-928	N Female	25"	Part no: A09-Y11NF
Fiberglass Base Station	2.1	902-928	N Female	15"	Part no: A09-F2NF-M
Fiberglass Base Station	5.1	902-928 N	Female	25"	Part no: A09-F5NF-M
Fiberglass Base Station	8.1	902-928 N	Female	65"	Part no: A09-F8NF-M

Antenna and Cable Selection Recommendations

These recommendations are based on ideal conditions and typical installations, intended to guide in designing a system, and may not apply to all installations.

Zlinx Product	RF Output	Distance	Obstacles	Cable	Antenna
ZZ24D-NA-SR	100 mW		None	N/A	Whip
ZZ24D-NA-SR	100 mW		None		Yagi
ZZ24D-NA-MR	50 mW		None	N/A	Whip
ZZ24D-NA-MR	50 mW		None		Yagi
ZZ24D-NB-SR	100mW		None	LMR-600	Whip
ZZ24D-NB-SR	100mW		None		Yagi
ZZ24D-NB-MR	50mW		None		Whip
ZZ24D-NB-MR	50mW		None		Yagi
ZZ9D-NA-MR	100mW		None		Whip
ZZ9D-NA-MR	100mW		None		Yagi
ZZ9D-NA-LR	1mW to 1W		None		Whip
ZZ9D-NA-LR	1mW to 1W		None		Yagi
ZZ9D-NB-MR	100mW		None		Whip
ZZ9D-NB-MR	100mW		None		Yagi
ZZ9D-NB-LR	1mW to 1W		None		Whip
ZZ9D-NB-LR	1mW to 1W		None		Yagi