D I V E R S I T Y
"How to design the ideal digital cordless phone"

by Thomas Jorgensen, Project Engineer at RTX Telecom, tjg@rtx.dk

Continuous voice transmission with no errors is always the goal when designing a cordless phone. Usually there are inevitable impairments to the link budget, either due to interference or due to path loss.

As regards link budget, the solutions are more output power, better sensitivity or antenna gain. These parameters are usually quite expensive to improve, or there may be type approval issues limiting the output power. This article will concentrate on how to design the best cordless phone with given output power and given sensitivity.

Multipath transmission
Multipath transmission will occur whenever the base station and the handset are not both inside the same anechoic chamber. When the handset and base station are within line of sight, the primary propagation will usually be the line of sight and secondary propagations due to reflections will be less significant. Reflected propagations become more significant if the line of sight is obstructed. In fact, reflected transmissions may well be dominant in a normal home environment.
Whenever there is more than one significant impinging wave (with different phases) on a mobile receive antenna, the receiver will be subject to varying signal levels as it moves around. This is caused by constructive and destructive addition of the impinging waves due to their different phase offsets. This mechanism is called multipath fading.

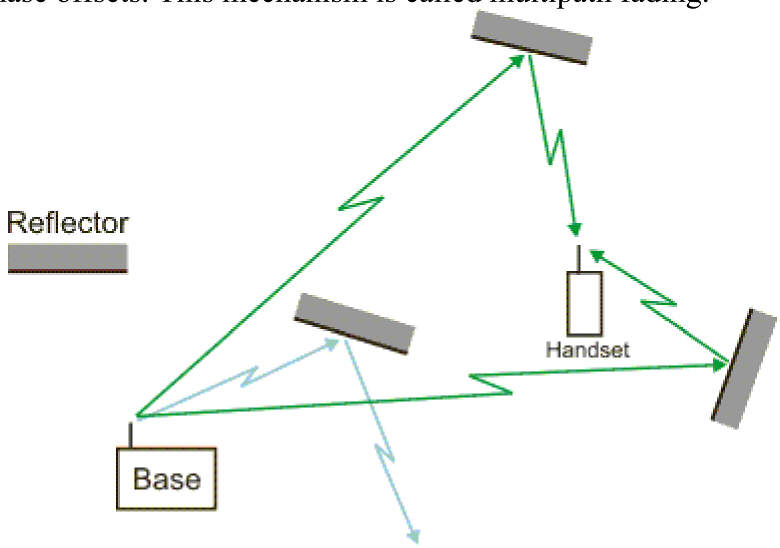

Figure 1. This figure illustrates a simplified multipath propagation, that will cause fading.

Antenna diversity

The home environment is relatively static, and a cordless phone does not move at high velocities. This implies that fading will be slow and generally not change through a timeslot. The idea of antenna diversity is that if receive antenna A is experiencing a low signal level

due to fading, also called a deep fade, Antenna B will probably not suffer from the same deep fade, provided the two antennas are displaced in position or in polarity. The option to select the best antenna significantly improves performance in indoor environments, but does not necessarily increase the maximum line-of-sight range of a product.
Antenna diversity is implemented by equipping the base station or handset (or both) with two antennas. Various selection schemes can be implemented, depending on the actual antenna setup. Preamble antenna diversity, also known as fast antenna diversity, has proven its use in fast frequency hopping systems. Preamble antenna diversity is implemented by comparing the RSSI value of each antenna in the beginning of each receive burst.

Frequency diversity

Frequency diversity exploits the fact that the multipath fading environment changes significantly when the carrier frequency changes. By setting up two or more parallel bearers at different frequencies, the receiver has the choice of which bearer to use. In practice, these bearers are also displaced in time, which is why it is also known as 'slot diversity'. We have implemented a 'dual slot diversity' algorithm for our frequency hopping protocol, which dynamically sets up two bearers if deemed necessary. Frequency diversity can use both RSSI information and CRC checks to select the best received burst.

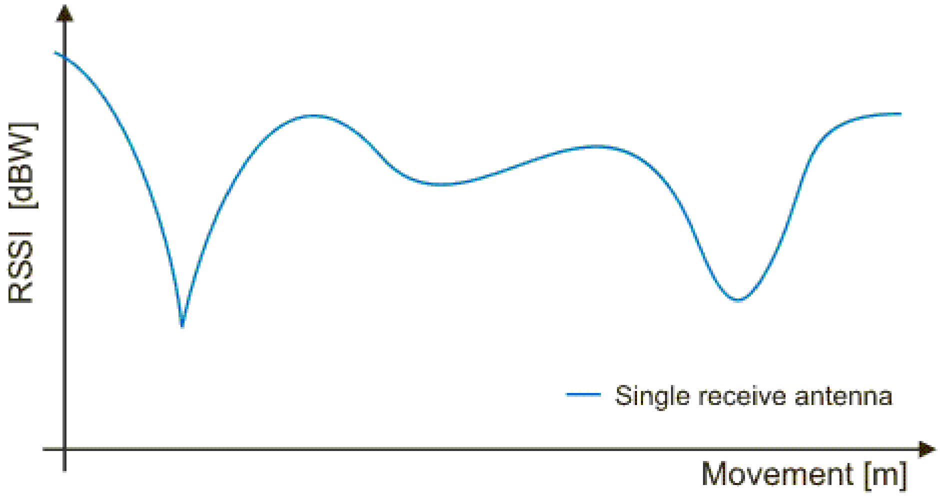

Figure 2. Typical Received Signal Strength Indication (RSSI) of a multipath faded signal.

Hopping vs. fixed frequency

The selected diversity scheme may be different for fast frequency hopping systems as compared to fixed frequency systems. Our 2.4GHz MARS system is an example of a fast frequency hopping system. It uses the 2.4GHz ISM band as specified in FCC regulations. In a fast frequency hopping system it is essential to use a preamble antenna diversity, because the frequency, and thus the multipath environment, changes for each burst.
DECT is an example of a (quasi) fixed frequency system, where each connection is allocated a specific frequency. Except when carrying out handover to another frequency, knowledge of the multipath fading environment obtained from previous bursts can be used to select the best antenna.

Antenna diversity in base station or handset.

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Or both? This question typically arises early in a cordless project. The antenna setup influences, or is influenced by, the mechanics of the cordless phone. The safe solution would be to just install two antennas in both handset and base station, and to use preamble diversity in both ends. This setup provides a total of four sets of propagation paths (only for non-frequency hopping systems).
However, with modern handset form factors, integrating two antennas in one handset may lead to compromises regarding free space around each antenna and proximity to wires and the display. Such compromises effectively reduce the efficiency of the antenna. Adding the second antenna also increases the BOM. One advantage of having two antennas in a handset is when the handset is held awkwardly or if one antenna is impaired by other objects.
The alternative is to have two antennas in either handset or base station. With only one antenna in the handset, there are better options to design an efficient antenna.
With one antenna in the base station and two in the handset, the handset is still capable of adapting to the local environment. However, this solution has slightly higher BOM for sets with multiple handsets.

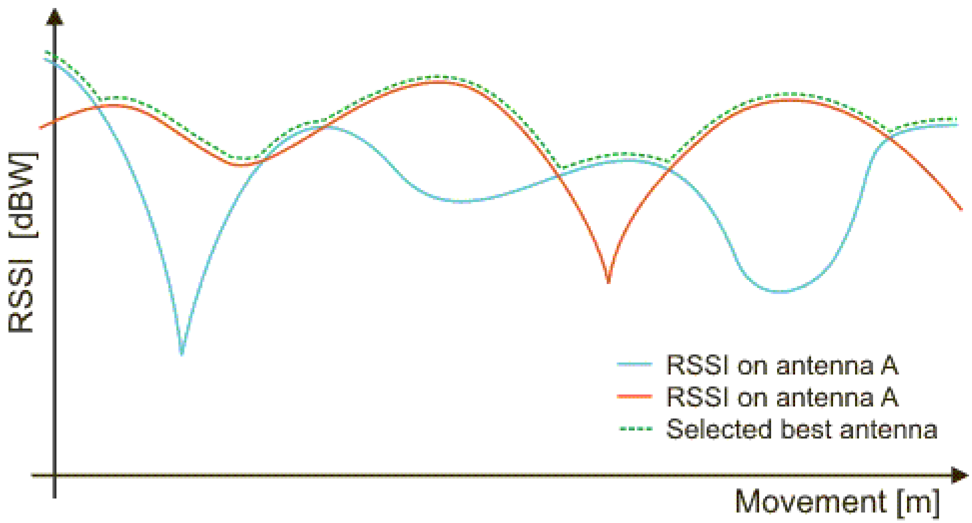

Figure 3. Demonstration of how two antennas can be used to ensure adequate signal level to the receiver.

DECT example: One antenna in handset, two in base station.

In this example, the base station is equipped with two antennas and preamble antenna diversity. The handset only has one antenna. This is the most widely used scheme for DECT systems.
1) The handset transmits a burst to the base station.
2) The base station uses RSSI information during preamble to select the best antenna.
3) 5 ms later, the base station transmits back to the handset, using the antenna from 2).
4) Go to 1).

This scheme utilizes the fact that any radio link is reciprocal. That means, that the best antenna chosen for reception in 2), will also be the best antenna for transmitting back to the handset in 3) - provided that the multipath fading environment does not change significantly within 1/200th of a second. This is normally a sound assumption. To move the handset 2 cm within 5ms, you have to run faster than 14km/h. To turn the handset 5° you must rotate the handset at more than 166 RPM.

DCT example: Two antennas in handset, one in base station.

In this example, the base station is equipped with one antenna. The handset is equipped with two antennas and preamble diversity. This scheme is widely used in our 2.4GHz solutions.
1) The base station selects a new frequency, and transmits one burst to the handset.
2) The handset uses RSSI information during preamble to select the best antenna.
3) 5 ms later, the handset transmits back to the base station on the same frequency, using the antenna from 2).
4) Go to 1).

The same principles are used here as in the DECT example.
Note that four antennas would not provide selection between four propagation paths in fast frequency hopping systems. This is because when the base station (or handset) selects a new antenna for transmission, no knowledge is available of which antenna should be used. Therefore the transmitter has to select a default antenna.

Please contact RTX Telecom for more information.

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RTX Telecom is headquartered at Stroemmen 6, DK-9400 Denmark
Tel: +45 9632 2300 . Fax; 45 9632 2310 . Webpage; www.rtx.dk