What makes WiMAX so hard?

WiMAX™, the much-heralded mobile broadband wireless technology, offers fantastic opportunities for companies looking to provide users with anywhere communication access, but its capabilities come at a price. The technology is highly complex, and requires a level of expertise never seen before in wireless technology development. So, what makes it so difficult?

The WiMAX physical layer (PHY) is based on a technique called Orthogonal Frequency Division Multiplexing (OFDM). OFDM was devised to overcome large-scale inter-symbol interference that occurs in broadband channels when they experience multi-path signals (i.e. when radio signals travel via an indirect route of many reflections of different length). Under these multi-path conditions, some frequencies within the channel suffer, as signals destructively interfere, causing frequency-selective fading. With OFDM, the wideband channel is sliced into many ‘narrow’ channels (from fewer than a hundred to two thousand, depending on the system). All these narrow channels are then used simultaneously to generate an aggregate broadband connection – the advantage being that frequency-selective fading only affects a small number of these narrow-band channels. This means that the system can be designed to be robust for non-line-of-sight channels with high data rates maintained – excellent for delivering high-speed data services to users out and about in urban environments. The narrow channels also lend themselves to other techniques that help to boost system performance such as the use of spatial diversity techniques.

OFDM, invented in the 60s, has only recently appeared in mass market products as low-cost processing power reached the point where it could be cost-effective. The technique is used in broadcast systems (DAB and DVB), DSL and WiFi. In all of these systems OFDM is used to support a link where a receiver listens to one transmitter at a time. Mobile WiMAX goes one step further. It adds capability for many users to transmit simultaneously (OFDM becomes OFDMA or Orthogonal Frequency Division Multiple Access). In this case each user is allocated a subset of the sub-carriers and/or a subset of the available ‘on-air’ time for themselves. This enables WiMAX to offer low-latency, high-speed data services and provide very efficient use of the available capacity.

OFDM relies on the many narrow carriers being orthogonal (i.e. they must not interfere with one another). With many users transmitting simultaneously from different locations and while moving, maintaining this orthogonally at the base-station requires additional complex algorithms. One example is that the clock timing of terminals needs to be maintained to within a few parts per billion. Typical crystal accuracies offer only a few tens of parts per million. Further, to minimise latency and maximise the ability to make use of all the bandwidth, the allocation of when and on which narrow-band sub-carriers each user can transmit, is done at the last possible moment. This means that a received burst needs significant levels of immediate processing before the structure of the data can be recognised and fully decoded.

As you can see from these examples, the technical effort required even before the technology reaches the mass market is phenomenal, but if you can overcome these issues, as we have for picoChip’s WiMAX basestation and mobile station reference designs, then a whole world of exciting possibilities opens up.

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WHAT DOES ORTHOGONAL MEAN?

OFDM uses a large set of sub-carriers (or tones) to carry data. The frequency response of a single tone has regular zero-crossings (see figure 1). By spacing the tones at these zero-crossings, they can be seen to be orthogonal (the main energy of each tone aligns with the zero-crossings of all the other tones used).

If the tones are off-frequency relative to one another then they lose this orthogonality and can be seen to interfere with one another (see figure 2).

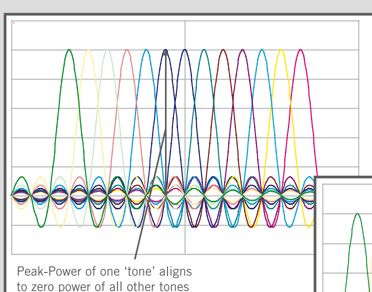

figure 1

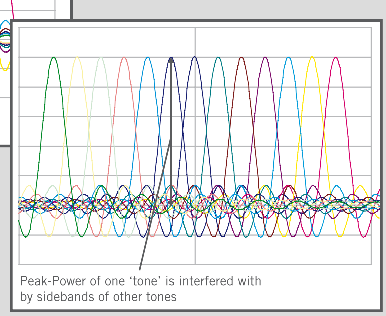

figure 2

WHY USE ‘NARROW’ FREQUENCY TONES?

Each tone carries a relatively slow symbol rate; in fact for WiMAX, symbols are approximately 32km in length, so short reflections from buildings and other objects are negligible in terms of overall symbol length, making the technique good for multi-path environments.