

ULTRA WIDE BAND *an overview*

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Ultra Wide Band (UWB) is a technique that has received a lot of attention recently, in particular in the US. The FCC has licensed its use and a number of new companies have staked their future on its success. In Europe there is more of an air of caution, with some concern about the interference it could cause. This article sets out to clarify what UWB is and how it applies to LPR applications.

WHAT IS UWB?

UWB is simple in principle. Very short pulses, which carry data, are sent from the transmitter to the receiver. For operating in the 3.1-10.6 GHz band (as defined by the FCC mask) a pulse width of 50-100 ps would be used. The narrow pulse leads to the wide spectrum. This in turn allows a low power spectral density for a given transmission rate, leading to the claim that it will not interfere with other users of that band.

The pulse rate will be determined by a number of factors. In many applications each pulse may carry one bit of data. Even for a data rate as high as 500 Mb/s (2ns period) a transmitter will still only have a low duty cycle. This therefore gives the potential for many transmitters to operate at the same time in the same area with acceptable interference. For lower data rates, multiple pulses per bit may be used either to reduce the individual pulse energy or to increase the range.

The transmission of pulses at regular intervals would lead to a number of problems. Firstly, a comb spectrum would be produced, and the peaks in power spectral density would cause interference to narrow band systems - See Figure 1 below.

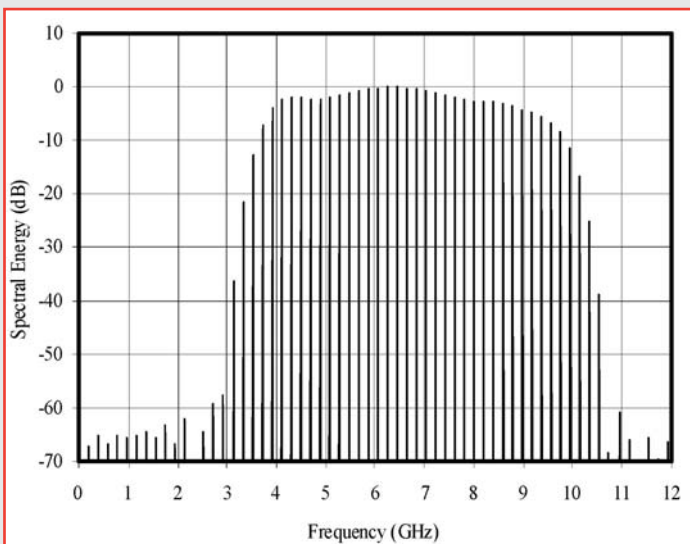


Figure 1 Comb spectrum due to regular UWB pulses

Secondly, signals from two transmitters may align in time at a receiver, preventing reception of the data. Pseudo random time hopping is typically used to overcome both these problems. Variation of transmit time may also be used to provide the data modulation. Alternatively pulse polarity may be used.

In principle, reception of a UWB signal is very simple. We amplify the signal, sample it at the time the pulse is expected and measure the voltage. The difficult part is acquiring and maintaining timing synchronization, since the sampling point must be aligned to better than ± 50 ps. Any errors in the local frequency reference will rapidly cause timing accuracy to be lost. Techniques therefore combining timing and clock frequency acquisition are required.

WHY UWB?

Given the high bandwidth circuitry that is required and the difficulties of synchronization with UWB, what is the payoff? This is found in a number of unique benefits that UWB offers:

- UWB provides a wide bandwidth signal more simply than techniques such as direct sequence spread spectrum (DSSS). Imagine a DSSS system with a 7GHz chip rate! This wide bandwidth and associated low power spectral density allows UWB to share the spectrum with other systems. Thus, UWB effectively liberates a whole new band for short range, wide bandwidth services.

- Moreover, self-interference in a UWB network is also very low, allowing a large number of UWB terminals to operate in a given area, either cooperatively as part of an ad hoc network or as independent links (or networks).

- The use of narrow pulses makes UWB very tolerant to multipath. Reflected pulses will not generally overlap, so will not interfere. The system benefits from the use of a 'RAKE' receiver to capture energy from multiple paths in the same way as conventional DSSS receivers.

- Another key advantage of UWB is that it can provide accurate (<1cm) range information. The process of acquiring tight time synchronization when used in a duplex link provides accurate round trip delay and hence range. Position can be determined using multiple fixed sources and even orientation can be ascertained by using multiple antennas.

- UWB also has many RADAR and imaging applications.

REGULATIONS

Because UWB must use spectrum that is also allocated to other systems, its regulation is clearly an important topic. In Feb 2002 the FCC first licensed operation in the US. They defined a set of spectrum masks for a range of applications. The most relevant here are those for communications, which are shown below.

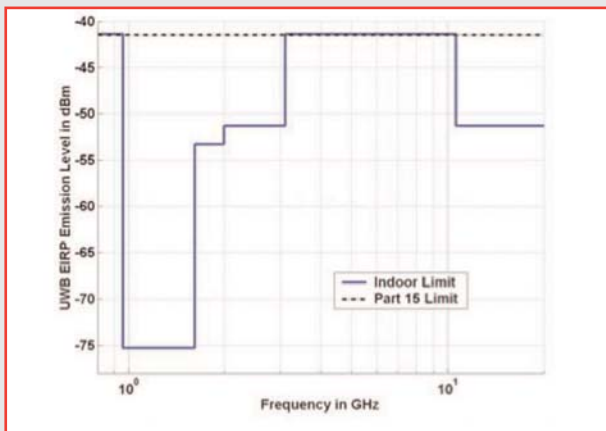


Figure 2 Indoor Emission Limit

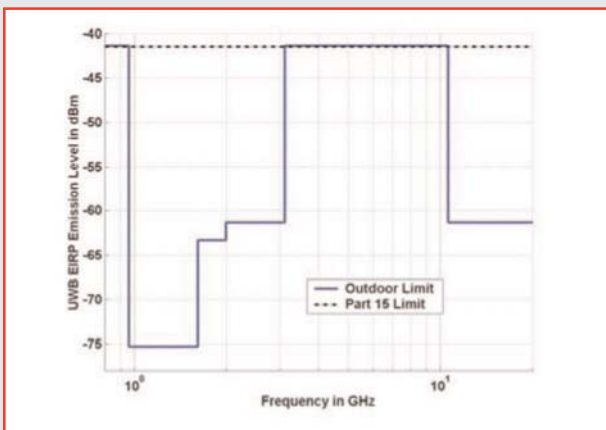


Figure 3 Outdoor Emission Limit

These set a limit at or below the 'Part 15' limits, which apply to any electrical equipment that is not designed to transmit, e.g. a laptop. For particularly sensitive bands, such as the GPS band, the limit is much lower. The stated intention of the FCC was to set a low limit, which will be revisited in 12 months. This will be increased as long as results do not indicate an interference problem.

In Europe ETSI have proposed to adopt similar limits, although they are likely to introduce a mask with a roll off rather than sharp edges. However, some groups have raised objections to UWB. At first this does not seem logical as any non-radio communications equipment can emit similar power levels anyway. However, UWB equipment is likely to maximize the transmit power, using the full mask, whereas unintentional emissions are likely to contain more discrete spurious frequencies with a lower total power. It is not clear at this stage what the cumulative effect of radiated power from multiple sources will have on the interference environment.

How this will be resolved is uncertain, however the concern is that, if Europe does not license UWB, it will miss out on the business opportunities, and US equipment will end up being used in Europe anyway.

IMPLEMENTATION

Most of the protocols and control for UWB can be implemented using standard CMOS ASICs as for most radio systems. For the RF front end, utilization of the full spectrum mask up to 10.6 GHz may complicate implementation in the short term, as current silicon processes currently only just support this. However, for many low-cost applications it is expected that the upper frequency will be limited in order to allow standard silicon processes, as the resulting total power and range limitations are not critical because most applications are very short range.

COMMERCIALIZATION

The early interest in UWB was largely driven by a few US venture capital funded companies, in particular Time Domain Corporation®, Multispectral Solution, and Xtremespectrum. These have all developed their own implementations, including ASIC developments. However, with the standards still changing these are still not final commercial products. The main drive for low-cost, high-volume UWB ASICs will come from the IEEE 802.15.3 PAN (Personal Area Network). As well as having the force of being an IEEE standard, this is being promoted by the commercial WiMedia Alliance (<http://www.wimedia.org>). However, market predictions suggest that we will not see this achieve high volumes until 2006.

There are many more specialized applications where size and cost are less critical. Flexible test beds such as the one under development by Roke Manor Research (Figure 4) can be used to develop these applications.



Figure 4 Roke Manor Research test bed

Exactly how the applications for UWB will develop is as yet uncertain, but it seems certain that we will be hearing a lot more about this interesting and novel technology in the next few years.

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