WHITE PAPER – ACHIEVING PERFORMANCE FOR

HIGH DEFINITION VIDEO OVER WIRELESS LINKS

By Link Research

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1. Introduction – operational requirements

As broadcasters move towards High Definition productions, the first applications for High Definition TV include the world's most prestigious, high profile, international sports events which are transmitted live. Wireless camera systems are now commonplace at live sports events so the shift to HD means there is a clear need for a digital wireless camera system for HD TV.

The broadcasters' requirement to capture fast moving games and races as they happen and to enable the feeds from the wireless cameras to be used alongside the video from a number of other wired cameras, means that the wireless link should not create a visible signal delay.

This paper describes the technical challenge presented by the requirement for a digital wireless camera system for HD that has ultra low signal delay and which will satisfy the needs of the most demanding broadcasters.

2. Bandwidth issues

Typically an HD signal has about six times as much data as an SD signal, coming from the camera over a serial link at around 1.5Gbps. To maintain the quality of the HD image it is essential that the full spatial resolution of the picture is maintained; this rules out down-sampling, wireless transmission and up-sampling approaches which seriously degrade picture quality. Link's unique FPGA technology maintains contribution quality at bit rates around 20 Mbps, and delivers high quality HD images at as little as 8Mbps, all at full HD resolutions and in all HD formats. All this is achieved using Link's ultra low delay technology which gives end to end (video in to video out) delay of less than 50ms for seamless mixing with wired cameras.

Once the first hurdle, to adequately compress the original images without sacrificing quality, has been overcome, the next is to encode and modulate this signal into a format that can be used in typical RF channels of 10 MHz bandwidth.

Many wireless solutions use DVB-T however, DVB-T was not optimised for such applications. It does not make full use of the typical channel bandwidth and its error correction capabilities can be significantly improved upon. At the signal bandwidths required for high quality HD transmission, DVB-T suffers excessively from drop-outs and interference.

So how do wireless camera systems, requiring ever increasing amounts of data and therefore increasing amount of required bandwidth , deal with the issues? Link has addressed this in several ways; firstly, by offering more efficient and flexible modulation systems, and secondly, by offering users the ability to use different parts of the RF Spectrum.

3. Improved Modulation Techniques

Although DVB-T was designed for static terrestrial systems, it is used in most of the more reliable wireless camera SD systems. DVB-T has the advantage of being compatible with readily available, off the shelf components, but has the disadvantages of not having been designed for optimal performance in mobile applications and is showing its age; particularly in the area of Forward Error Correction where DVB-T's Reed-Solomon/Viterbi system is significantly outperformed by the latest developments in FEC technology.

Link Research has developed a new COFDM-based modulation system, Link Modulation System (LMS-T), which has taken the advantages of DVB-T and developed it to improve robustness and throughput specifically for highly mobile wireless camera systems. LMS-T uses fewer carriers (a 512 point FFT rather that 2K for DVB-T). This gives improved doppler performance for high speed vehicles and reduces sensitivity to phase noise giving a more robust link.

Typically 10MHz is allocated by regulatory bodies for wireless camera operation . Nominally DVB-T uses 8MHz, and the remaining 2MHz is not used. LMS-T uses 9.4MHz bandwidth and this alone give up to 25% additional throughput. The linearity and performance of Link's output RF stages still ensures that systems can be run in adjacent frequency slots.

LMS-T also has much deeper interleaving than DVB-T, spreading the data over more carriers and over a greater time period. This makes it much more resistant to burst interference and short duration fades that are typical of mobile use.

Error correction has also been addressed by replacing Viterbi by LDPC (recently adopted for DVB-S2). The improvement over the existing Viterbi encoding of DVB-T is roughly equivalent to doubling the transmit power or increasing the throughput by 33% at the same power, with LMS-T's FEC rate 2/3 LDPC offering performance that exceeds that of DVB-T FEC rate ½.

DVB-T	FEC\Guard	1/16	1/32
QPSK	½	5.85Mbps	6.03 Mbps
16QAM	½	11.71Mbps	12.06 Mbps
64QAM	½	17.56Mbps	18.10 Mbps
LMS-T Modulation	Guard / FEC	1/8	1/16
QPSK	2/3	9.215 Mbps	9.757 Mbps
16QAM	2/3	18.43 Mbps	19.51 Mbps
(64QAM)	2/3	27.64 Mbps	29.27 Mbps
LMS-T Modulation Dual Channel 20Mhz	Guard / FEC	1/8	1/16
QPSK	2/3	18.43 Mbps	19.51 Mbps
16QAM	2/3	36.86 Mbps	39.02 Mbps
(64QAM)	2/3	55.28 Mbps	58.54 Mbps

Overall LMS-T has a throughput that is 65% higher than DVB-T at the same level of robustness, which is a major advantage for Wireless Camera systems transmitting high bit rate HD signals. A further option available with LMS-T is support for dual-channel operation to double the throughput where additional channels are available for licensing or the channel allocations are 20MHz or wider. In its dual-channel mode LMS-T can support bit rates as high as 55Mbps (64QAM, rate 2/3) whilst retaining highly reliable link performance. The LinkHD system offers both DVB-T for compatibility, and LMS-T for best performance.

4. Wider Choice of Operating Bands

As more and more wireless products hit the market, finding frequencies at which to operate wireless camera systems is becoming a major problem. Highly funded mobile telephone operations, Wireless LAN etc are taking a lot of the bandwidth which normal Wireless Camera operations, Electonic News Gathering (ENG) and Sports would have been licensed to use. There are also a lot more wireless cameras systems in use. Events where there are more than 20 frequency allocations for camera system are not uncommon.

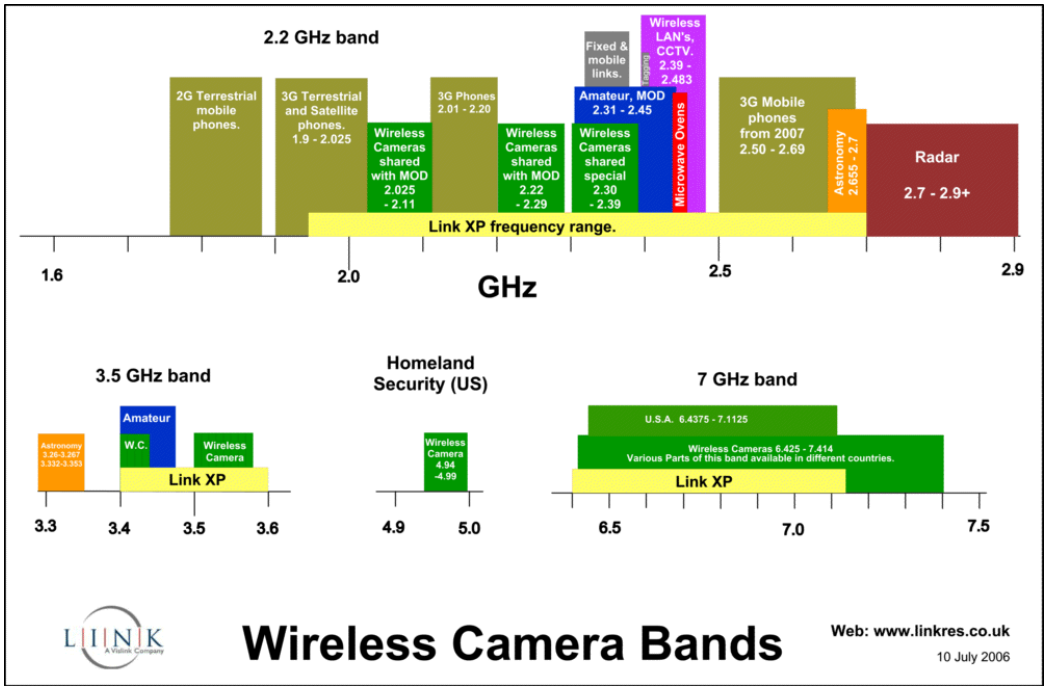

Diagram showing Wireless Camera Coverage and other uses.

Most of the early digital wireless camera systems were based in the 2GHz band. This has been filling up with mobile phone, WiFi allocation, and pre-allocated bands making it difficult for the operator to get a frequency allocation in an acceptable band. Since 2004 Link's wireless camera systems have covered the whole 1.95GHz - 2.7GHz band, which gave users the ability to operate anywhere within that band with one unit.

Pressures on the 2GHz band, as can be seen from the diagram above , have encouraged Link to develop systems for the 3.4 - 3.58GHz and the 6.425 - 7.125GHz Bands. Further bands are planned but these are highly dependant upon local regulations and markets . The modularity of the Link Research systems, where downconverters are used to convert the received data to UHF for coax or fibre transport, means that much of the equipment is common between the bands. Consequently changing to new bands can be done without requiring heavy investment in completely new equipment.

5. HD Receivers and Diversity

An optimised modulation scheme like LMS-T provides significant performance advantages for wireless camera systems, but it must be matched by similarly optimised demodulation and decoding equipment. Link's wireless camera systems pioneered the use of diversity reception to greatly improve the reliability of the RF link. Receiver diversity is combined with in-house decoding technology which is tailored to the realities of the wireless environment, with very fast signal acquisition and advanced error concealment, minimising the visual impact of drop-outs due to interference or operating at long range.

The LinkHD receivers use Maximum Ratio Combining MRC diversity on their RF inputs for optimal performance from multiple antennae. It also employs Link Research' s renowned ASI packet diversity system to maximise error free picture delivery. It maintains ASI packet compatibility with the SD equipment as far a Link Researches Cellular Diversity networks, which allow wide area coverage with simple implementation. This award-winning technology has proven itself in applications ranging from the Oxford-Cambridge Boat Race, to golf courses to city-wide news gathering networks, providing unprecedented freedom of action for event coverage.

6. LINKHD unmatched High Definition Wireless performance

Link Research has drawn deep on their knowledge and experience of SD wireless systems to develop solutions that overcome the challenges of wireless HD. The system offers excellent ultra low delay encoding (<60msec), novel and robust DVB-T and LMS-T modulation techniques, and multi -frequency options to make a unique and flexible unit.

For more information both technically or commercially please contact Link Research Limited. sales@linkres.co.uk or visit www.linkres.co.uk