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Wireless HD Video: Raising the Throughput Bar

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It is difficult to imagine a wireless technology with more innovation and dynamism at work than ultra wideband (UWB), particularly for the delivery of HD video.

After a period of relative quiet in the UWB arena, new products are emerging to raise the throughput bar. Recent independent tests put Radiospire (www.radiospire.com) in the lead.

Testing by octoScope verified that Radiospire's AirHook technology achieved throughput of 1.6 Gbps – fast enough for uncompressed HD video distribution over distances of 15 feet. Radiospire sponsored the test.

This article will first review the promise and technical challenges facing UWB, report on the most recent test results, and analyze Radiospire's approach to UWB. We will also discuss the throughput and encryption considerations for HD video distribution.

Leapfrogging technologies

It was less than a year ago that the industry eagerly anticipated the arrival of Certified Wireless USB (CW-USB) and wondered how close real-world systems would come to the advertised 480 Mbps PHY rate quoted by the technology's trade association, the WiMedia Alliance. Some WiMedia companies were promoting their technologies for video distribution – with the help of data compression.

In independent testing conducted by octoScope and published by EE Times and Wirelessnetdesignline, however, performance of CW-USB chips and systems proved to be disappointing. But the same testbed confirmed that Pulse-Link's CWave technology achieved a 675 Mbps PHY rate and 500 Mbps of application layer throughput.

Now Radiospire has taken the lead. It remains to be seen how WiMedia and Pulse-Link will respond, not to mention the UWB technology community, which has already taken initial steps toward standardizing a 60 GHz technology.

UWB video challenges

UWB operates in the noise floor of traditional wireless applications and is able to share the already allocated spectrum with other services while only negligibly raising their noise floor.

The low transmit power limit of -41.3 dBm/MHz EIRP (Effective Isotropic Radiated Power) curtails the range of UWB to about 10 meters, but the wide available spectrum of 3.1 to 10.6 GHz, enables high throughput applications, making UWB technology well suited for short range High Definition (HD) video transport, connecting devices such as the DVD players, set-top boxes and displays.

After the FCC approved the UWB spectrum allocation in February of 2002, the IEEE 802.15 committee attempted to standardize the MAC and PHY layers to operate in the UWB band, but abandoned this effort in January of 2006 for lack of consensus. Many of the companies originally working on the IEEE 802.15 standard joined the WiMedia Alliance and focused on the CW-UWB technology that was evaluated in octoScope's recent EE Times test.

In that test the WiMedia-based products exhibited an order of magnitude lower throughout than Pulse-LINK (675 Mbps), the only non-WiMedia product tested. Now Radiospire, another player outside the WiMedia camp, has set a new record of 1.6 Gbps.

Although WiMedia is regarded as the UWB standard, companies such as Pulse-LINK and Radiospire point out that other MAC and transport standards, such as the IEEE 802.15.3b, TCP/IP and HDMI (High Definition Multimedia Interface) can also bridge the gap between UWB PHY technologies.

The original goal of UWB was short range HD video distribution. HDMI, in particular, is an uncompressed video interface, requiring more throughput (table 1) than was achievable in the UWB band until Radiospire came along.

Table 1: *Uncompressed video throughput requirements*

Format	**Resolution**	**Bits/pixel**	**Frames/second**	**Total uncompressed throughput***
720p	1280 x 720	24	60	1.3 Gbps + audio
1080i	1920 x (1080/2)	24	60	1.5 Gbps + audio
1080p (YCrCb)	1920 x 1080	12	60	1.5 Gbps + audio
1080p (RGB)	1920 x 1080	24	60	3.0 Gbps + audio

** Audio bandwidth varies with the number of channels. 8-channel audio requires 74 additional Mbps of transport bandwidth: 8 ch x 192 kHz x 2 (Left/Right) x 24 bits/sample = 74 Mbps.*

Why uncompressed video?

Uncompressed video is required for several important applications, including wireless display, gaming and content protection.

Compression techniques, such as MPEG, can result in the loss of information that may be visible on large high resolution displays, especially if inexpensive encoders are used.

Video compression techniques, such as MPEG 2 and MPEG 4, reduce video information by transmitting only the differences from frame to frame whenever possible instead of sending entire video frames. The need to process multiple frames during compression introduces an inevitable delay that is perceptible to humans and unacceptable for applications such as wireless display and gaming.

Because MPEG based compression relies on video data and changes from frame to frame, it cannot work on encrypted video since encryption purposefully hides the video information being sent. DRM (digital rights management) encryption of video data, intended to prevent piracy, makes compression impossible. Such is the case with the HDMI where the video signal is encrypted and cannot be compressed. The simplest way to implement wireless HDMI is to transport the HDMI signal as is – encrypted and uncompressed.

To enable uncompressed HD video transmission, the industry has created the IEEE 802.15.3c standards group that is developing a high speed airlink specification for the 60 GHz unregulated band. An industry Interest Group, WirelessHD (www.wirelesshd.org), has also created its own 60 GHz specification specifically tailored for HD video distribution. These 60 GHz initiatives were formed because it was widely believed that uncompressed video transmission wouldn't be achievable in the UWB band. Now Radiospire has proven otherwise.

The 60 GHz technology still faces challenges such as expensive power amplifiers, high path losses and shadow effects. The shadow effect is a serious issue for 60 GHz whereby a person or an object located in the beam can disrupt the airlink transport. To address the shadow effect disruptions, sophisticated beam steering is being employed by the emerging 60 GHz solutions, but this can be costly. The Radiospire AirHook technology avoids these issues since it operates at lower UWB frequencies from 3.1 to 4.8 GHz.

Given the high performance requirements for uncompressed HD video distribution and the relative immaturity of 60 GHz radio technology from a cost and performance point of view, the Radiospire UWB chipset is presently the only market-viable solution. Radiospire claims that its technology is spectrum agnostic and can operate in the UWB 3.1-4.8 and 6-10 GHz bands or move up into the 57-66 GHz band as the 802.16.3c standard and technology matures.

Even as progress is made in the 60 GHz technology, the UWB band may continue to be the spectrum for more cost-effective implementations of HD video distribution. Lower frequencies typically offer a higher degree of robustness to a wireless link.

Test results

Radiospire with its AirHook ™ UWB chipset has demonstrated the highest airlink throughput in the UWB industry of about 1.6 Gbps. The top device in our recent EE Times test, Pulse-LINK's CWave™, performed at 675 Mbps PHY data rate and delivered approximately 500 Mbps TCP throughput. WiMedia devices, comprising most of the UWB market, reached only around 50 Mbps application layer throughput. We were unable to verify whether the WiMedia PHY data rate reached the advertised 480 Mbps.

The WiMedia vendors claim that the low throughput is due to early driver implementations. The top performing new generation WiMedia chipset from Alereon is expected to reach 160 Mbps, but this is still an order of magnitude lower than Radiospire's 1.6 Gbps.

octoScope has verified the 1.6 Gbps performance of the Radiospire AirHook chipset both on the bench and working as an HDMI cable replacement. The airlink transport of uncompressed 1080p HD video and 8 channel audio worked at 15 feet of range, through obstructions and at any antenna orientation.

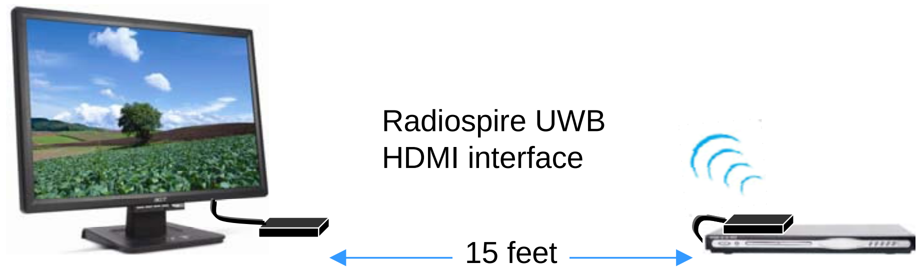


Figure 1: *Testing verified studio grade performance of the Radiospire wireless UWB based HDMI cable replacement reference design.*

The data converters worked at 1.92 Giga samples per second with 5.5 bit effective resolution. The Radiospire device handled 1.7 GHz of bandwidth from 3.1 to 4.8 GHz, per design.

The system test setup included two displays placed side by side for a visual comparison of signal quality on the airlink vs. the ideal cabled signal. One of the displays was connected to the video source through an HDMI cable and the other display was connected through the AirHook airlink (figure 2).

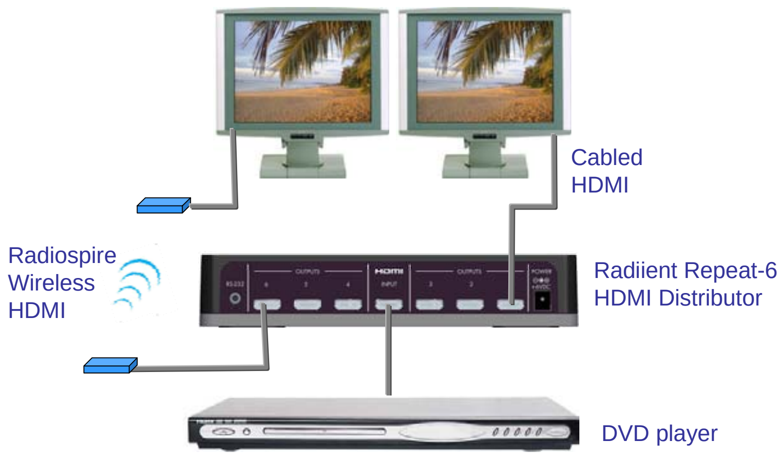


Figure 2: Radiospire system test setup – *two displays side by side with one connected through an HDMI cable and the other via the Radiospire UWB link. The Radiient repeater was used to split the HDMI signal into two identical synchronized streams.*

The airlink delivered approximately 1.6 Gbps at all antenna and device orientations and with humans and furniture blocking the beam. The display quality on the wired and wireless HDMI links were indistinguishable to the naked eye under all test conditions (figure 3). The audio on both displays was synchronized with no perceptible delay indicating low latency on the UWB link.

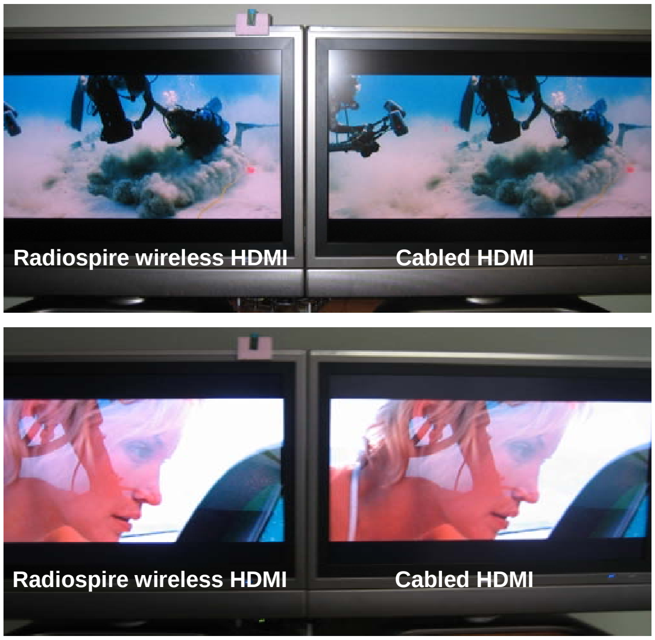


Figure 3: Comparison of the video quality *between the wired and wireless links revealed no visible differences under any of the test conditions, for any antenna orientation and with obstructions in the beam.*

The video quality was tested with 2.4 GHz Wi-Fi interference (streaming video from a website to a laptop) right next to the Radiospire device and with 900 MHz interference from a nearby baby monitor. We have observed no degradation in video quality due to this interference.

We also verified the transmit power at the antenna port of the transmitter for FCC compliance (figure 4). This was intended to be an informal verification.

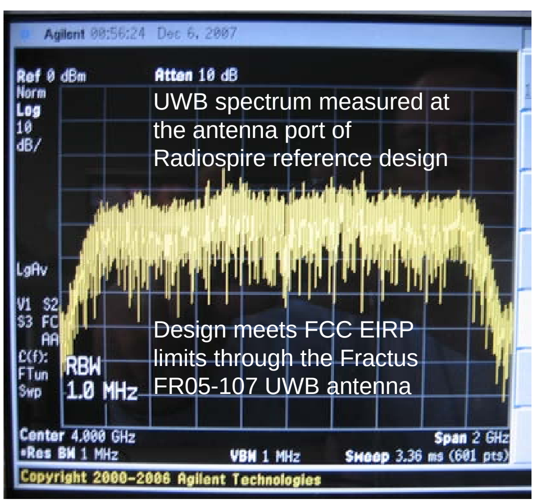


Figure 4: Informal FCC compliance verification – *conducted spectrum measurement at the antenna port of the transmitter. The average power at the antenna port is below -40 dBm/MHz and with some isotropic losses through the antenna meets the FCC limit.*

Tables 2 and 3 summarize the tests we have performed and the test results.

Table 2: Bench-top verification *of the Radiospire AirHook chipset*

Bench-top Tests	
ADC and DAC operation at 1.92 Gsps	√
1.7 GHz of bandwidth	√
Operation at 1.6 Gbps	√
FCC compliance conducted power informal verification	√

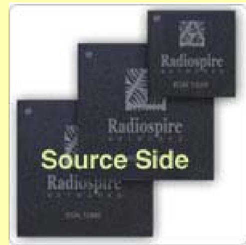
Table 3: System verification *of the Radiospire AirHook chipset*

System Tests	**With obstructions in the beam**	**With 802.11 interference**	**With 900 Mbps interference**	**At variety of antenna orientations**
System operation at 12 ft, 720p, 1.6 Gbps (video quality)	Flawless	Flawless	Flawless	Flawless
System operation at 15 ft, 720p (video quality)	Flawless	Flawless	Flawless	Flawless
System operation at 12 ft, 1080p, 1.6 Gbps (video quality)	Flawless	Flawless	Flawless	Flawless
System operation at 15 ft, 1080p, 1.6 Gbps (video quality)	Excellent	Excellent	Excellent	Excellent
Audio synchronization on both displays	No detectable asynch	No detectable asynch	No detectable asynch	No detectable asynch

AirHook technology review

The Radiospire AirHook chipset implements a UWB point to point airlink with a transmitter on one end and a receiver on the other end. The chipset is composed of three devices on the TX end of the link and three counterpart devices on the RX end of the link (table 4, figure 5).

Table 4: Radiospire AirHook chipset

Display-Side (RX) 	**Source-Side (TX)** 
RSN1080 Digital Baseband ASIC	RSN1080 Digital Baseband ASIC
RSN1055 Dual 6-bit 2 Gsample/sec ADC	RSN1050 Dual 6-bit 2 Gsample/sec DAC
RSN1025 Direct Conversion Receiver	RSN1020 Direct Conversion Transmitter

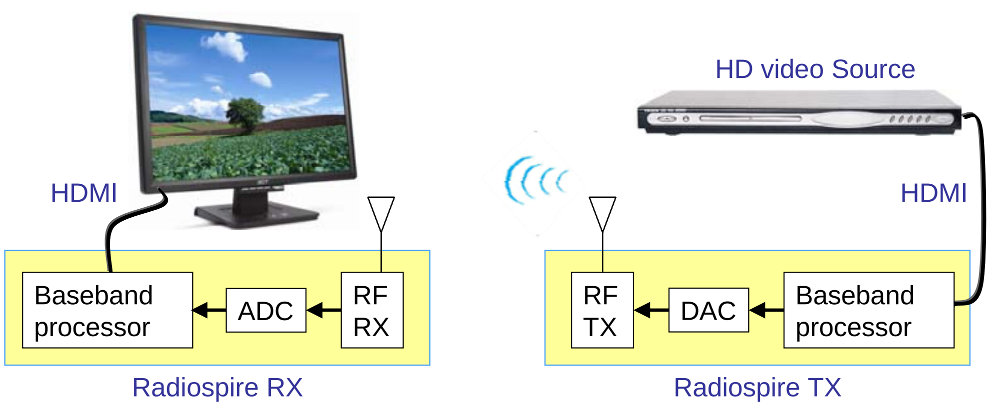


Figure 5: Radiospire wireless HDMI solution – *UWB TX and RX. The video interface supports almost any standard format including HDMI, DVI, XGA and analog video such as NTSC, composite and S-video.*

The AirHook chipset employs OFDM signaling with 512 carriers using 16-QAM modulation. The spectrum of the RF signal is 1.7 MHz wide, from 3.1 to 4.8 GHz. The 6-bit ADCs (Analog to Digital Converters) and DACs (Digital to Analog Converters) operate at 1.92 Gsamples/sec on an 850 MHz baseband signal.

The Radiospire Baseband processor (figure 6) incorporates Low Density Parity Check Coding (LDPC) Forward Error Correction (FEC) functionality – powerful FEC technology that significantly reduces bit error rate. While the raw airlink data rate reaches 2.2 Gbps, the LDPC corrected data rate is 1.6 Gbps, the throughput required for 1080p HD A/V transport.

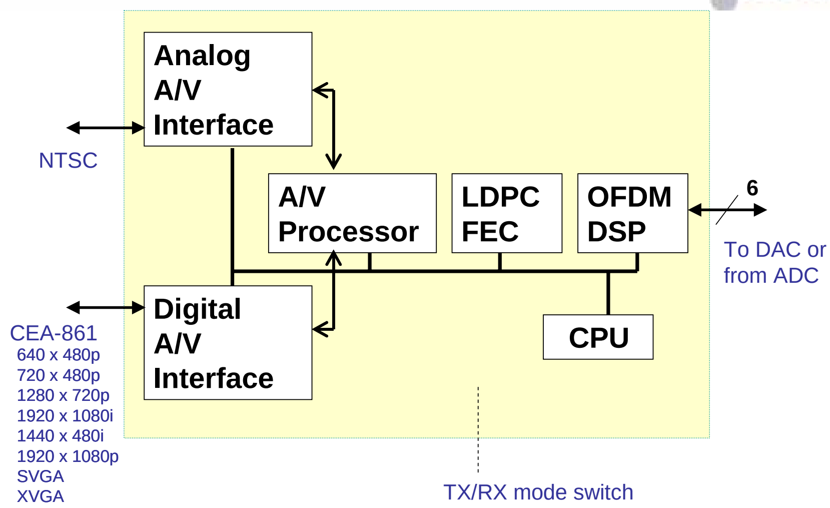


Figure 6: Radiospire Baseband Processor *able to operate in either transmit or receive mode and interfacing between the video interface, such as the HDMI or the SVGA, and ADC or DAC chips*

The Radiospire ADC and DAC (figure 7) have been segregated into their own 0.35um SiGe BiCMOS ICs for optimum performance.

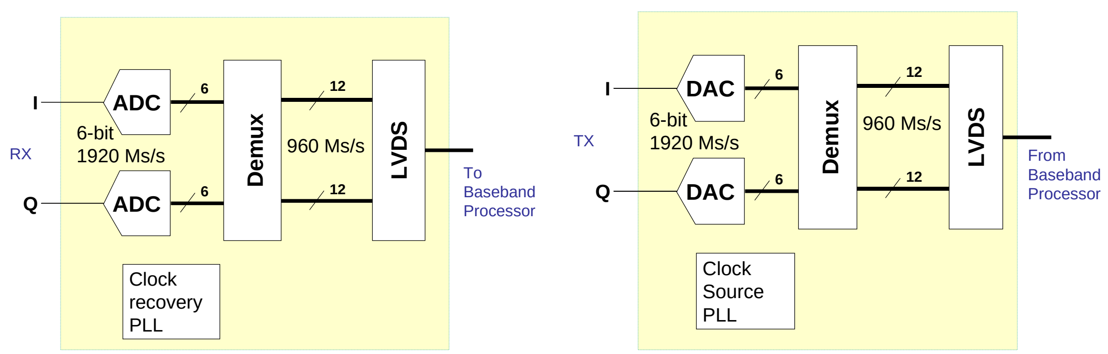


Figure 7: Radiospire ADC and DAC devices *interfacing between the RF front end and the Baseband Processor*

The Radiospire RF receiver and transmitter (figures 8, 9) have also been segregated into their own 0.35um SiGe BiCMOS ICs to optimize signal integrity and bit error rate performance.

As evident from figures 6-9, the clean segregation of the AirHook architecture and focused implementation of each functional block may explain why Radiospire has been able to reach 1.6 Gbps on their UWB interface.

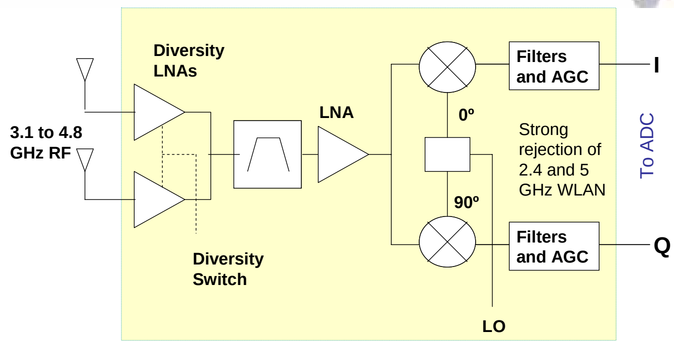


Figure 8: Radiospire RF Receiver device *interfacing to the ADC*

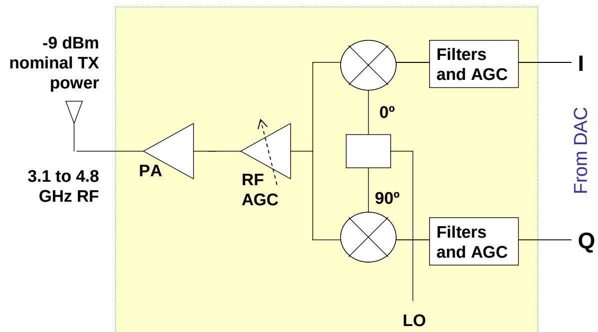


Figure 9: Radiospire RF Transmitter device *interfacing to the DAC*

Conclusion

Following our recent EE Times UWB test, we were glad to discover that the throughput performance of UWB now has a new record of 1.6 Gbps – performance verified for the Radiospire AirHook chipset. This is a significant step up from the 675 Mbps PHY rate of Pulse-LINK's CWave, the winner of our last test and much higher than WiMedia, which delivered around 50 Mbps at the CW-USB application layer and now promises around 160 Mbps with the next generation products.

It is notable that the two highest performing UWB chipsets available today are not based on the WiMedia standard and exceed the verified and expected WiMedia performance by an order of magnitude.

Radiospire is the first to enable uncompressed 1080p HD video transport in the UWB band at a level of throughput that seemed unreachable just a short while ago. While Radiospire's technology can be adapted to the emerging standards based 60 GHz band, the UWB solution is the only working solution on the market today. Radiospire's robust performance at a variety of antenna orientations, in the presence of interference and through obstructions will enable solid and successful UWB based products.

Appendix A: Test Methodology

Performance validation involved the following steps:

- Bench-top validation of the data converters
- Bench-top validation of radio performance
- Validation of system performance

Validation of data converters and radio performance was done in collaboration with a Radiospire engineer by observing the test waveforms and the recovered data captured by a logic analyzer and processed by the Radiospire test software.

The transmit and receive units were separated by 12 to 15 feet with the couch obstructing the path between the two ends of the airlink (figure 10).

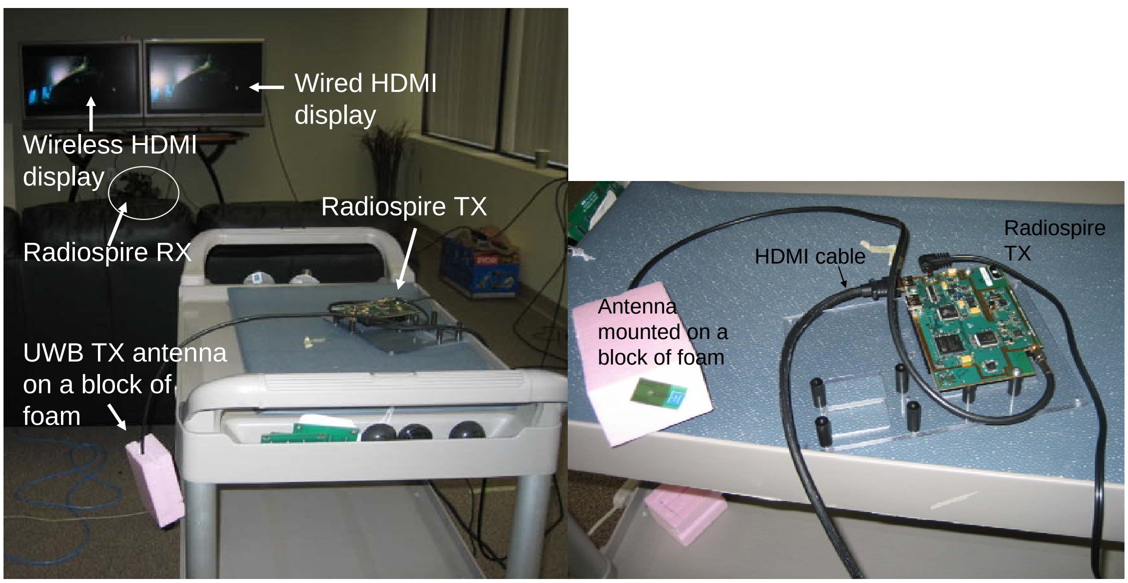


Figure 10: Radiospire system test setup: *left – transmitter with antenna hanging down and obstructed by the couch from the receiver; right – close-up of the Radiospire reference design*

The antenna used on the Radiospire reference design was the UWB chip antenna from Fractus SA (FR05-107). The antenna was connected via coaxial cable and was mounted on a block of foam making it easy to rotate it around and point it up or down. The cart itself was also rotated to the 0º, 90º, 180º and 270º positions (figure 11).

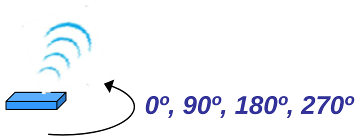


Figure 11: *Video quality test was performed at 4 orientations of the cart with the transmitter rotated 0º, 90º, 180º and 270º with respect to the receiver. The antenna itself was also rotated and pointed up or down.*