



**A 4 Gbps Wireless True Uncompressed  
1080p-Capable HD A/V Transceiver  
Using 60 GHz**

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Imagine the full quality of a wired A/V connection for uncompressed high definition 1080p, coupled with the ease of use, ease of placement, and unified control capabilities of a fully interconnected wireless system.

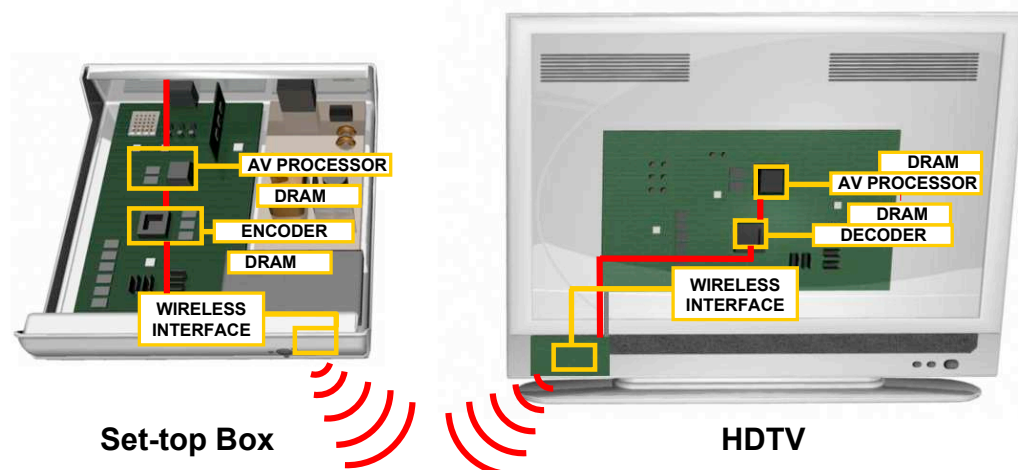
This presentation will introduce the world's first chipset capable of achieving this using 60 GHz wireless transmissions.

## Agenda

- Benefits of Uncompressed High Definition Wireless A/V
- WirelessHD Overview
- Obtaining Very High Wireless Data Rates
- Challenges and Solutions for 60 GHz Operation
- Wireless Video Area Network Design
- SiBEAM's Uncompressed 60 GHz Wireless High Definition Chipset
- Conclusion

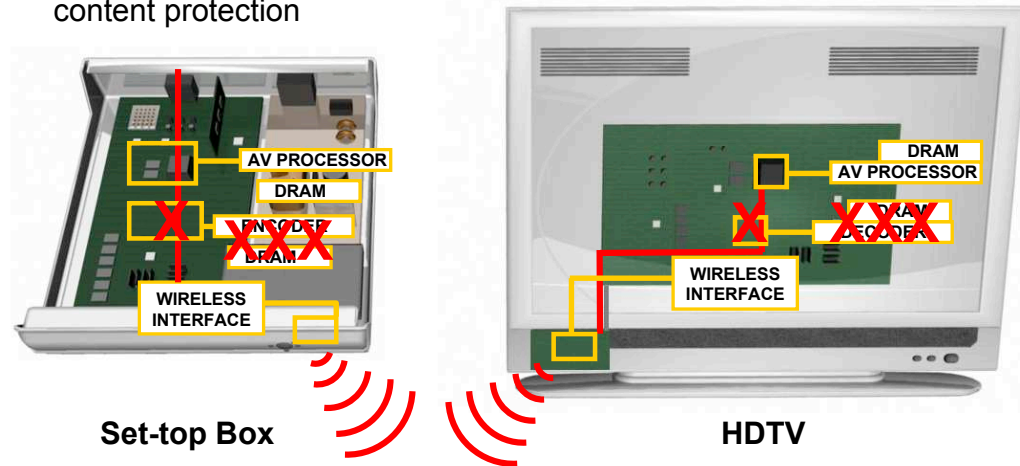
## Challenge of Compressed Plus UWB / WiFi

- Required encoder / decoder is significant system cost adder
- Impacted consumer experience – both latency and image quality
- Lack of standards – interoperability & content protection issues
- Interference with other 2.4 GHz, 5 GHz or UWB wireless solutions



# The Uncompressed Value Proposition

- Lower cost solution w/o video encoder & decoder
- Preserves best image and audio quality
- Avoids encoding generated latency
- No interference with 2.4 GHz, 5 GHz, and UWB wireless solutions
- Available WirelessHD specification for interoperability and content protection



# Enabling Wireless Video Area Networks



## Achieving Interoperability via the WirelessHD™ Consortium

*Started in early 2005, seven market leaders and industry experts have joined together to create a special interest group, the WirelessHD™ Consortium, to develop an interoperable wireless specification for a wireless high-definition digital interface to enable a wireless video area network (WVAN) for high-definition baseband audio / video (A/V) streaming and high-speed media transmission for consumer electronics (CE) devices.*



## WirelessHD Key Characteristics

- Interoperability supported by major CE device manufacturers
- High-speed wireless, multi-gigabit communications technology in the unlicensed 60 GHz band
- Uncompressed HD video, audio and data transmission, scalable to future high-definition A/V formats
- Smart antenna technology for reliable, non line of sight (NLOS), high-quality consumer experience
- Device control for simple operation of consumer electronics products and network
- Secure Communications
- Quality of Service (QoS) for A/V applications

# Architecting a Multi-Gbps PHY

- Highest quality, low-latency HD content requires very high data rates
  - Uncompressed 1080p content requires raw data rates of about 4 Gbps at very low bit error rates
- This requires **very high spectral efficiency** or **large amount of spectrum**
  - Raw data rate = **Spectral Efficiency (bps/Hz) \* Bandwidth (Hz)**
- **Higher spectral efficiency leads to higher cost, less range and robustness**
  - **High spectral efficiency requires strong signals and complex processing**
- **Large amount of spectrum requires operation in a large (unlicensed) band**
  - **Multi-GHz unlicensed spectrum with reasonable Tx power available world-wide at 60 GHz**
  - **A better overall solution!**

# 60 GHz Advantage for High Data Rates

	Total Spectral Availability	Max Permitted Transmit Power (EIRP)	Max Data Rate	Bps / Hz Required to get to 4 Gbps (11a/g = 2.7)	World-Wide Availability
<b>WirelessHD</b>	7.00 GHz	8,000 mW (39 dBm)	~4,000 Mbps	1.6 bps/Hz w/ 2.5 GHz channel	Y
<b>802.11n</b>	0.67 GHz	160-3200 mW (22-35 dBm)	600 Mbps	100.0 bps/Hz w/ 40 MHz channel	Y
<b>UWB</b>	1.5 GHz – 7.5 GHz*	0.1 mW (-10 dBm)	480 Mbps	8.0 bps/Hz w/ 520 MHz channel	N

\* Depending on geography

**60 GHz makes cost-effective multi-gigabit data rates possible!**

## Challenges & Solutions for 60 GHz Operation

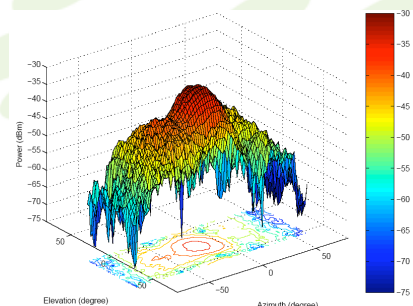
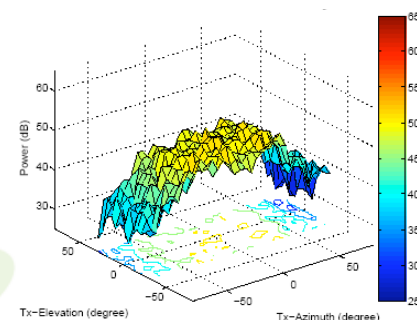
- 60 GHz operation requires focused (directional) beams for high data rates at even moderate range
  - Result of Friis' equation, high carrier frequency, and required signal strength for high data rates:

$$Power_{Rx} = \frac{Power_{Tx} \cdot Gain_{Tx} \cdot Gain_{Rx} \cdot c^2}{(4\pi \cdot Distance \cdot Frequency)^2}$$

- Fixed “horn” antennas typically unacceptable due to required manual alignment and line-of-sight operation
- Dynamic “smart antennas” which electronically move a focused directional beam provide solution
  - An array of antennas are used to form an agile focused beam
  - Similar technology as radar - automatic operation - “just works”
  - Key component of SiBEAM OmniLink60 technology

## Real-Time Beam Steering Operation

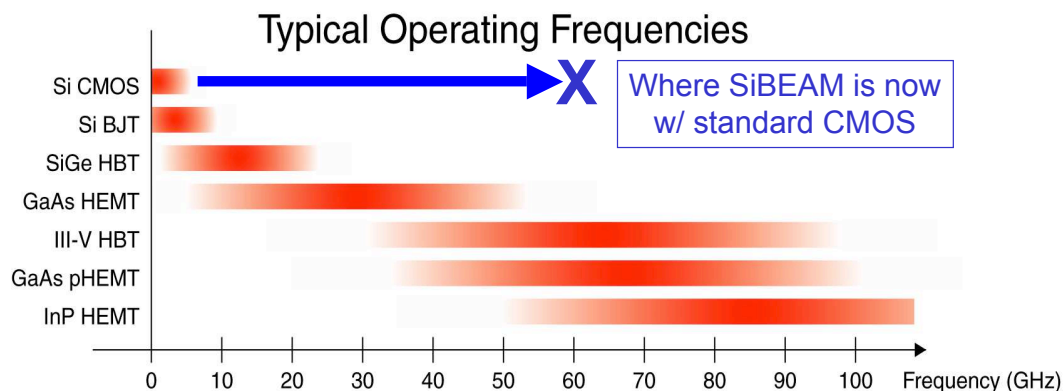
- SiBEAM 60 GHz silicon, packaging, and real-time adaptive beam-forming algorithms enable non-line of sight streaming A/V
- Seamless dynamic adaptive beam-steering achieved – avoids obstacles while maintaining A/V stream
- Environment can be searched and optimal beam found in millisecond time scales
- Beam automatically adjusts if environment changes
- Omni-directional modes allow broadcast operation for device discovery and coordination



## Designing Cost Effective Smart Antenna Systems

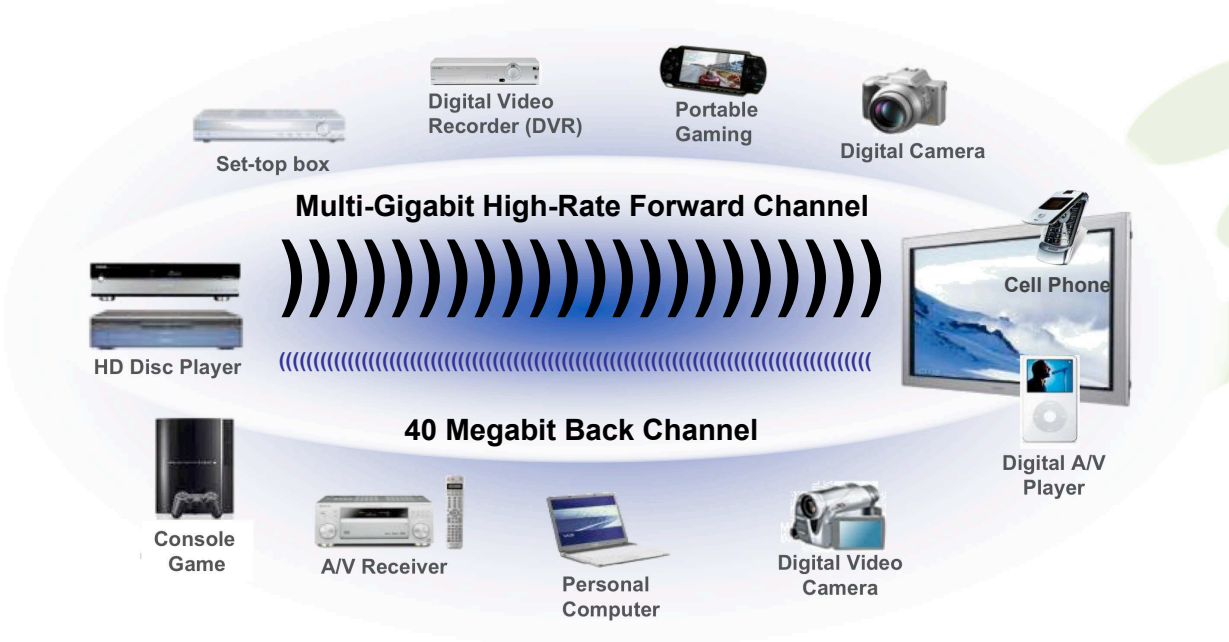
- Large number of antennas (10 to 100) needed for the required antenna array gain
- Antenna size scales inversely with carrier frequency, resulting in millimeter-scale antennas for 60 GHz
- SiBEAM has developed micro array antenna design techniques to leverage standard packaging processes to fabricate antenna arrays on the same package that houses the 60 GHz circuits
- Cost-effective solutions require cost-effective circuit implementation

## SiBEAM Breakthrough for Microwave CMOS



- CMOS offers enormous cost reduction while providing higher integration and reliability
- Each new process generation moves the frequency 20–40% higher
- SiBEAM's approach allows full use of the capabilities of the technology

## Wireless Video Area Network (WVAN) Topology



## PHY Provides Omni and High Throughput

Two types of Physical Layer (PHY) modes supported at ranges of 10+ meters:

- High-rate PHY (HRP):
  - Used for video and audio transmission
  - 1-4 Gb/s in beam-formed uni-directional mode
    - Supports uncompressed 1080p / 24 bit color @ 60 fps
    - Deep color capable enhancements
  - OFDM with QPSK and 16-QAM modulation
- Low-rate PHY (LRP):
  - Used for commands, beacon, broadcast and ACKs as well as audio
  - 2.5 - 10 Mb/s in omni-directional mode
  - 20 - 40 Mb/s in beam-formed uni-directional mode
  - OFDM with BPSK modulation



## A MAC Architecture Optimized for Streaming High Definition Content

- Streaming low-latency, high-quality HD A/V requires careful MAC design
  - Some standards such as 802.11 / WiFi are more data-centric
- Time-Division Multiple Access (TDMA) scheduling promotes better QoS
- Central Coordinator schedules the traffic for the WVAN
  - One of the devices present (typically a display in the network) automatically becomes the Coordinator
  - All devices receive periodic beacons from the coordinator indicating schedule to allow them to precisely time transmits and receives
  - Coordinator also tracks WVAN members' entry and departure
- All communications are direct between devices (not via coordinator)
  - Results in greater network efficiency and relaxes coordinator requirements

## Wireless Video Area Network Security

WVAN security is obtained on many levels:

- Proven strong encryption techniques
- Full digital content protection for Hollywood content
- Consumer content protection for user content and control
- Multi-Gbps uncompressed content to evade data capture
- 60 GHz & beam-formed communications for spatial containment
- Additional proximity controls

## Demonstration

2-3 minute video clip demonstrating  
60 GHz uncompressed 1080p WirelessHD prototyping system:

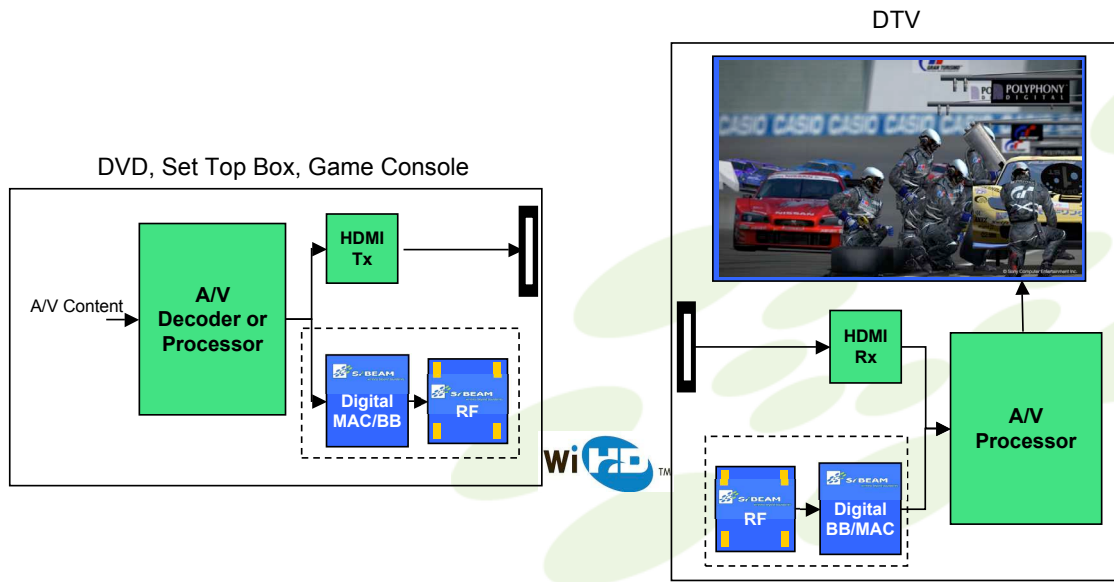


## SOLUTIONS Technology & Performance

- Multi-Gbps data rate for *uncompressed* audio/video/data content
  - Reliable connections (wired equivalent  $< 10^{-10}$  BER)
- OmniLink60™ technology for non-line-of-sight A/V applications in 60 GHz band
- 1080p, 60Hz video at 10m
  - Deep Color support at 720p/1080i
- High performance 8-channel, 192kHz audio
  - PCM and compressed data formats
- Hollywood approved secure content delivery
- Low cost, low component count, small form factor module
  - Standard CMOS logic process for low cost
  - Innovative package technology simplifies design
    - Completely integrated element micro antenna arrays

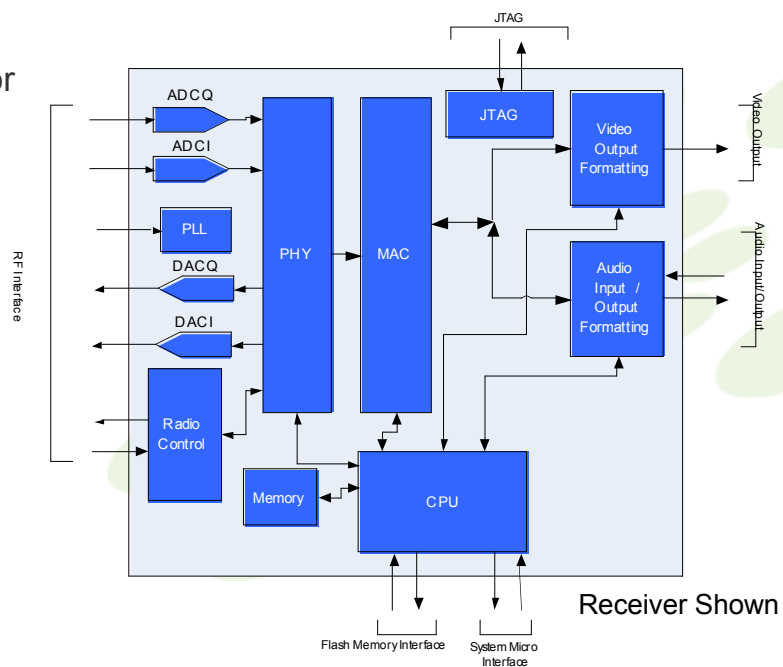


# SOLUTIONS Simplicity for Ease of Development



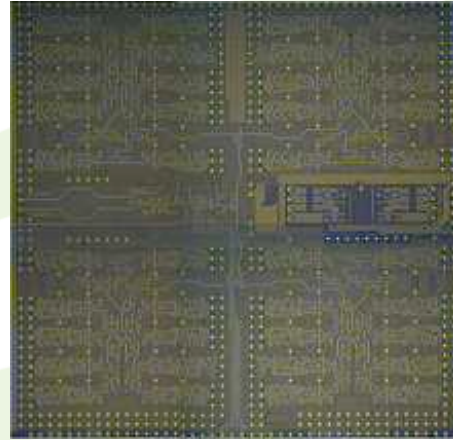
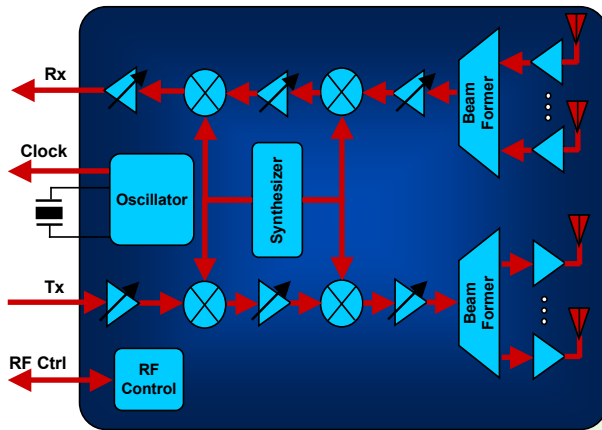
# SOLUTIONS Complete Receiver Integration

- Complete solution for WirelessHD system
- All WWAN control managed by embedded CPU
- Standard CE audio / video interfaces



Receiver Shown

## RF Chip Block Diagram and Die Photo



## Conclusions

- Uncompressed high definition wireless A/V enables highest quality experience with reduced cost & complexity
- WirelessHD specification enables interoperability
- Very high wireless data rates possible through use of wide license-free 60 GHz band
- Robust non-line-of-sight (NLOS) operation possible through OmniLink60's™ smart antenna technology
- Wireless video area network allows central control
- SiBEAM's uncompressed 60 GHz wireless high definition chipset delivers “antennas-to-bits” integration