



Wireless Communications Forum: A glimpse of the future of wireless

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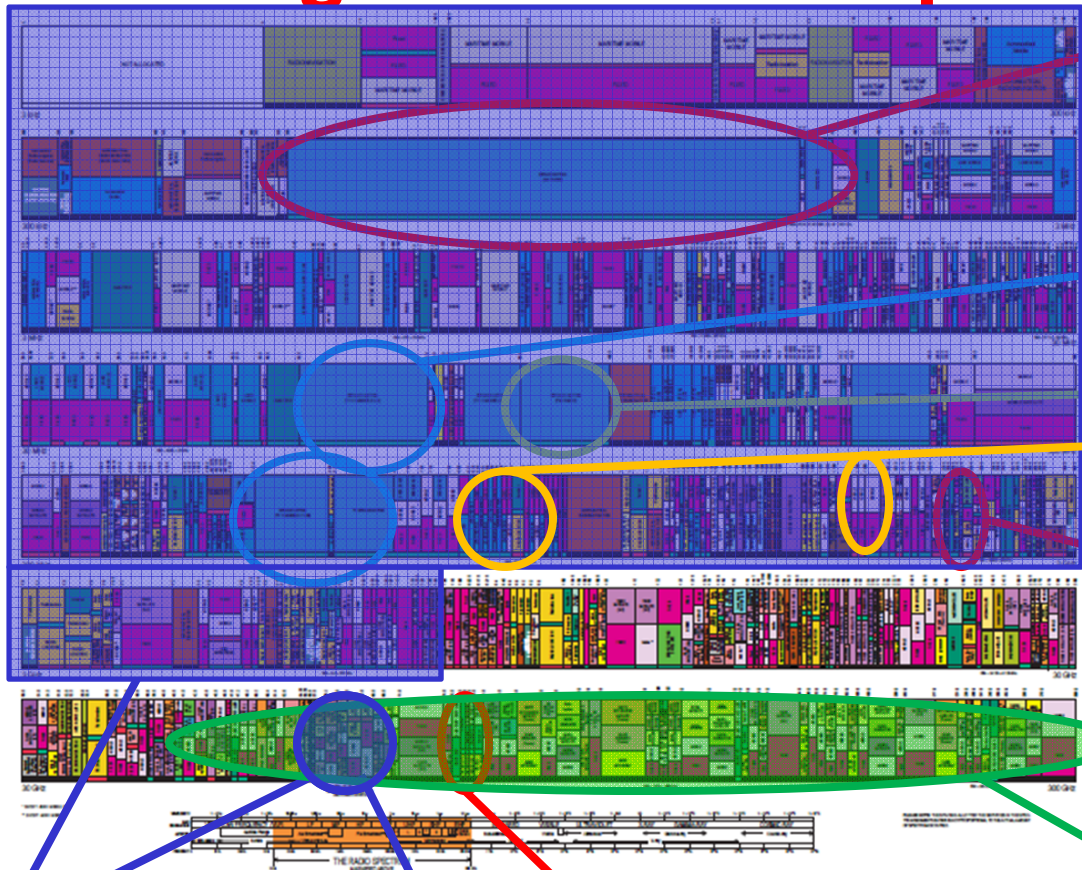
mm-Wave and sub-mm-Wave offers Orders of Magnitude more Spectrum

UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM

RADIO SERVICES COLOR LEGEND		
[Blue Box] AIR FORCE	[Yellow Box] AIR FORCE	[Red Box] AIR FORCE
[Orange Box] AIR FORCE	[Green Box] AIR FORCE	[Purple Box] AIR FORCE
[Light Blue Box] AIR FORCE	[Light Green Box] AIR FORCE	[Light Red Box] AIR FORCE
[Light Orange Box] AIR FORCE	[Light Blue Box] AIR FORCE	[Light Purple Box] AIR FORCE
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ACTIVITY CODE	
[Red Box]	COMMERCIAL
[Green Box]	INDUSTRIAL
[Blue Box]	RESERVED

U.S. DEPARTMENT OF COMMERCE



AM Radio

TV Broadcast

FM Radio

Cellular

Wi-Fi

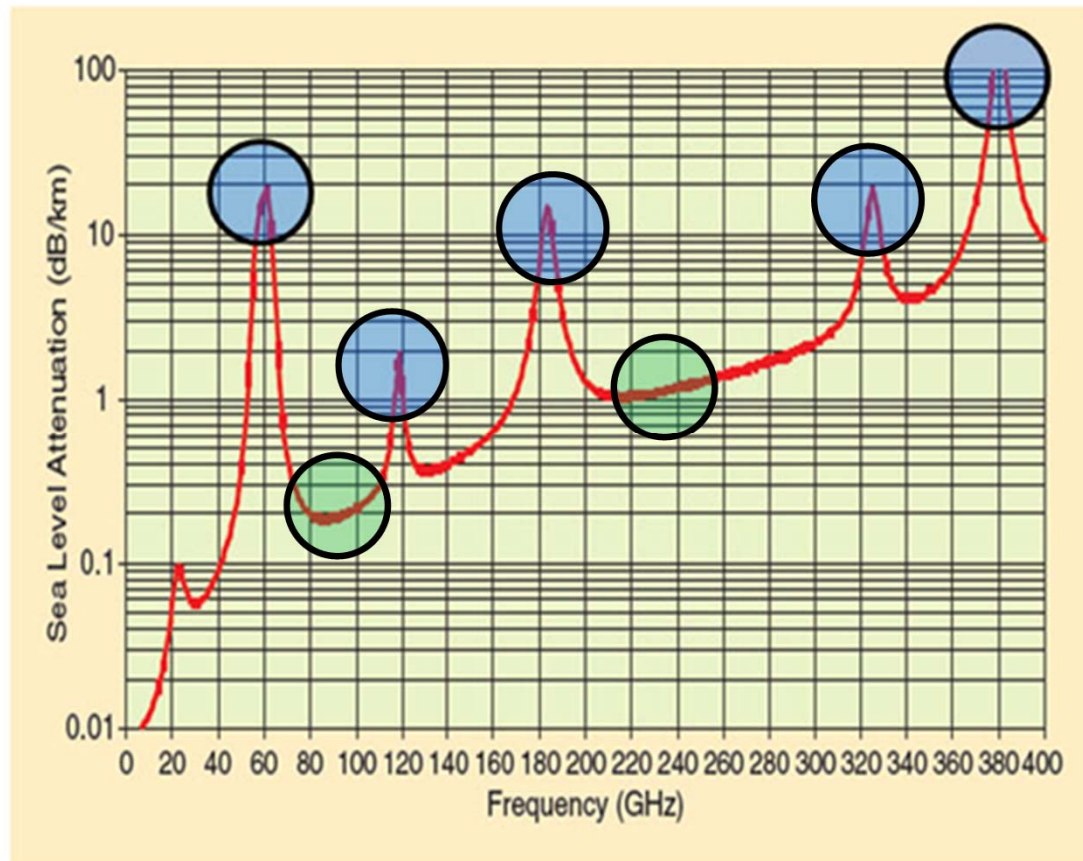
Active mm-Wave CMOS IC Research

77GHz Vehicular Radar

60GHz Spectrum

Shaded Areas = Equivalent Spectrum!

mm-Wave and sub-mm-Wave THz Propagation

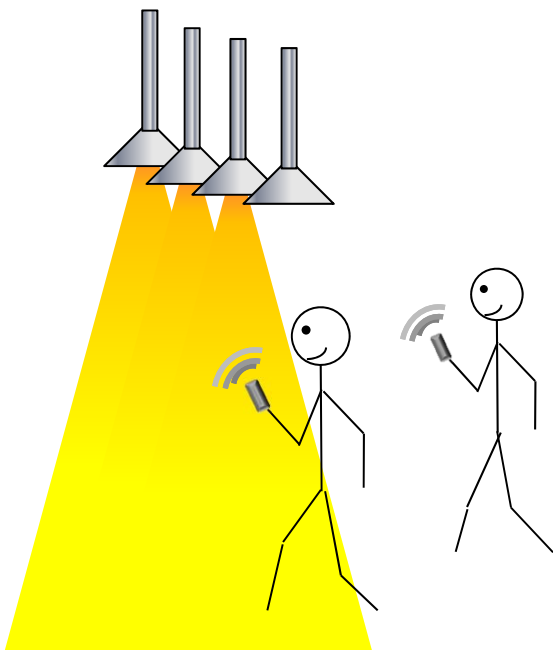


- 60 GHz, 120 GHz, 183 GHz, 325 GHz, and 380 GHz for shorter-range applications
- World-wide governmental agreement on 60 GHz!
- 100 GHz and 240 GHz for longer-range applications

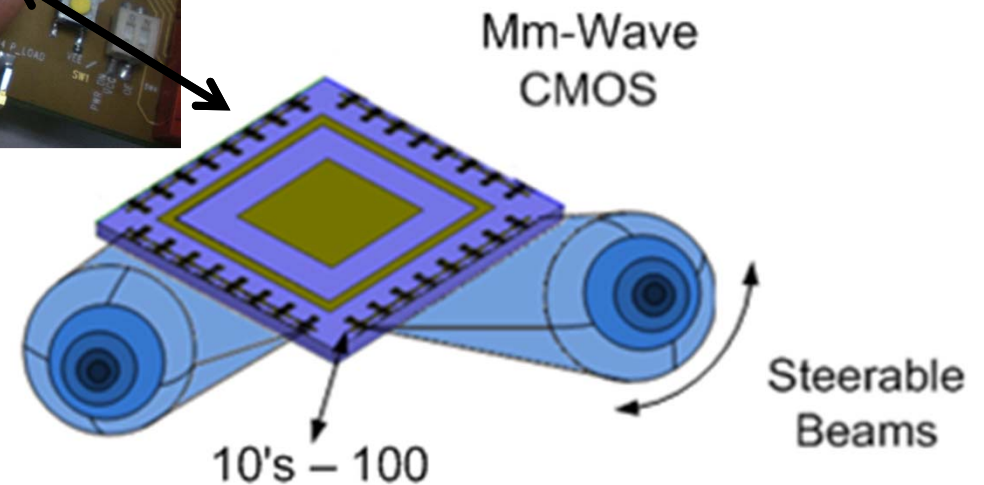
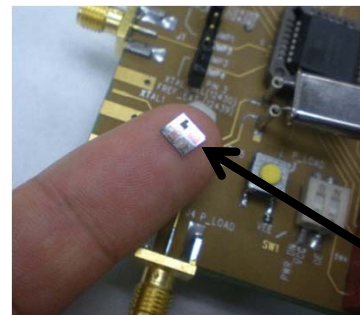
mm-Wave & sub-mm-Wave Short Range Applications

- 60 GHz band products **ready for release: TV set top boxes available soon**
- Applications: Information Showers, Wireless Interconnects, magnetic media & hard-drive replacement

Information Showers

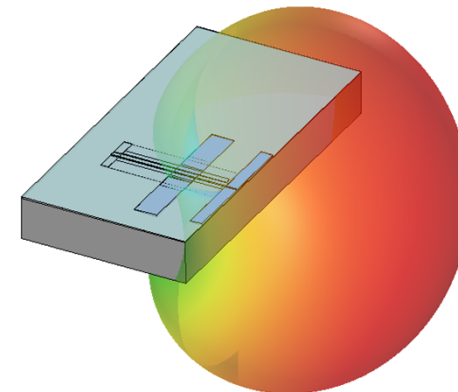
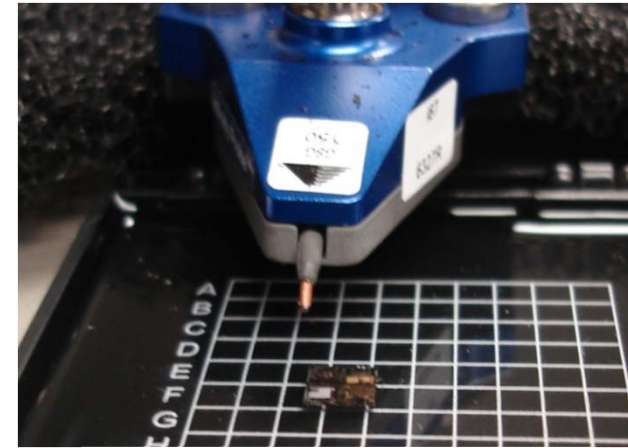


Inexpensive Ubiquitous Integrated Transceivers



Probe Station for mmWave RFICs and On-Chip Antennas

- mmWave Anechoic Chamber to measure 3D on-chip antenna patterns

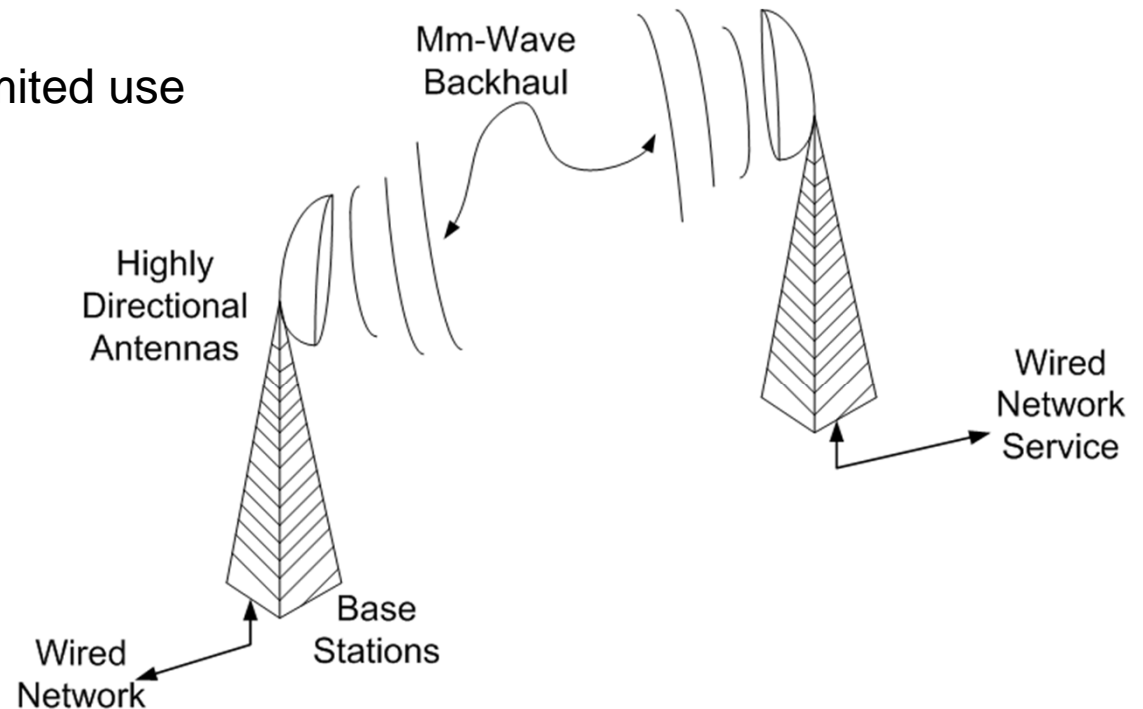


•Gutierrez, F.; Agarwal, S.; Parrish, K.; Rappaport, T.S., "On-chip integrated antenna structures in CMOS for 60 GHz WPAN systems," Selected Areas in Communications, IEEE Journal on , vol.27, no.8, pp.1367-1378, October 2009.

•Rappaport, Theodore S.; Gutierrez Jr., Felix; Al-Attar, Talal, "Millimeter-Wave and Terahertz Wireless RFIC and On-Chip Antenna Design: Tools and Layout Techniques," GLOBECOM Workshop on Multi-Gigabit mm-Wave and Tera-Hz Wireless Systems (MWTS), 2009 IEEE, vol., no., pp.1-7, Nov. 30 2009-Dec. 4 2009.

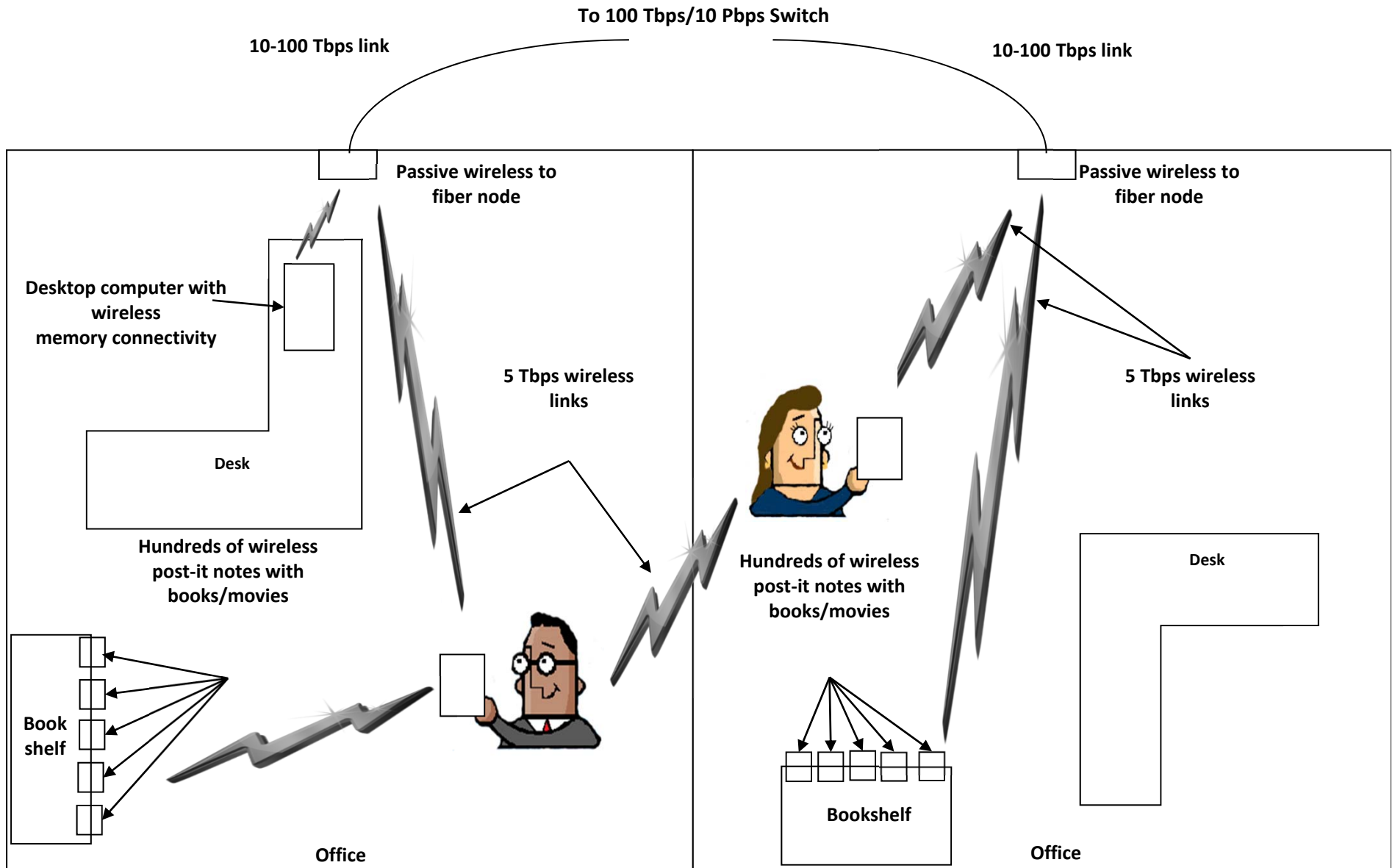
mm-Wave Long Range Applications

- Tremendous **data rate growth** for cellular systems
 - 10 % of 2.85 Billion users w/data in 2007 → Growing **Exponentially**
- Wireless mm-Wave and sub-mm-wave backhaul **Required!**
- 60 GHz backhaul already in limited use
- Highly directional antennas



Buddhikot, M.M.; , "Cognitive Radio, DSA and Self-X: Towards Next Transformation in Cellular Networks (Extended Abstract)," *New Frontiers in Dynamic Spectrum*, 2010 *IEEE Symposium on* , vol., no., pp.1-5, 6-9 April `2010

Office of the future



60 GHz Current mm-Wave Standards

Name	Forum Type	Status	Maximum Data Rate (Gbps)		Applications
			OFDM	SC (Single Carrier)	
WirelessHD	Industry Consortium	Spec. 1.0, Jan 2008	4	–	Uncompressed HD video
ECMA-387	International Standard	Draft 1.0, Dec 2008	4.032	6.35	Bulk data transfer and HD streaming
802.15.3c (TG3c)	International Standard	Released October 2009*	5.7	5.2	Portable point-to-point file transfer and streaming
802.11ad (TGad)	International Standard	Target completion Dec 2012	>1		Rapid upload/download, wireless display, networking distribution of HDTV
WiGig	Industry Consortium	Released May 2010*	7 Gbps*		File transfers, wireless display and docking, and streaming high definition

Singh, H.; Su-Khiong Yong; Jisung Oh; Chiu Ngo; , "Principles of IEEE 802.15.3c: Multi-Gigabit Millimeter-Wave Wireless PAN," *Computer Communications and Networks, 2009. ICCCN 2009. Proceedings of 18th International Conference on* , vol., no., pp.1-6, 3-6 Aug. 2009

"WiGig Alliance Publishes Multi-Gigabit Wireless Specification and Launches Adopter Program," WiGig press release, Retrieved July 4, 2010, from

Properties at THz

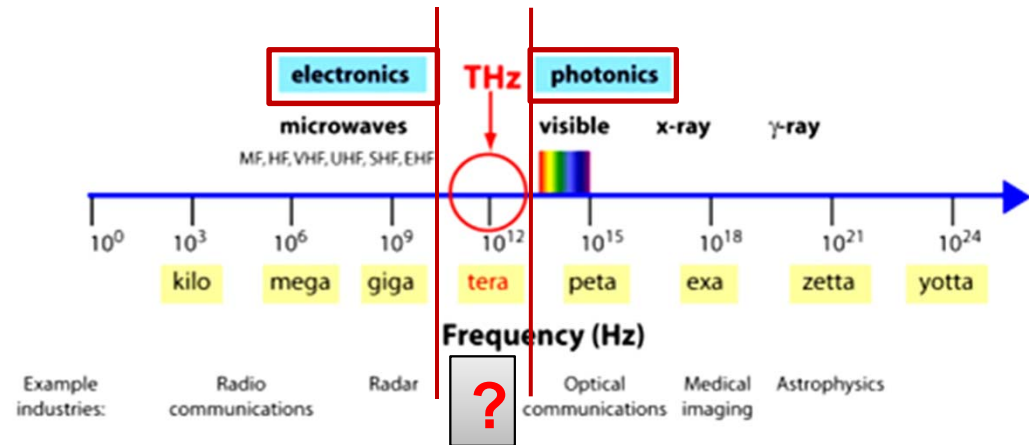
Frequency Range

Terahertz region – 0.3-10THz

But loosely – 100GHz and upwards

Wavelengths

3 mm to 30 μm



1 THz ~ 1 ps ~ 300 μm ~ 33 cm^{-1} ~ 4.1 meV ~ 47.6°K

Properties

- Behaves partly as light - Can be focused with a lens
- Behaves partly as Radio Frequency waves for propagation – we can use antennas and metal structures for radiation and guidance at these frequencies
- **Thought** to be Non-ionizing (health wise safer)

Material Properties

- Good penetration cloth, wood, concrete, plastics, paper
- Absorbed heavily by water in various frequency bands within the THz range
- Reflected by metals
- A lot of naturally occurring compounds have resonances and interactions in this regime

For more information on this topic

- “Broadband Wireless Personal Area Networks – 60 GHz and Beyond”
- 10 – 11am Thursday Dec 9, 2010 in Riverfront South Hall
- Business and Tech Forum
- Speakers:
 - Ted Rappaport, University of Texas WNCG
 - Marco Corsi, Texas Instruments
 - Robert Heath, University of Texas WNCG