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**Submission Title:** [Low to medium data rate IR-UWB PHY in IEEE 802.15.8]

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**Re:** [IEEE P802.15 TG8 (Peer Aware Communications) Call For Applications (15-12-0202-01-0008)]

**Abstract:** [Exploring possibilities of using IR-UWB PHY for 802.15.8]

**Purpose:** [Response to IEEE P802.15 TG8 (Peer Aware Communications) Call For Applications (15-12-0202-00-0008)]

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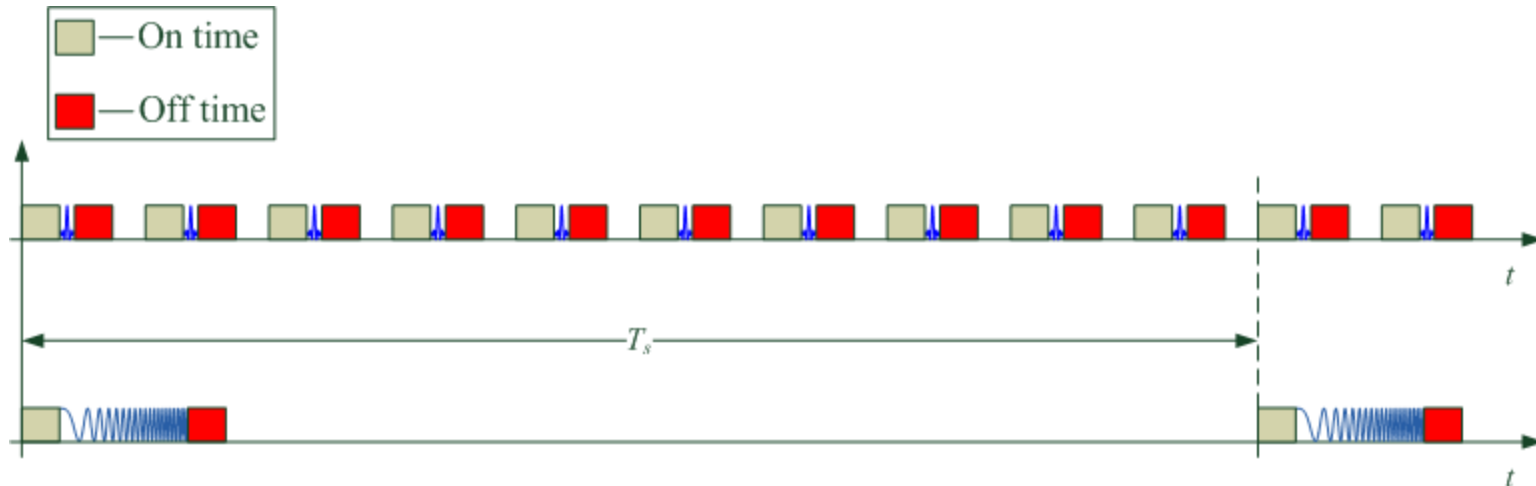
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# Low to medium data rate IR-UWB PHY in IEEE 802.15.8

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## IR-UWB

- Large bandwidth ( $> 500$  MHz).
- Low regulated Tx power (typically  $-15$  dBm for 500 MHz bandwidth).
- Low duty cycle (typically 3%)
  - Reduced Tx/Rx power consumption.



# Regulatory considerations

## FCC part 15 rules: § 15.519 Hand held UWB systems.

(Applicable to PAC)

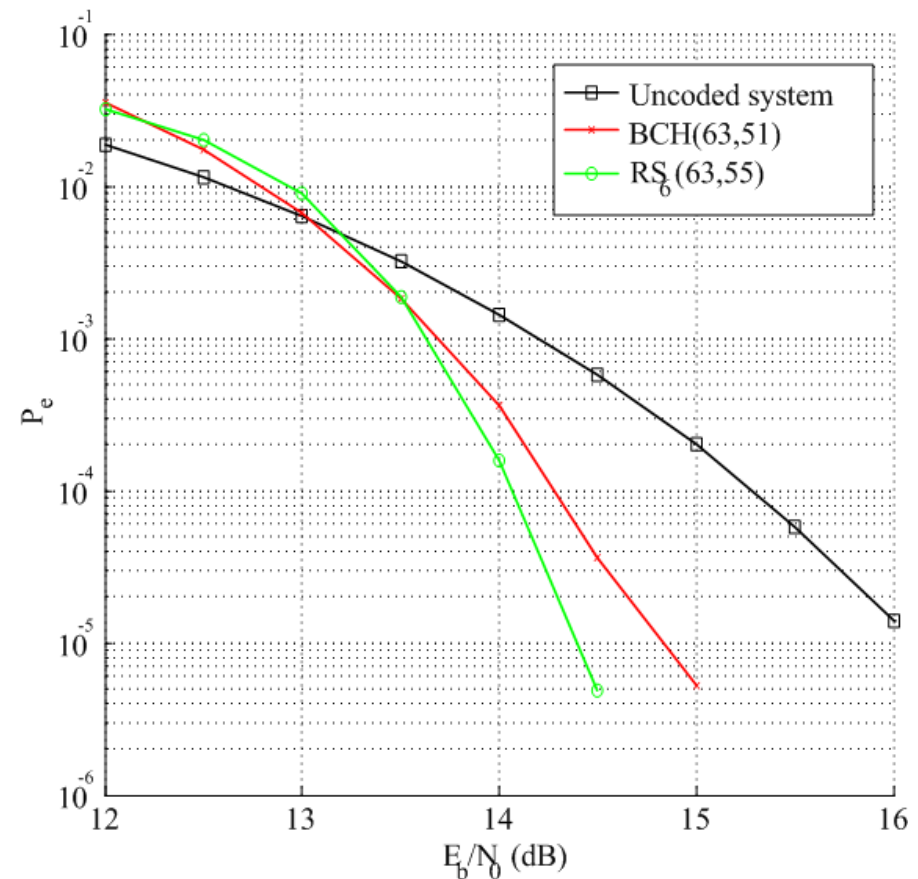
- (a) UWB devices operating under the provisions of this section must be hand held, i.e., they are relatively small devices that are primarily hand held while being operated and do not employ a fixed infrastructure.
- (1) A UWB device operating under the provisions of this section shall transmit only when it is sending information to an associated receiver. The UWB intentional radiator shall cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting.
- (2) The use of antennas mounted on outdoor structures, e.g., antennas mounted on the outside of a building or on a telephone pole, or any fixed outdoors infrastructure is prohibited. Antennas may be mounted only on the hand held UWB device.
- (3) UWB devices operating under the provisions of this section may operate indoors or outdoors.
- (b) The UWB bandwidth of a device operating under the provisions of this section must be contained between 3100 MHz and 10,600 MHz.

# Receiver Architectures

- Low to medium data rate IR-UWB usually employs low complexity receiver architectures that do not involve channel estimation:
  - Energy detection receivers for PPM and OOK modulations.
  - Correlation receivers for DPSK modulation.
- Multipath fading in these receivers is low.
- For low data rates high time-bandwidth product of signal in detection hinders the performance because of noise x noise factor.

# Typical performance

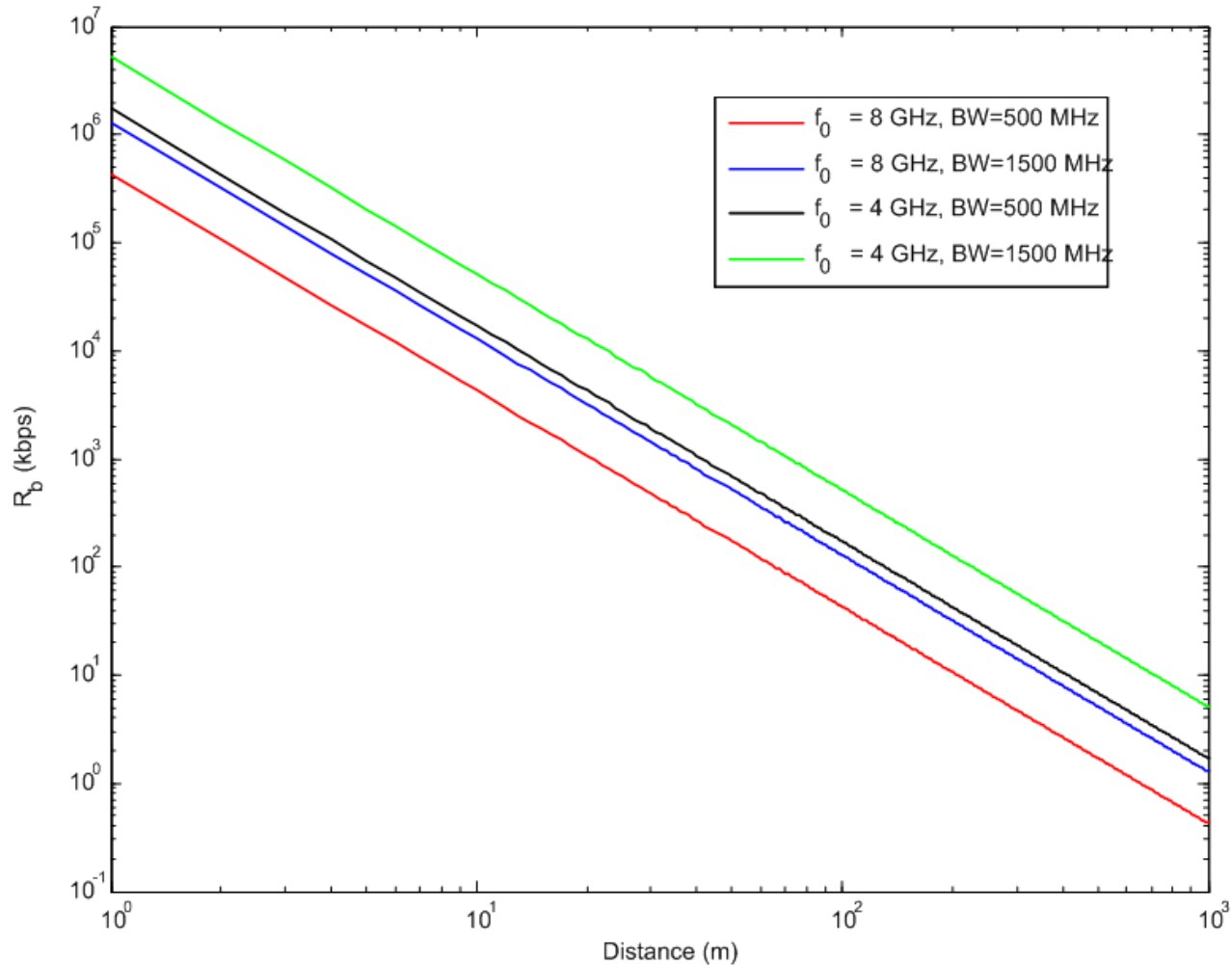
- Duty cycle 3.1%.
- 2-PPM modulation
- Chirp pulse with chirp pulse compression.
- 500 MHz Bandwidth.
- Energy detection.
- Raw data rate 97.65 kbit/s.
- AWGN channel (performance changers little in multipath channels).
- High band UWB, central frequency 8 GHz.
- Signal dimension in detection is 16.



# Link budget analysis

Factor	Symbol (unit)		
Tx power	P_Tx (dBm)	-15	-15
Distance	D (m)	10	30
Carrier frequency	f_0 (GHz)	8	8
Path Loss	P_l (dB)	70	80
Tx antenna gain	G_Tx (dBi)	0	0
Rx antenna gain	G_Rx (dBi)	0	0
Multi-path fading	Mp (dB)	0	0
Noise figure	Nf (dB)	7	7
Temperature	T_0 (K)	300	300
Power at detection	P_Rx(dBm)	-85	-95
Bit rate	R_b (kbps)	97.65	97.65
Eb/N0	Eb/N0 (dB)	31	21
Required Eb/N0	Eb/N0_req (dB)	15	15
Link margin	Lm (dB)	16	6

# Range vs. Data rate





# Conclusions

- Due to its low duty-cycle IR-UWB transceiver can achieve low power consumption.
- Main constraint of IR-UWB as well as any other kind of UWB is its low regulated Tx power.
- IR-UWB can achieve 100 kbps at distances of roughly 100 m.
- Using somewhat more complex modulation/detection can extend the range.
- Using larger bandwidth can extend the range.
- Using low UWB band (3.1-5.6 GHz) can extend the range.
  - Problem with interference from licensed system which are primary users in this band (LTE, WiMax).