Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [ETRI HBC PHY Proposal for BAN]
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Abstract: [Human Body Communication Physical Layer Proposal for Body Area Networks]

Purpose: [Response to "TG6 Call for Proposals" –IEEE P802.15-08-0811-02-0006]

HBC (Human Body Communication) PHY Proposal for BAN

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Outline

- Introduction
- System Principles
  - Body Channel Characteristics
  - HBC System Overview
- Performance Analysis
  - Simulation Results
  - Link Budget
  - System Verification
- Conclusions

PHY Requirements for BAN?

Why HBC for BAN?

INTRODUCTION

PHY Requirements for BAN?

- Data Rate:
  - 10 Kbps to 10 Mbps
  - The lowest mandatory rate at 3 m Range
- Distance: 1 m (typically) to 3 m
- Low Power
- Low Complexity
- Regulatory Compliance

What is the Features of HBC?

- ***TAP*** (Touch And Play)
  - Intuitive Service, Quick Setup, Easy Use
  - Afford Privacy & Security
- ***Direct Digital Baseband Signaling***
  - Easy to Implement
  - Low Power Consumption
  - Small Size

What is the Features of HBC? *–cont.*

- Support Data Rate up to 10 Mbps
  - ***10^{-6} BER*** Performance ***without FEC***
- Low Interference Generation*
  - Low Radiation
- ***Low Shadowing Effect*****

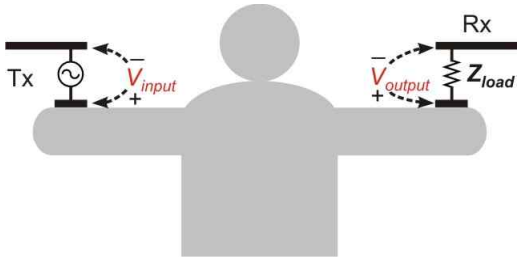
* *IEEE802.15-08-0295-00-0006*
** *IEEE802.15-08-0122-00-0006*

Body Channel Characteristics
FSBT(Frequency Selective Baseband Transmission)
HBC System Overview

SYSTEM PRINCIPLES

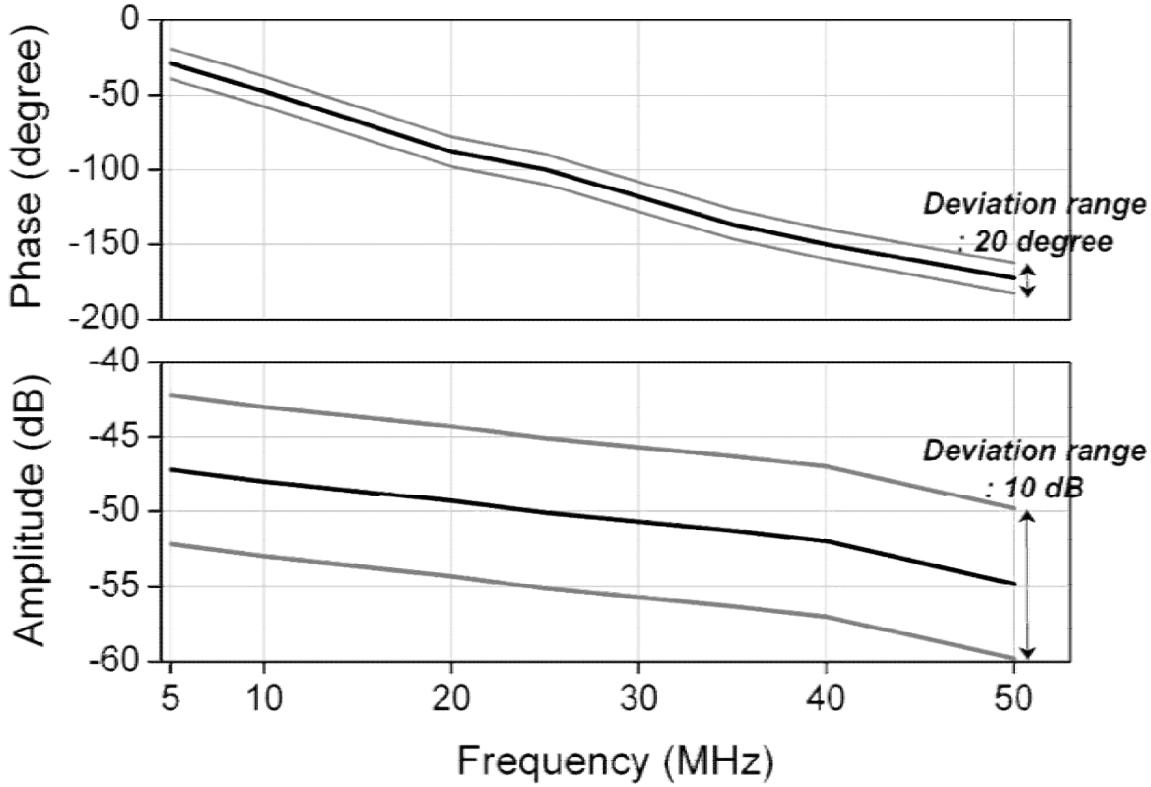
Frequency Response

- The frequency response has been modeled in the frequency range of 5 Mhz ~ 50 Mhz.



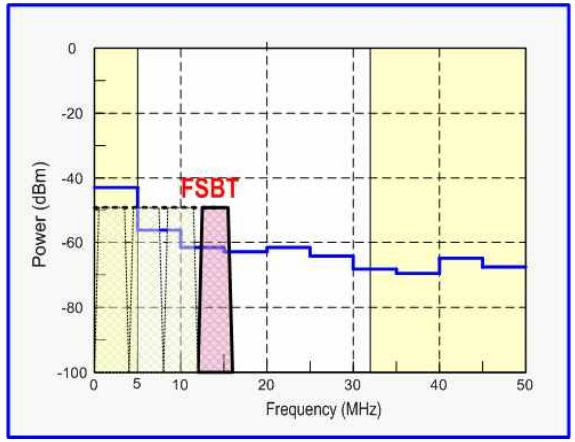
$$\text{Amplitude} = \frac{|V_{output}|}{|V_{input}|}$$

$$\text{Phase} = \frac{\angle V_{output}}{\angle V_{input}}$$



How to transmit Digital Signal Directly?

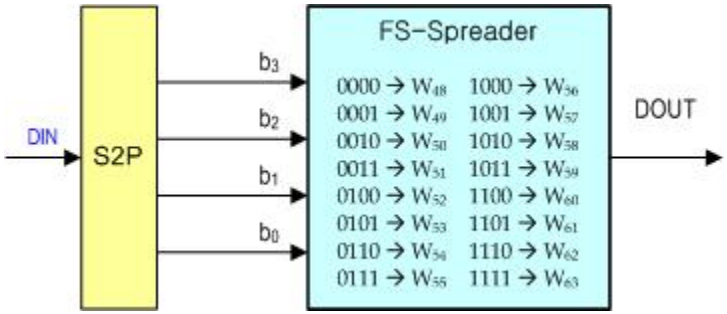
- ***FSBT*** Background
  - – Direct Digital Transmission
    - ***No RF***
  - – Band Selection
    - ***Avoid Low Frequency***
    - $P_{internal\ Signaling} >> P_{external\ radiated}$
  - – More ***Processing Gain***

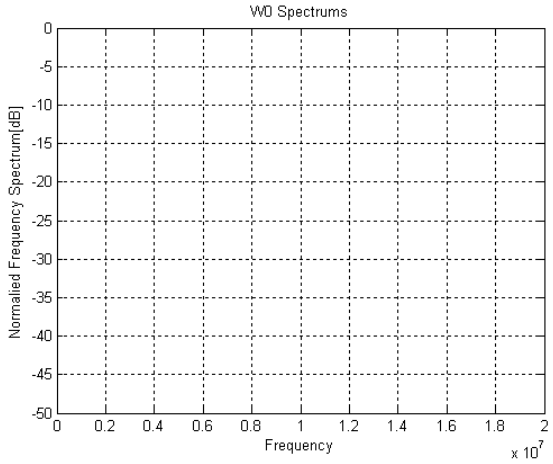


FSBT: Frequency Selective Baseband Transmission

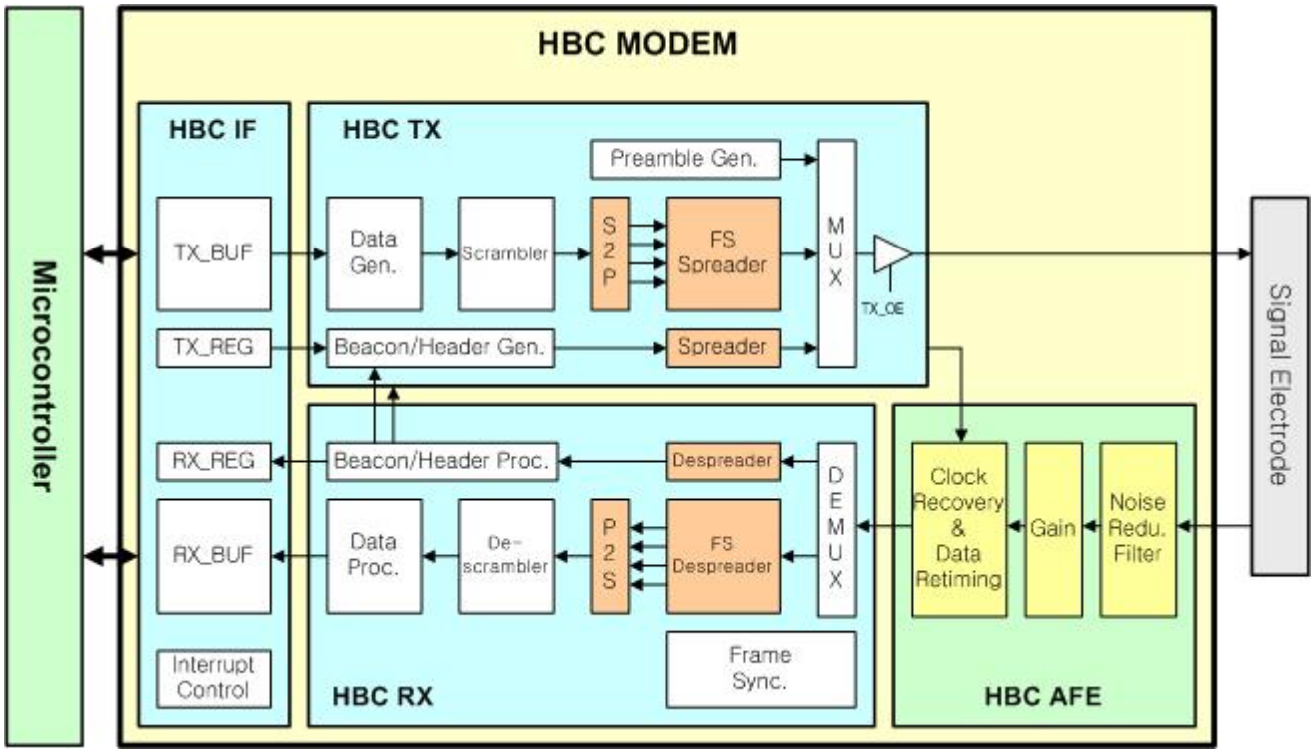
What is FSBT?

- Baseband Signaling
  - Characteristics of ***Walsh Code***
    - Each Walsh code has the ***Fundamental Freq***.
    - Use sub-group of Walsh Code in ***Selected Band***
    - Get Processing Gain by Spreading





HBC System Overview



Simulation Parameters

BER Performance Evaluation

Link Budget

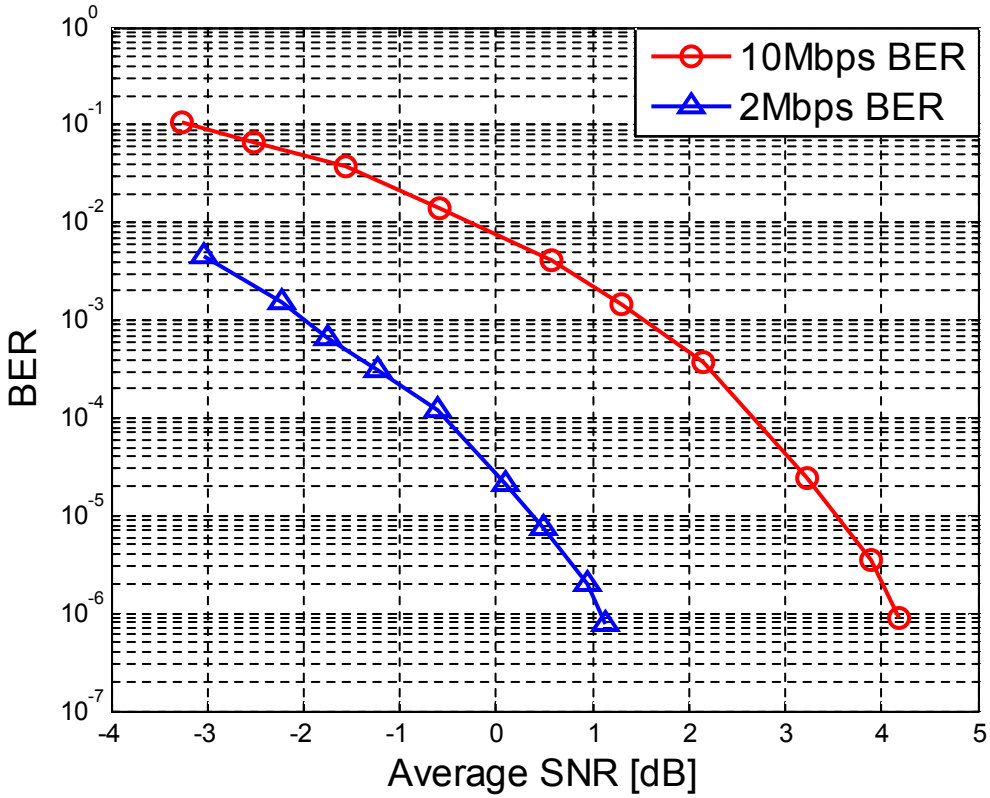
PERFORMANCE ANALYSIS

Simulation Parameters

- Baseband Transmission Square Wave
- Data Rate: Up to 10 Mbps
- Chip Rate: Max. 64 Mcps
- Spreading Code: Walsh Code
- On-Body Channel Model

BER Performance Evaluation

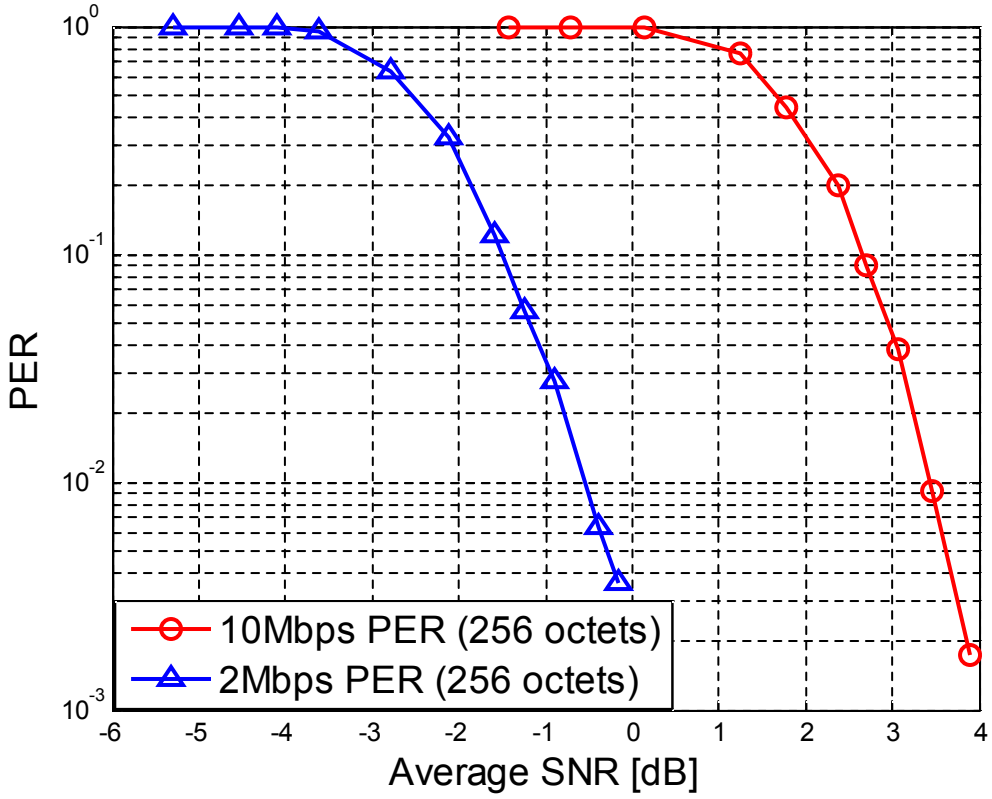
- On-Body Channel Model



BER performance

PER Performance Evaluation

- On-Body Channel Model

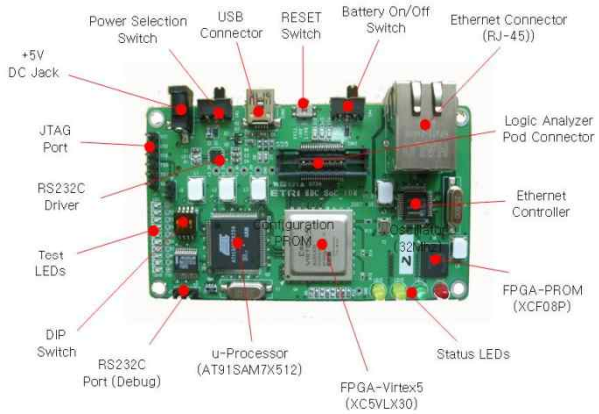


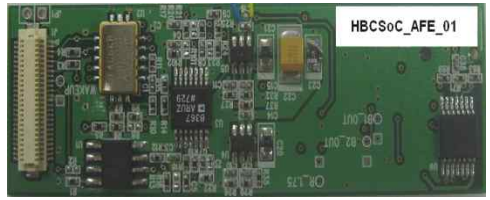
PER (256 octets) performance

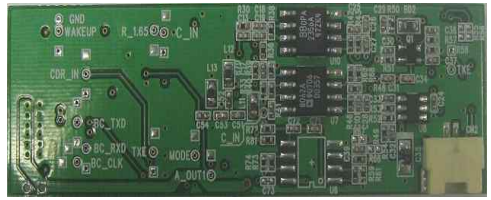
Link Budget

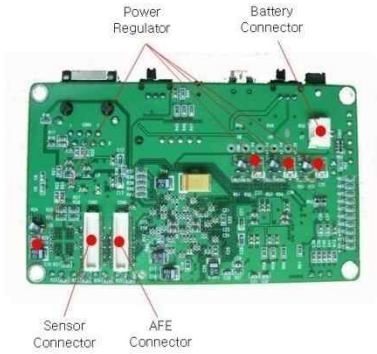
Parameter	Value	
Information Data Rate [Mbps]	10	2
Tx Power [dBm]	-15.1	-15.1
Path Loss [dB]	55	54
Bandwidth [dBHz]	74	69
Rx Input Power (P_R) [dBm]	-70.1	-69.1
Rx Noise Figure (N_F) [dB]	10	10
Noise Power (N= kTB+ N_F) [dBm]	-90	- 95
SNR Required (S) [dB]	4.2	1.1
Implementation Loss (I) [dB]	3	3
Rx Sensitivity(R= N+S+I) [dBm]	-82.8	-90.9
Link Margin (M=P_R –R) [dB]	12.7	21.8

Test Module


Power Selection Switch
USB Connector
RESET Switch
Battery On/Off Switch
Ethernet Connector (RJ-45))
+5V DC Jack
JTAG Port
Logic Analyzer Pod Connector
RS232C Driver
Ethernet Controller
Test LEDs
FPGA-PROM (XCF08P)
DIP Switch
RS232C Port (Debug)
u-Processor (AT91SAM7X512)
Status LEDs
FPGA-Virtex5 (XC5VLX30)

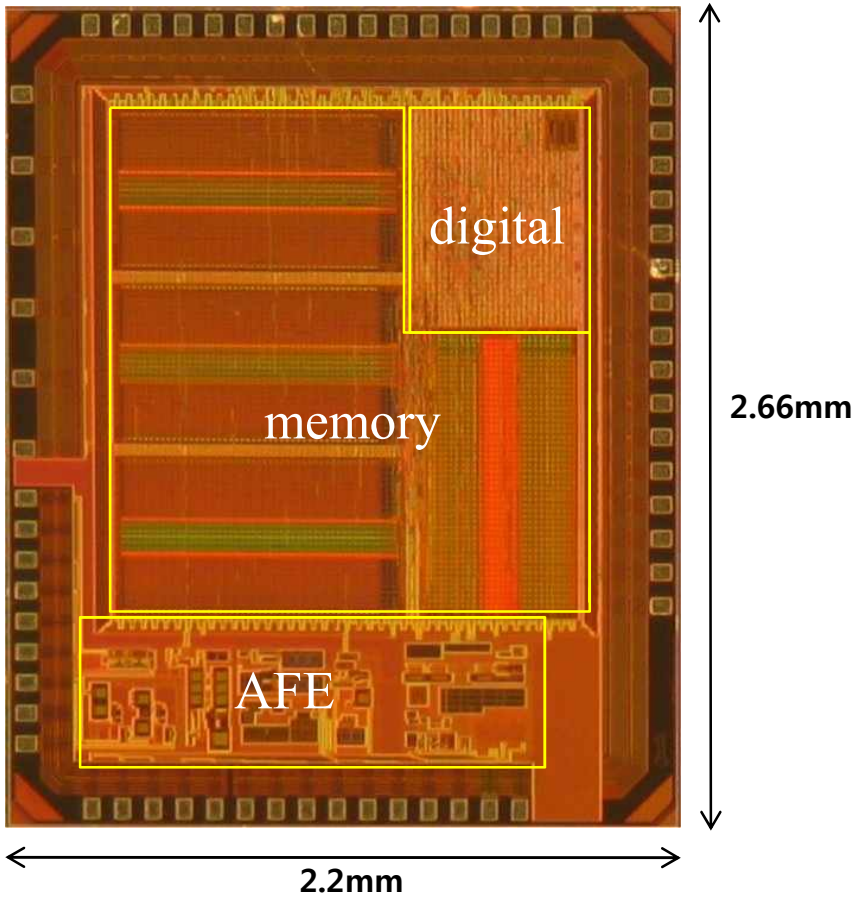

HBCSoC_AFE_01




Power Regulator
Battery Connector
Sensor Connector
AFE Connector

HBC Modem Chip

- Configuration
  - 130nm CMOS technology
  - AFE, Modem, and Memory
- Power Consumption
  - AFE +Digital core :
    - 8.41mA @ 1.2V
  - Digital I/O :
    - 3.0mA @ 3.3V
  - Total power consumption :
    - 20mW at 10Mbps
  - Sleep mode :
    - Less than 10uW

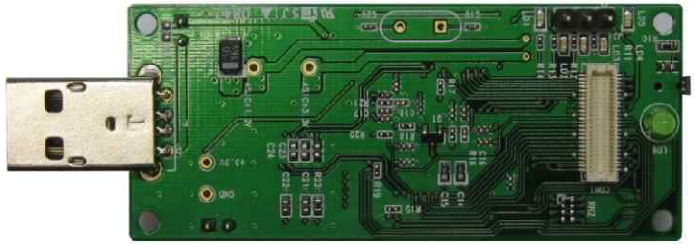


<Chip photograph of HBC SoC >

Prototype USB Dongle

- Controller Board
  - MCU: AT91SAM7X256(Atmel)
  - Interface:
    - Modem to MCU: I²C/USART
    - Host: USB
  - Board size : 70mm x 30mm
- HBC Modem Board
  - HBC Modem
  - 2 pin connector : electrode
  - Board size : 48mm x 25mm

Modem board



Controller board

USB dongle case

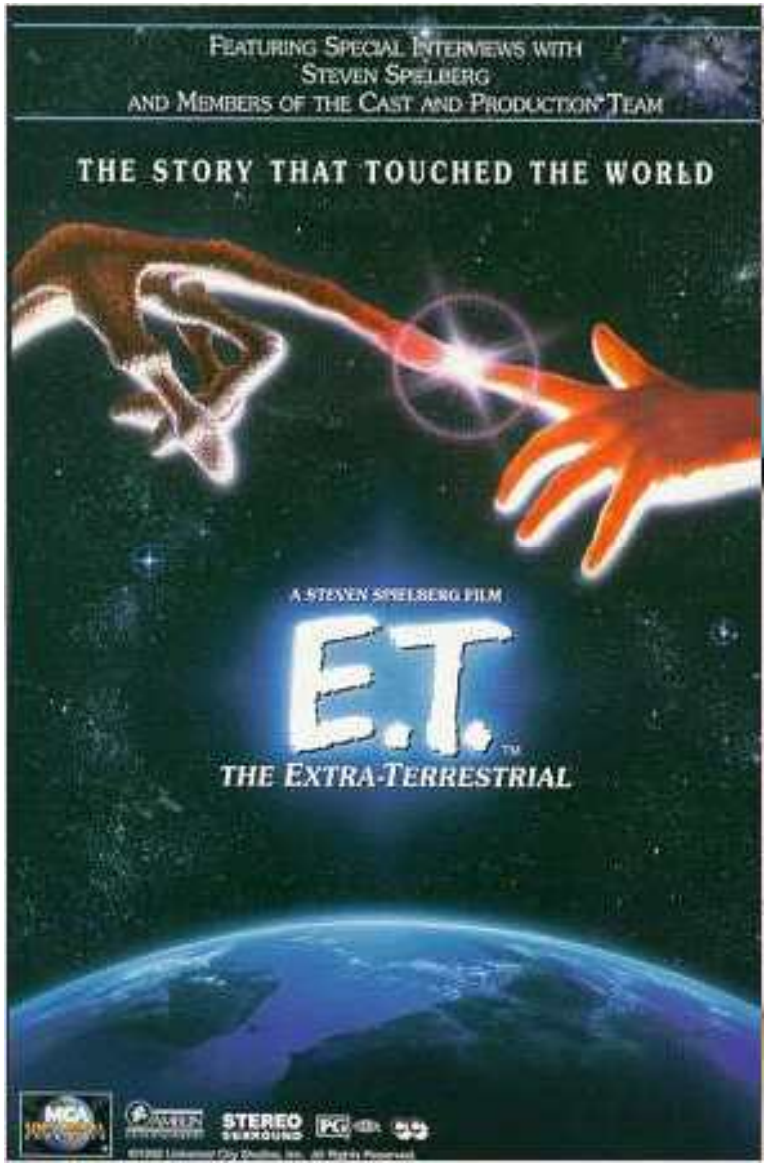
CONCLUSIONS

Conclusions

- TAP (Touch And Play)
  - Intuitive Service/Context Aware Service
  - Quick/Simple Pairing
- FSBT (Frequency Selective Baseband Transmission)
  - No RF (Direct Digital Transmission)
  - Low Interference Generation
  - Simple/Small Architecture
  - Quick Development Time

Conclusions *–cont.*

- Data Rate
  - Scalable from 10 Kbps to 10 Mbps
  - 10^{-6} BER without FEC
- Low Power Consumption
  - Active Mode: 20 mW @ 10 Mbps
  - Sleep Mode: Less than 10 uW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Q & A