Ultra-Wide-Band Location, Identification and Communication

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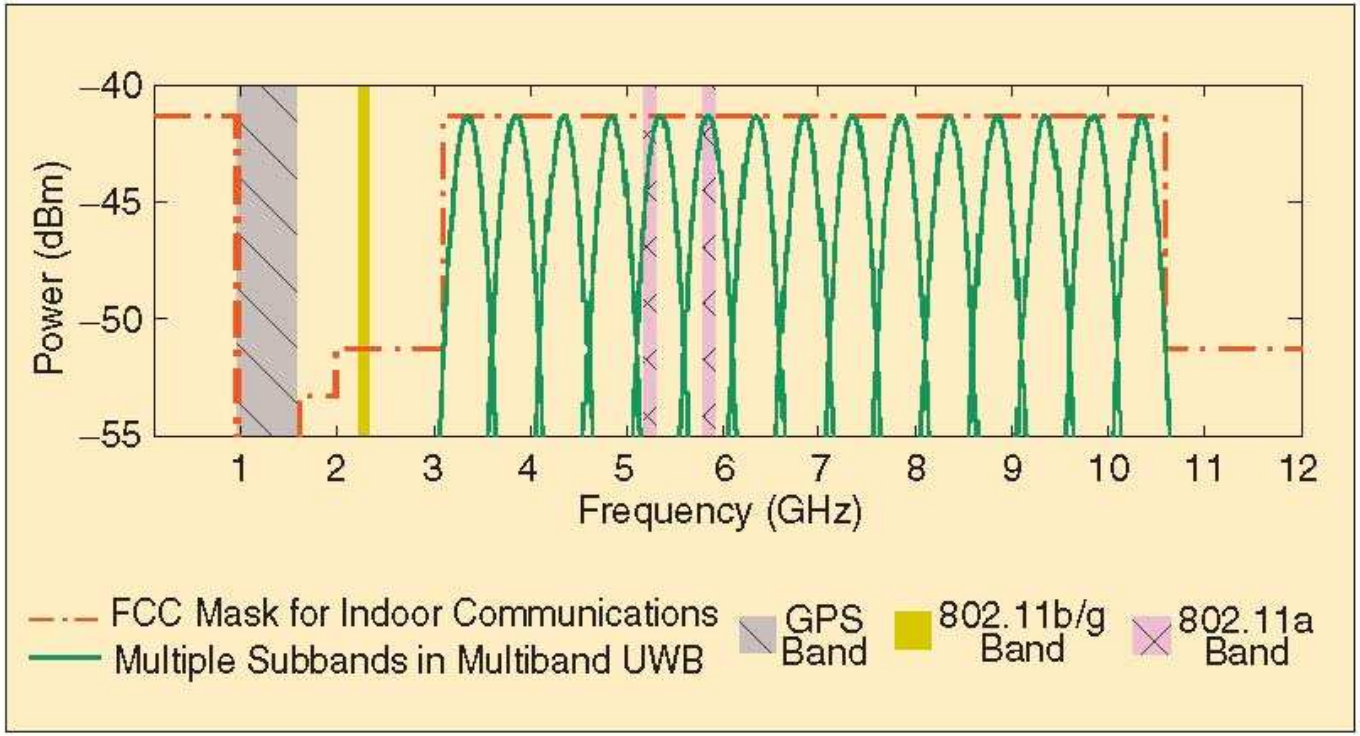
- **Introduction**
- **Proposed System**
- **Preliminary Results**
- **Conclusion**



▲ *16. Multiple subbands in multiband UWB.*

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What is UWB?

- **Bandwidth > 20%**
- **Bandwidth > 500 MHz**
- **> 20 years of military applications**
- **US FCC 2002a, b standards**
  - **0.5 mW evenly spread from 3.1 to 10.6 GHz**
  - **50 μW average power**
- **IEEE 802.15.3a, 4a study groups**
  - **High and low data rate personal area networks**

UWB History

2000

MSSI – 34 UWB development programs for Government & military (1994-present)

1994 First UNCLASSIFIED UWB communications programs

1990

1990 OSD/DARPA "Assessment of Ultra-Wideband (UWB) Technology"

1986 Ross/Fontana – First fielded "short pulse" UWB Communications system

1984 Ross/Fontana collaboration on UWB communications systems development (MSSI/ANRO)

1980

1978 Bennett & Ross – "Time-Domain Electromagnetics and Its Applications" – Seminal paper on UWB
Ross et al. – First demonstrated (free space) UWB communications system

1974 Morey – Fundamental patent on UWB ground penetrating radar U.S. Patent No. 3,806,795

1973 Ross – Fundamental patent on UWB communications U.S. Patent No. 3,728,632

1972 Robbins – Fundamental patent for UWB single-pulse detector U.S. Patent No. 3,662,316

1970

1965 G. Ross – Sperry Research development of UWB technology (1965-1980)

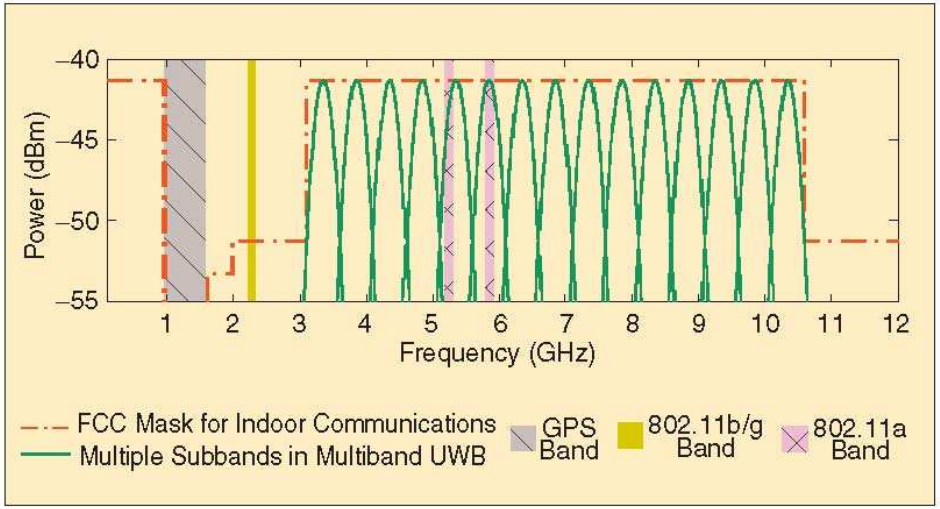
1963 G. Ross – Ph.D. thesis in time-domain electromagnetics

1960

Late 1950's Need for impulse response analysis of microwave N-ports (Lincoln Lab, Sperry, others)

Frequency Domain vs. Time Domain

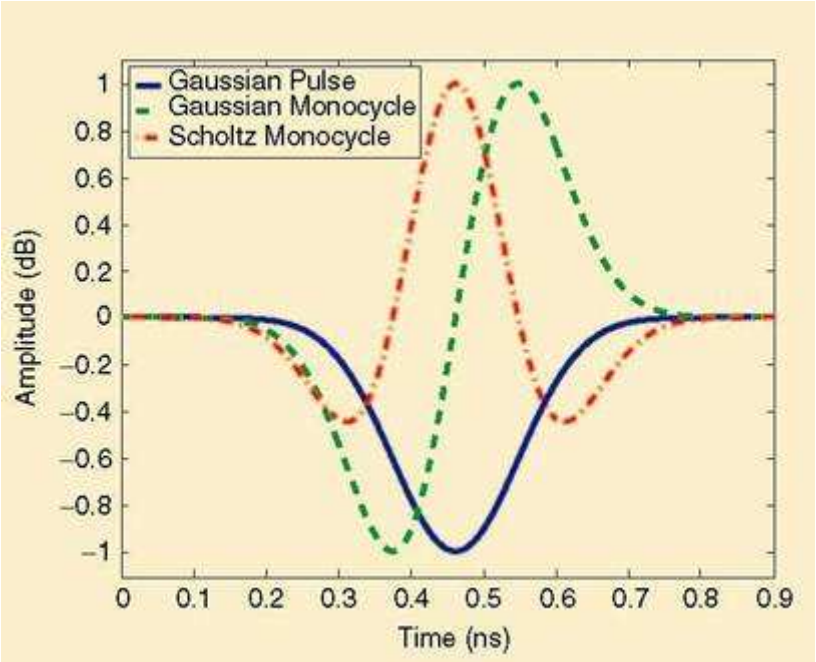
Frequency Domain



▲ *16. Multiple subbands in multiband UWB.*

Sixteen 500 MHz channels

Time Domain



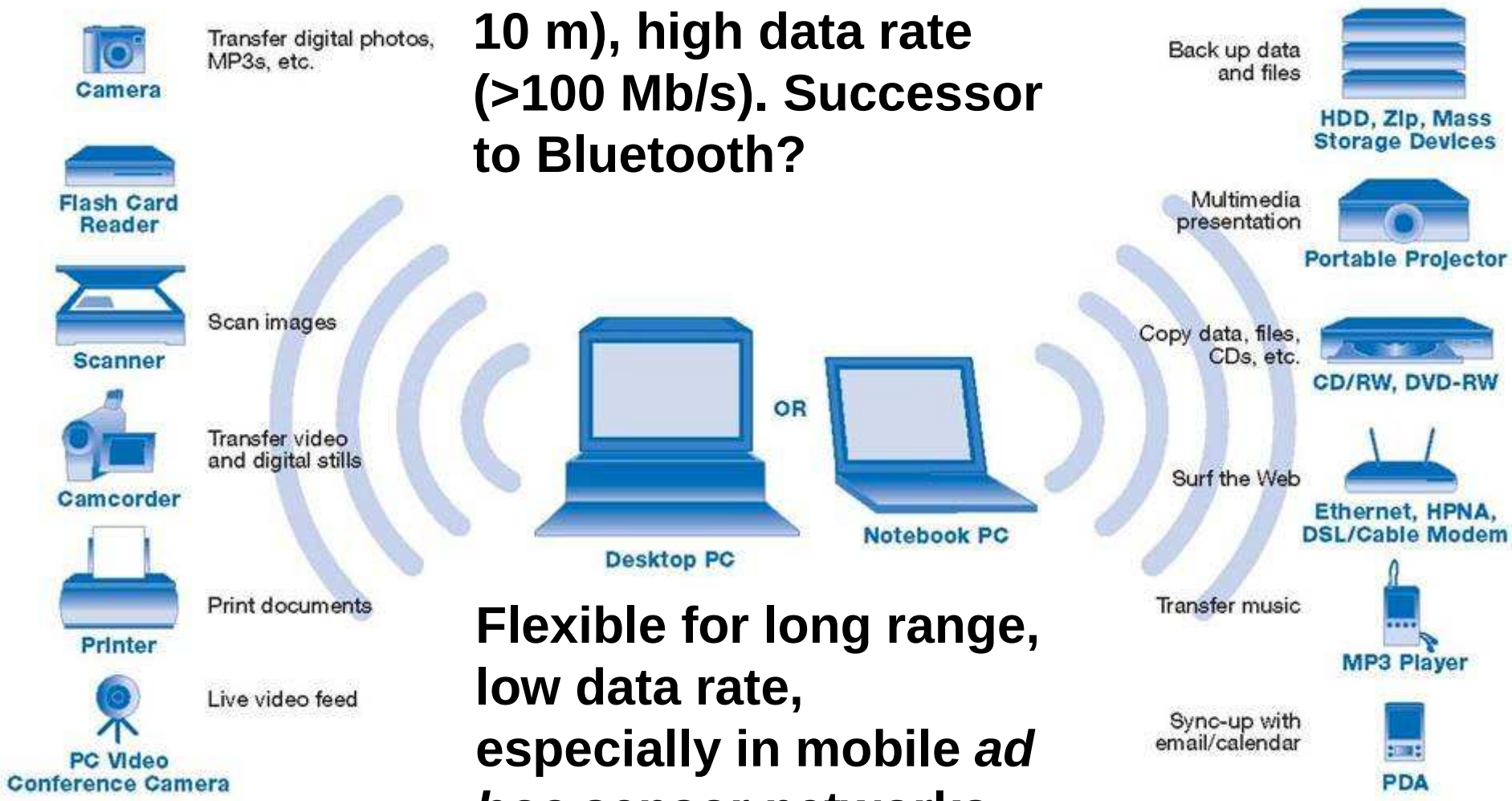
Sub-ns impulse (carrier-less)

UWB Advantages

- **License free**
- **Noise like, little interference to others**
- **Difficult to intercept or detect**
- **Low complexity and flexible**
- **Low power**
- **Low cost**
- **Resistant to multi-path fading and jamming**
- **See through wall**
- **Precision timing for location, tracking, etc.**

UWB Applications

Indoor, short range (1-10 m), high data rate (>100 Mb/s). Successor to Bluetooth?



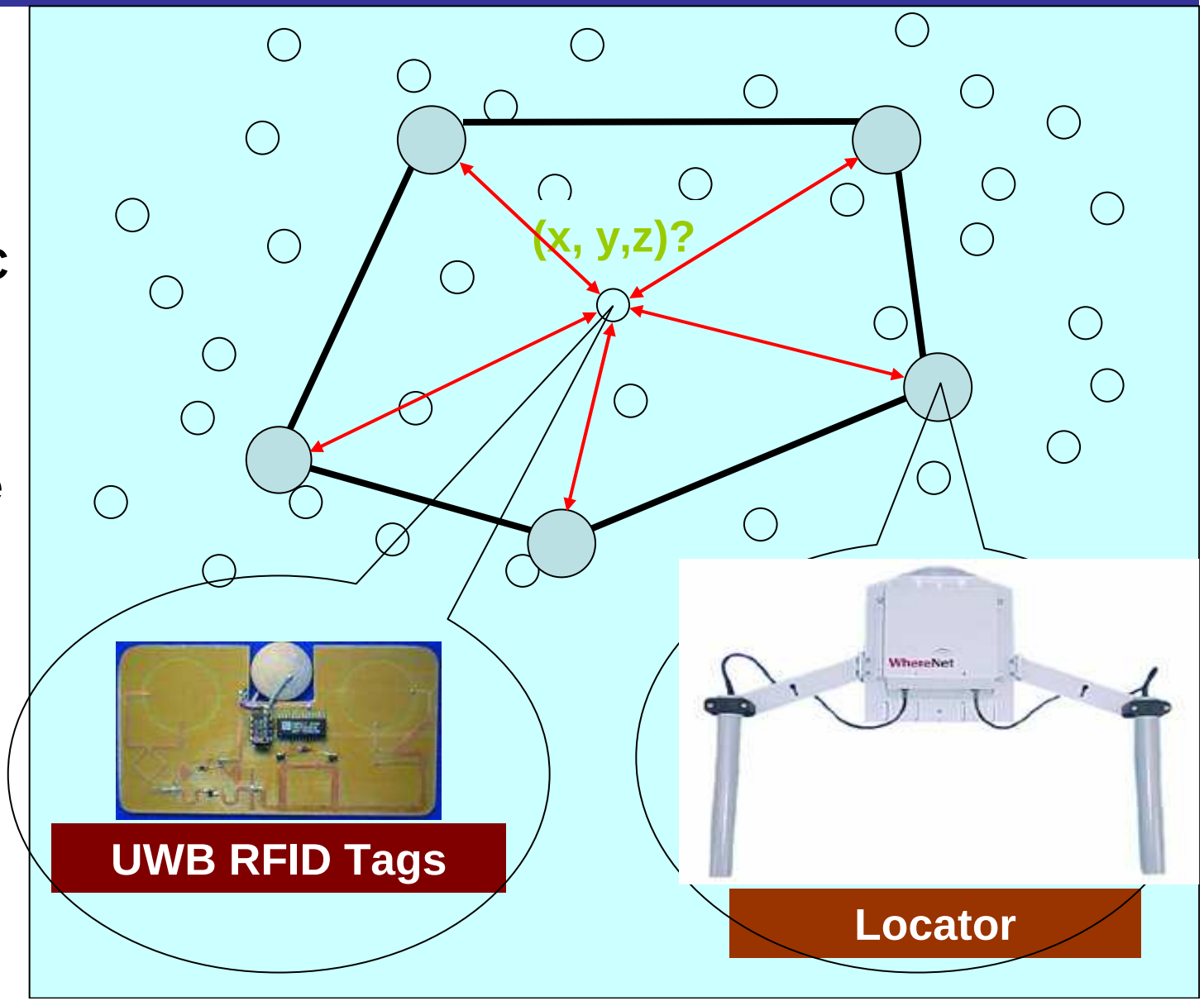
Flexible for long range, low data rate, especially in mobile *ad hoc* sensor networks

Location by UWB

- **Distance determined by pulse arrival time, 0.1 ns = 3 cm**
- **Location determined by triangulation using multiple sensors**

Proposed System

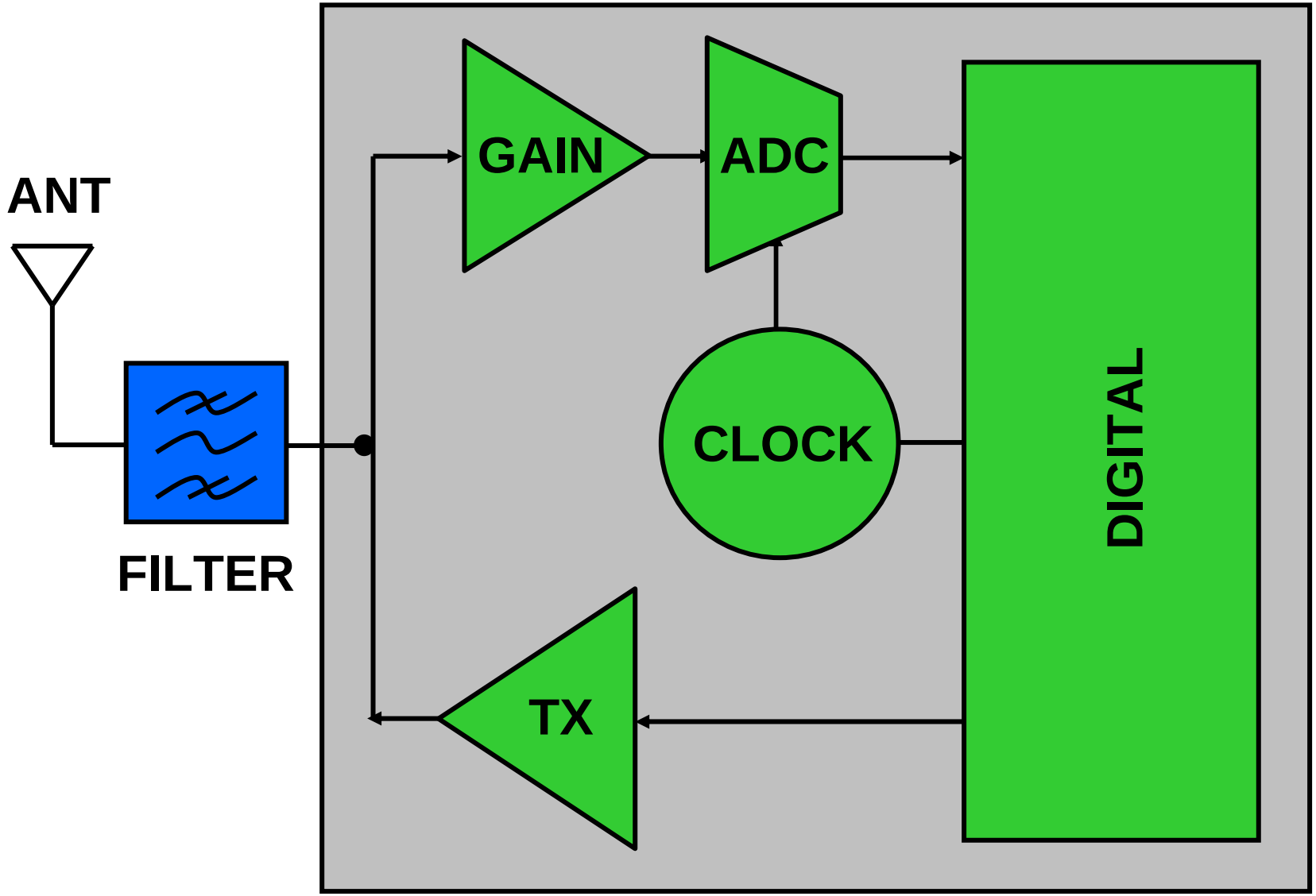
- **UWB location, identification & communication**
- **Locator power may exceed FCC mask**
- **Scalable to 1,000s of RFID tags, both active (< 10 mW) and passive (< 100 µW)**
- **Centimeter resolution over 100's of meters**



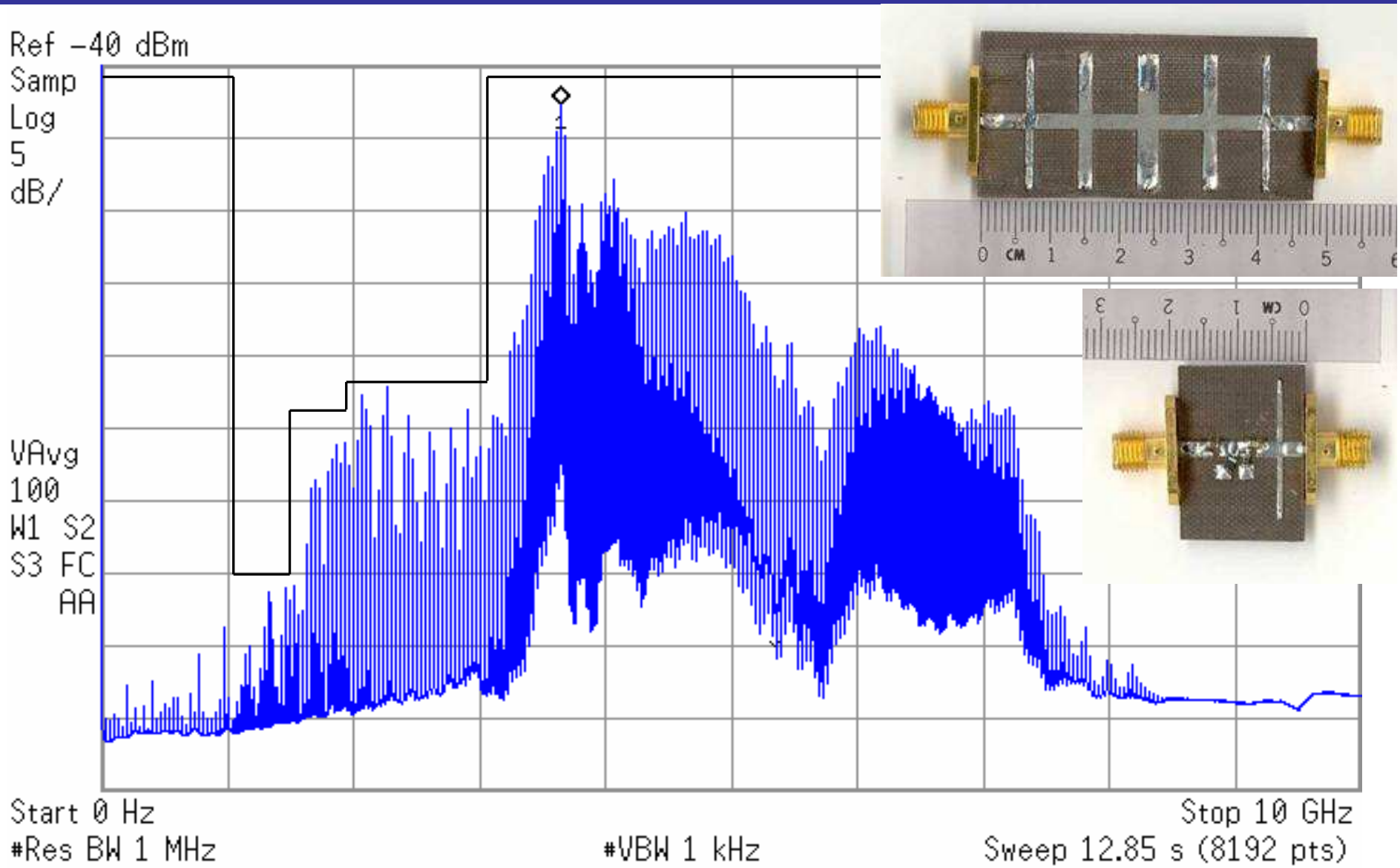
Applications of Proposed System

- **Pervasive healthcare**
- **Safety and disaster recovery**
- **Entertainment and gaming**
- **Smart space and collaborative workspace**
- **Education and training**
- **Logistics**
- **Environmental monitoring/protection**

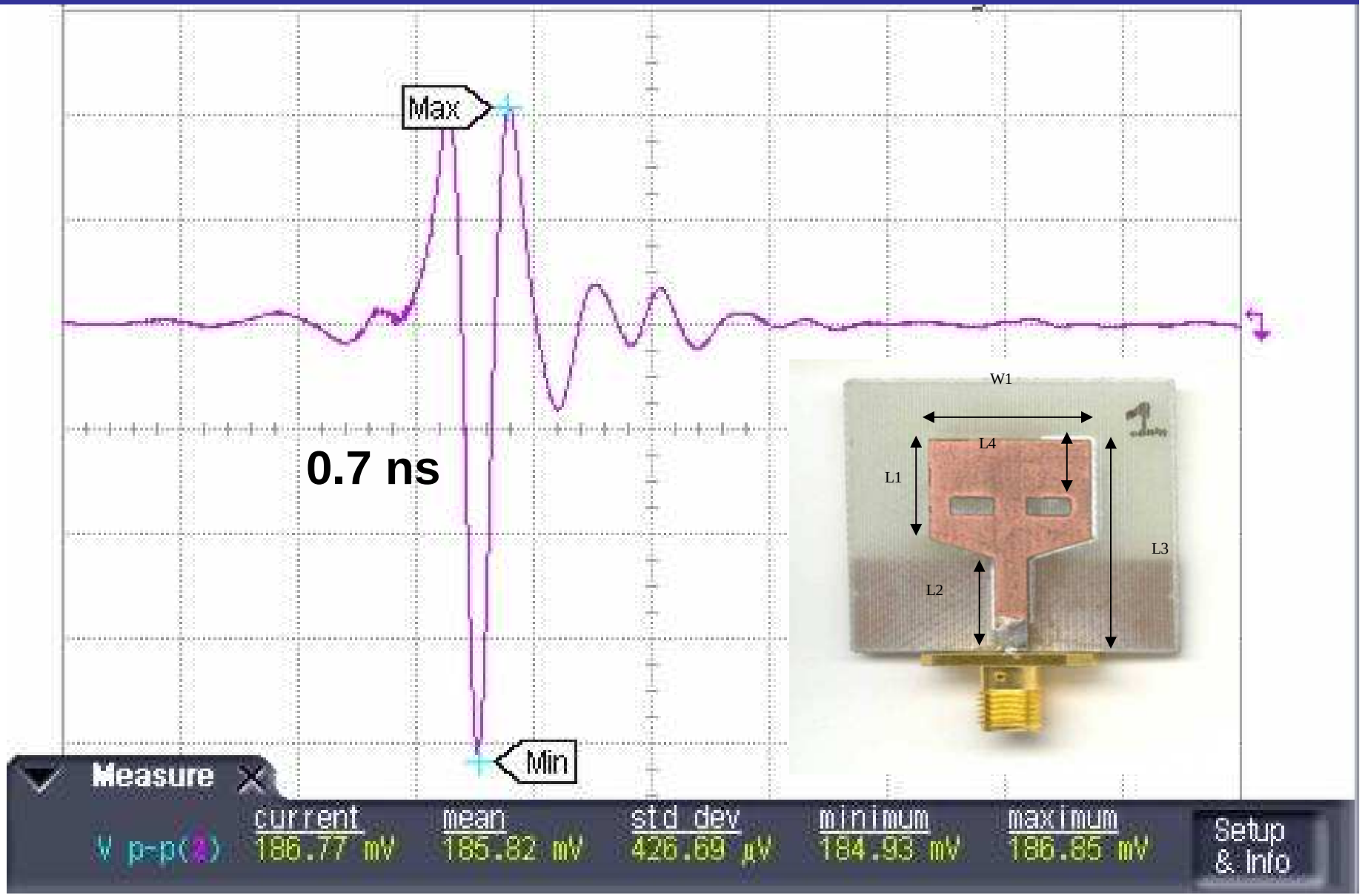
UWB Transceiver



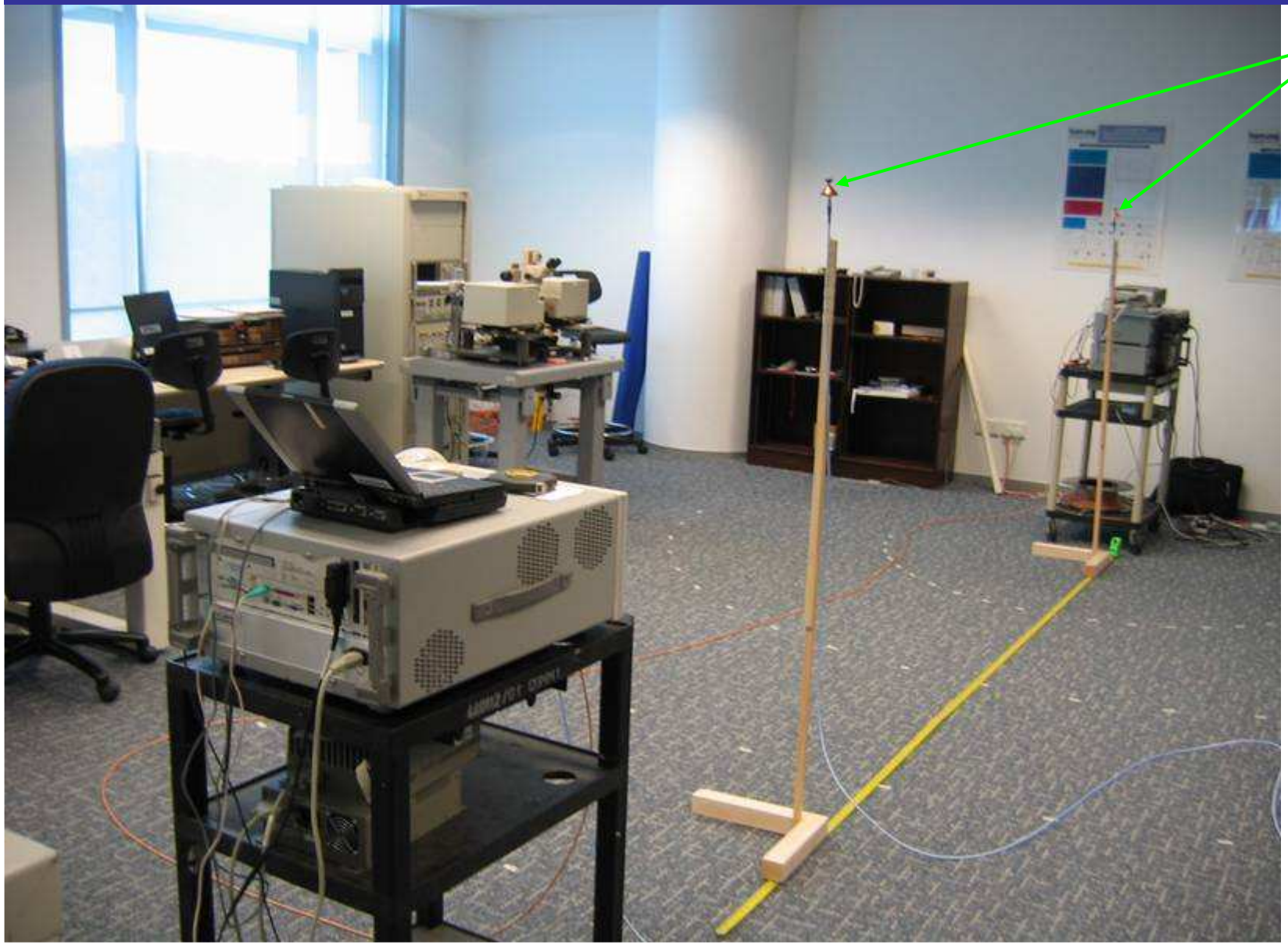
Fifth-Order Derivative Gaussian Pulse Generator



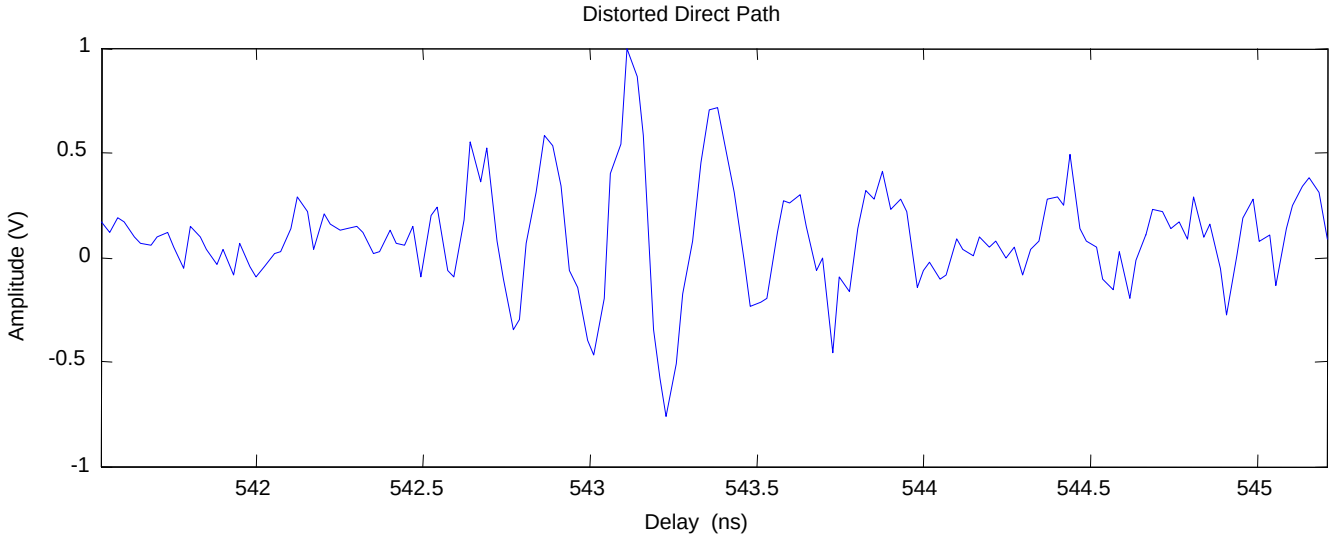
Low-Cost Antenna on Printed Circuit Board

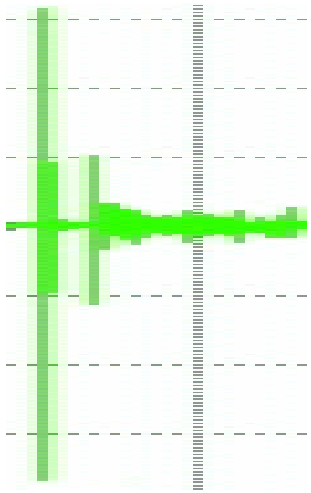


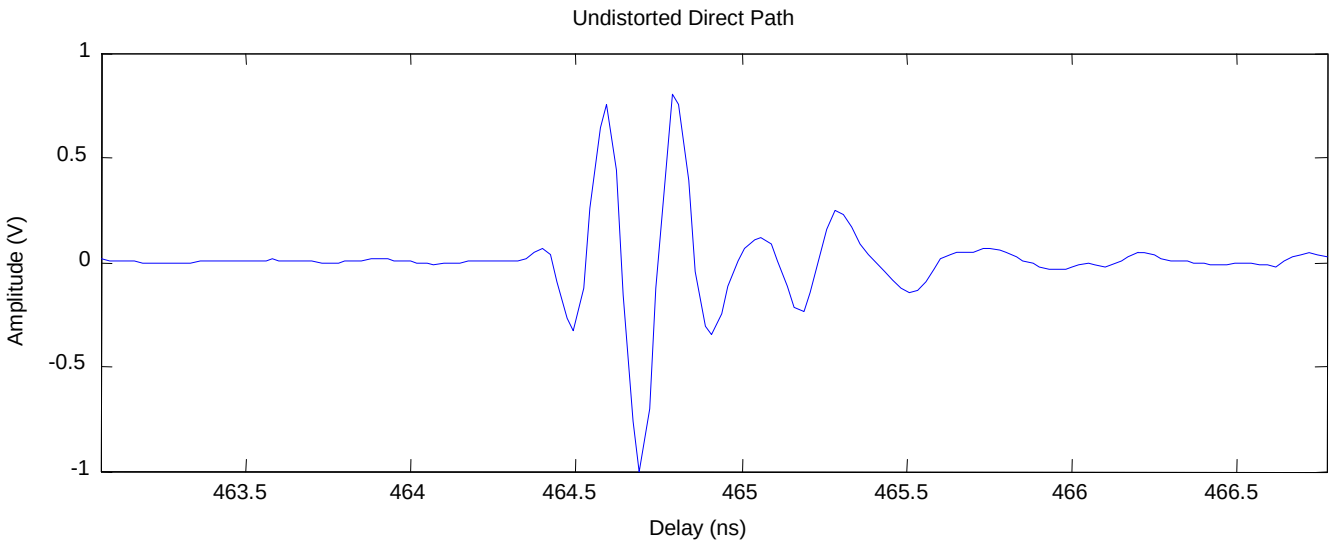
Bi-conical Antenna

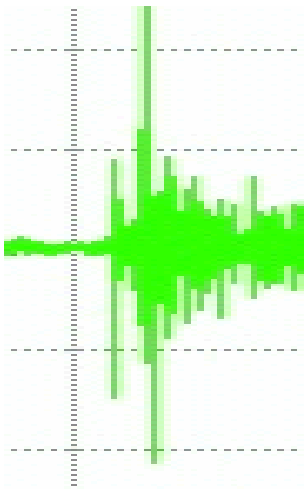


Antenna Test

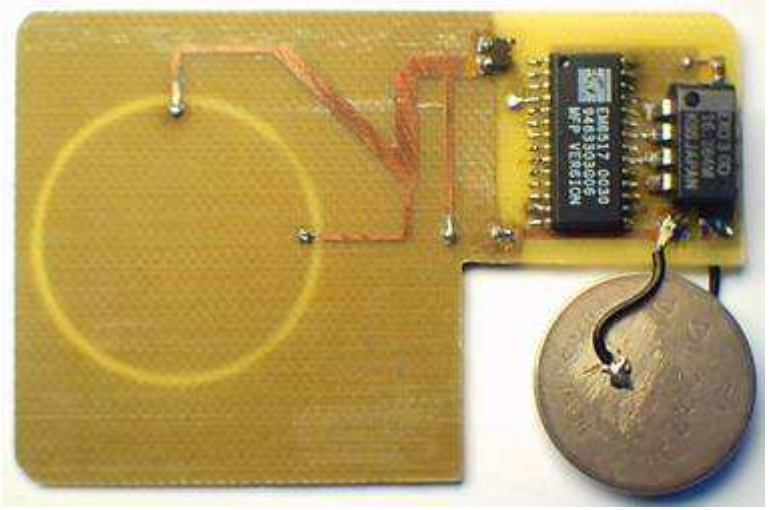


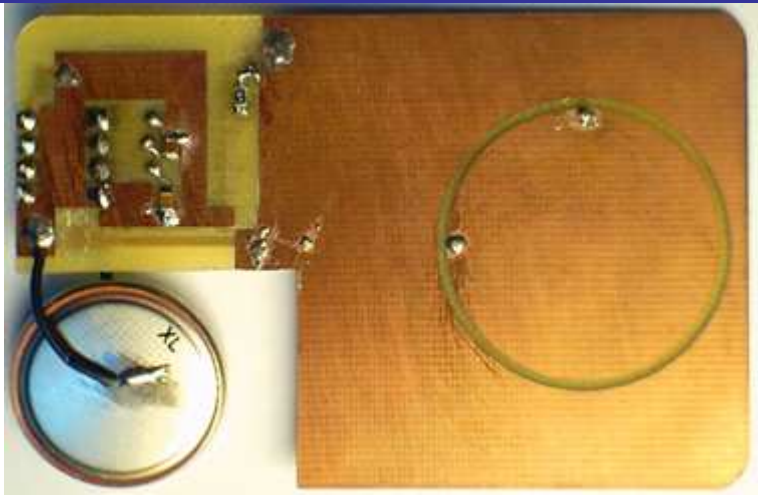




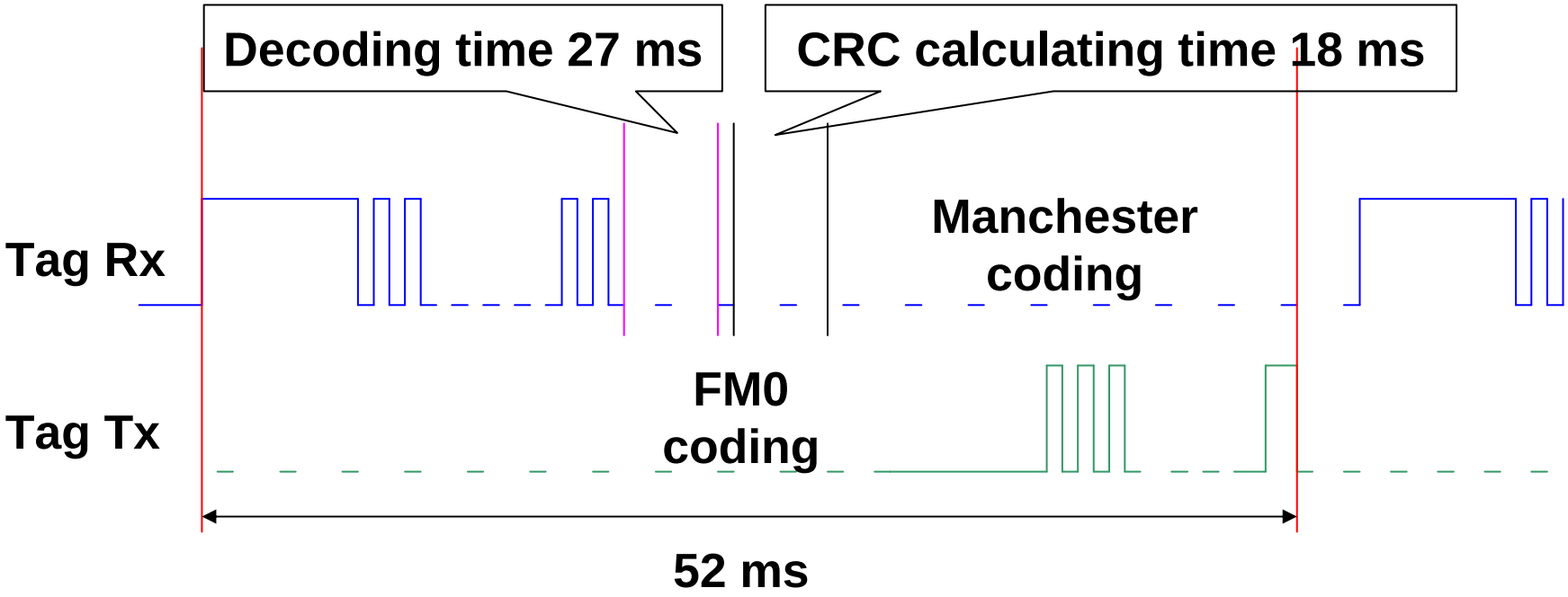


UWB RFID Tag



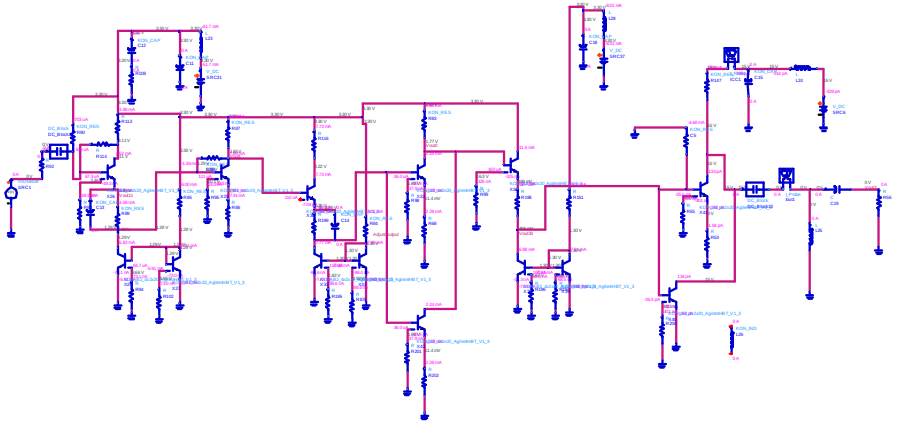


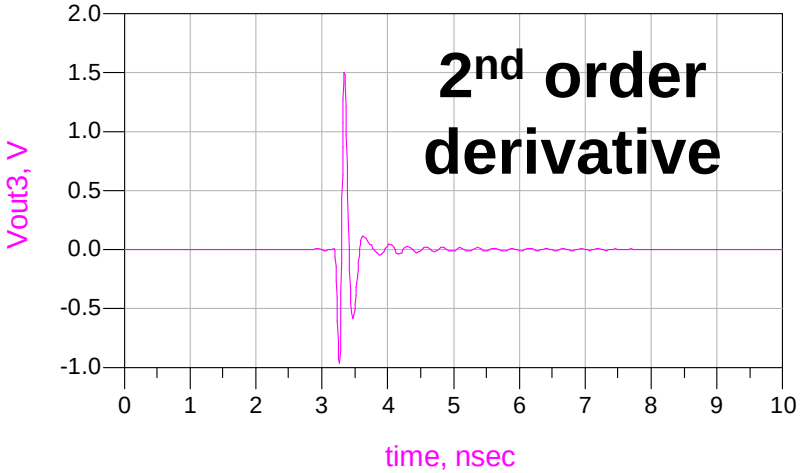
- **4 bit micro-controller, 3V, 12uA**
- **480KHz oscillator, 3V, 22uA**



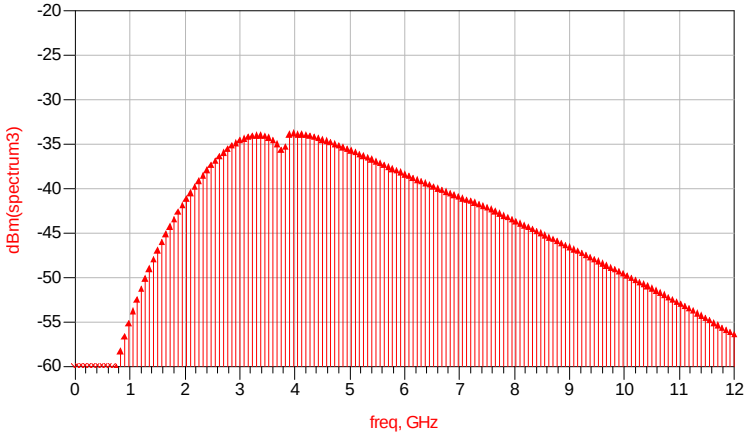
UWB Transmitter Amplifier

- **Integrated transmitter amplifier and derivative circuit**
- **To be fabricated by Knowledge*On foundry in Korea using high-voltage HBT technology**





Time-Domain Output



Frequency-Domain Output

Future of Project

- **Monolithically integrated high-voltage UWB amplifiers, transmitters and receivers**
- **Antenna array techniques to enhance UWB signalling, medium access control, and ToA/AoA positioning**
- **Low-power UWB RFID tags and readers**
- **Ranging algorithms and error models**
- **Cross layer design and optimization to enhance positioning accuracy, update rate, and scalability**

Future of UWB

- **Niche applications first**
- **Personal area network later**
- **IEEE 802.15 pushing US FCC for additional spectrum and power**
- **Commercial interests pushing US DoD to open up UWB R&D**
- **Europe? Asia?**