Submission Title: [A small printed dipole UWB antenna for mobile handset applications]
Date Submitted: [“13 September, 2004”]
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Re: [Technical contribution]

Abstract: [This presentation presents a printed dipole UWB antenna for mobile handset applications. The antenna features a small-sized radiator and can be manufactured with printed circuit technology.]

Purpose: [To provide technical contribution to the IEEE 802.15.3a.]

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A Small Printed Dipole UWB Antenna for Mobile Handset Applications

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Outline

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2. Previous/related work
3. Antenna structure
4. Measurement procedure
5. Measurement results
   - VSWR
   - Gain and group delay
   - Omni-directionality
   - Gain patterns
   - Antennas with different ground plate sizes
6. Conclusions
Motivation

• Requirements on antennas
  – For digital TV, DVD player, digital camcorder, notebook computer
    • Cheap manufacturing cost
    • Possibility of integration with the system board
    • Impedance bandwidth, gain and phase requirements
  – Additional requirements for mobile handsets
    • Small form factor
    • Omni-directional radiation pattern

Classic theory on antenna size
Minimum size of UWB antenna (3.1-10.6GHz) is about 30mm

Use “ceramic antenna configuration”
• Make the system board part of the antenna
• Minimize the size of the radiating element
Previous/related work

- Taiyo-Yuden/TRDA’s ceramic chip UWB antenna
  - Announced in June 2004
  - Ceramic chip size: 8mm×6mm×1mm

- Samsung’s ceramic UWB antenna
  - Reported in May 2004 in UWBST 2004
  - Ceramic chip size: 10mm×5mm×1mm
  - Semi-circular conductor patch on a single layer of ceramic
Antenna structure

- **Planar structure**
  - Planar dipole antenna with a Co-Planar Waveguide (CPW) feed
  - Direct feeding arrangement can be used as well.
  - Ground plates of different shapes and sizes can be used.
  - Electric components can be mounted on the central portion of the ground plate.

- **The radiating element**
  - Size: 6.1mm × 11.2mm

**Main features**
- Completely planar structure
- Can be produced with PCB technology
- Does not use ceramic material → near-zero manufacturing cost
Measurement procedure

1. Cable through
   - Measure the effect of cable+amplifier
   - Beware of high received power level

2. Horn-Horn
   - Use #1 to remove cable+amp effect
   - “Take the square root” to get the gain and phase response of a single horn

3. Horn-AUT
   - Use #1 to remove cable+amp effect
   - Use #2 to remove horn effect
Measurement (1/9)

- VSWR < 2.13 for $3.1\,GHz < f < 10.6\,GHz$
- VSWR < 2 for $f > 3.14\,GHz$

[Graph showing VSWR values across different frequencies]

UWB frequency band
• Max gain = 0.41 dBi @ f = 3.9 GHz
• Min gain = -13.05 dBi @ f = 6.35 GHz
• There exists a pattern null @ f = 6.35 GHz
  – Due to the off-center feed of the dipole antenna
Measurement (3/9)

- Maximum group delay variation = 285.1 ps
- The space wave propagation factor has been calibrated out.
  - So that the measured value reads close to time zero

The graph shows the group delay (boresight) across the UWB frequency band. The maximum group delay variation is indicated by a vertical arrow pointing upwards from the graph, indicating a value of 285.1 ps.
Measurement (4/9)

- **Omni-directionality**
  - Omni-directionality = max gain/min gain (on the azimuth plane)
  - Max. omni-directionality = 14.7 dB @ 6.33 GHz
  - Min. omni-directionality = 2.62 dB @ 7.53 GHz
Measurement (5/9)

- The main beam changes direction with frequency
  - For $f < 4.5 \text{GHz}$, it is in the boresight direction
  - For $f > 4.5 \text{GHz}$, the main beam splits and points in the edge-on direction
- High level of cross-polarization component
  - Very strong at an angle from boresight
  - Caused by large current flowing in the horizontal directions
Measurement(6/9)

- Typical radiation pattern of a dipole antenna
  - Deep nulls at angle=0°, 180°
  - Strong radiation in the direction of the ground plate in the low-frequency range
- Low cross-polarization level in the plane
  - Currents on the radiating element and the ground plate cannot produce cross-polarization component in the plane of the antenna
Measurement (7/9)

- Radiation pattern of a dipole antenna
  - Nulls at angle=0°, 180°
  - The main beam points above the horizon in the high-frequency range
  - Weaker radiation than in the elevation plane 1

- Low cross-polarization level in the plane
  - It is due to the cancellation effect of horizontally flowing currents.
  - Cross-pol level expected to rise off the observation plane
Measurement (8/9)

Different ground shape and size

Central portion of ground removed

40.5mm×57mm

VSWR<2 for f>3.03GHz

VSWR<2 for f>2.91GHz
Measurement (9/9)

- Central portion of ground removed
- Smaller ground plate

VSWR < 2 for f > 2.85GHz
VSWR < 2 for f > 3.06GHz
Conclusions

1. A printed dipole UWB antenna with a small radiating element has been presented.
   • Designed with focus on completely planar realization with small radiating element size
   • The dipole uses the ground plate of the system board as part of the antenna.
   • Operable over the entire UWB band
   • The off-center feed results in large gain variation (13.46 dB) and makes the main beam slightly tilt toward the ground plate.
   • Boresight group delay variation = 285.1 ps
   • Omni-directionality w.r.t. frequency = 14.7 dB Max.

2. Other features
   • Does not need expensive ceramic process
   • Can be manufactured completely with PCB technology
   • Electronic components can be mounted on the central portion of the ground plate without affecting the antenna performance.

3. Applications
   • Suitable for mobile handset applications