## IEEE P802.11
## Wireless LANs

## Preliminary RadioLAN Template

# 5 GHz, U-NII Band, L-PPM

## Differential Pulse Position Modulation

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## Abstract

This document is the preliminary submission template for IEEE 802.11, Tga meeting to be held in Utrecht, Netherlands. This document is based on documents 97/145r1, 98/38, 98/75, 98/132, 98/133.

Follows a short summary of the three proposals being considered by the committee.

| Company | Lucent Tech. + NTT | BreezeCom + NEC | RadioLAN |
|---|---|---|---|
| Modulation method | OFDM DBPSK, DQPSK or 16-QAM in each subcarrier | Offset Quadrature Modulation (OQPSK/OQAM) | Differential Pulse Position Modulation (16-DPPM, 4-DPPM) |
| Pulse shaping features | 48 subcarriers out of 64 | 50% Square-Root Raised Cosine | 50% Square-Root Raised Cosine |
| Error Correction Coding | Convolutional K=7, R=1/2 or R=3/4 Inter-carrier interleaving | Hamming (31,26) with interleaving, uncoded option | Uncoded, option for Reed Solomon (15,13) coded with interleaving |
| Rates supported | 5 Mbit/s    (DBPSK, R=1/2) 10 Mbit/s  (DQPSK, R=1/2) 15 Mbit/s  (DQPSK, R=3/4) 20 Mbit/s  (16-QAM, R=1/2) 30 Mbit/s  (16-QAM, R=3/4) | 21 Mbit/s (OQPSK, coded) 25 Mbit/s (OQPSK, uncoded) 42 Mbit/s (OQAM, coded) 50 Mbit/s (OQAM, uncoded) | 10 Mbit/s (4-DPPM) 20 Mbit/s (16-DPPM) 20 Mbit/s (16-DPPM, coded) |
| Number of channels in U-NII band | 5 in 100 MHz, 10 in 200 MHz 15 MHz channel spacing | 4 in 100 MHz, 9 in 200 MHz 20 MHz channel spacing | 3 in 100 MHz, 7 in 200 MHz 30 MHz channel spacing |
| Applicable documents | 97/92, 97/123, 97/137, 98/02, 98/03, 98/12, 98/71r1, 98/72, 98/73, 98/74, | 98/76r1, 98/109, 98/144 | 97/145r1, 98/38, 98/75, 98/132, 98/133 |

### TGA Performance Template

#### General Description, Parameters Common for all Rates

| Parameter | Value(s) |
|---|---|
| Data Rates Supported | 10 Mbps uncoded<br>20 Mbps, uncoded<br>20 Mbps, coded (optional) |
| Channel Spacing | 30 MHz |
| Center Frequencies | **9-Channels Plan:**<br>Lower:<br>5170 MHz<br>5200 MHz<br>5230 MHz<br><br>Middle:<br>5270 MHz<br>5300 MHz<br>5330 MHz<br><br>Upper:<br>5745 MHz<br>5775 MHz<br>5805 MHz |
| Power Levels | **9-Channels Plan:**<br>Lower:  50 mW<br><br>Middle:  250 mW<br><br>Upper:    1000 mW |
| Sensitivities | -77 dBm at 10 Mbps<br>-75 dBm at 20 Mbps<br>-72 dBm at 20 Mbps (coded) |
| CCA threshold | -70 dBm |
| Clock Rate accuracy | 100 ppm |
| Carrier Frequency accuracy | 100 ppm |
| Waveform implementation accuracy specification method | Per Waveform Mask |
| Power Backoff in RF PA | 0 to 1.5 dB back-off from Psat for all rates |
| Implementation Complexity | The complexity of the RF transmitter, the RF receiver, and the baseband processor for L-PPM is rather low.  The receiver is non-coherent and therefore quite simple. The baseband processor will be a single-chip Silicon integrated circuit implemented in either  high-speed CMOS, or BiCMOS.<br>The DC power consumption is quite efficient due to the pulsed nature of this system, with a low duty cycle.<br>We believe this to be the simplest and most readily achievable approach as compared to the other five proposals. |

**Per-Rate Feature Summary**

| Proposal and Rate | ECC method | Interleaving method | Suggested minimal sensitivity | Suggested Adjacent Channel rejection | Suggested Alternate Channel rejection | Implementation Accuracy |
|---|---|---|---|---|---|---|
| RadioLAN 10 Mb | None | None | -77 | 17 | 35 | Low |
| RadioLAN 20 Mb | None | None | -75 | 15 | 30 | Medium |
| RadioLAN 20+RS | Reed-Solomon (15, 13) | Depth 4 | -72 | 13 | 30 | Medium |

**Per-Rate Performance Summary**

| Proposal and Rate | Pr [dBm] at PER=10%, AWGN, 64b | Pr [dBm] at PER=10%, AWGN, 1000b | Trms at PER=10%, noise free, 64b | Trms at PER=10%, noise free, 1000b | Pr [dBm] @ 20%, with Trms @ 10%, 64b | Pr [dBm] @ 20%, with Trms @ 10%, 1000b |
|---|---|---|---|---|---|---|
| RadioLAN 10 Mb | -90 dBm | -89 dBm | 200 nsec | 180 nsec | -73 dBm | -70 dBm |
| RadioLAN 20 Mb | -85 dBm | -84 dBm | 150 nsec | 140 nsec | -66 dBm | -63 dBm |
| RadioLAN 20+RS | -83 dBm | -82 dBm | 140 nsec | 130 nsec | -65 dBm | -64 dBm |

**Performance in Interference**

| Proposal and Rate | Sensitivity @NF=10 dB, no degr. [dBm] | CCI immunity [dB] | ACI immunity [dB] | CW jammer immunity [dB] | Narrowband Gaussian noise immunity [dB] | Phase noise tolerance, [dBc] |
|---|---|---|---|---|---|---|
| RadioLAN 10 Mb | -77 dBm | 8 dB | 17 dB | 9 dB | 6 dB | 5 dBc |
| RadioLAN 20 Mb | -75 dBm | 10 dB | 15 dB | 10 dB | 9 dB | 7 dBc |
| RadioLAN 20+RS | -72 dBm | 10 dB | 13 dB | 11 dB | 10 dB | 8 dBc |

**PA Backoff and Link Budget**

| Proposal and Rate | Sensitivity @NF=10 dB, no degr. [dBm] | Backoff [dB], average Pt=150 mW, (U-NII regulations) | Backoff [dB], average Pt=150 mW, (restricted regulations) | Loss [dB] at average Pt=150 mW | Loss [dB] at saturated Pt=250 mW, (U-NII regulations) | Loss [dB] at saturated Pt=250 mW, (restricted regulations) |
|---|---|---|---|---|---|---|
| RadioLAN 10 Mb | -77 | 0.5 | 0.5 | 99 | 100.5 | 100.5 |
| RadioLAN 20 Mb | -75 | 1 | 1 | 97 | 98 | 98 |
| RadioLAN 20+RS | -73 | 1 | 1 | 95 | 96 | 96 |

**Interference Limited Aggregate Rate**

Indoor (35*log(DR)) propagation model:

| Proposal and Rate | CCI immunity [dB] | D2/D1, Interferer to Transmitter dist. ratio | Fraction of Area covered | Aggregate rate per AP, single rate | Aggregate rate per AP, multirate | Aggregate rate per AP, multirate, multichannel (for 3 channels & 100 MHz) | Aggregate rate per AP, multirate, multichannel (for 7 channels & 200 MHz) |
|---|---|---|---|---|---|---|---|
| RadioLAN 10 Mb | 8 | 1.692667 | 0.55169 | 5.516896 | 5.516896 | 16.55069 | 38.6183 |
| RadioLAN 20 Mb | 10 | 1.930698 | 0.465713 | 9.314251 | 10.17402 | 30.52207 | 71.2150 |
| RadioLAN 20+RS | 11 | 2.061986 | 0.426632 | 8.532643 | 10.17402 | 30.52207 | 71.2150 |

Free Space (20*log(DR)) propagation model:

| Proposal and Rate | CCI immunity [dB] | D2/D1, Interferer to Transmitter dist. ratio | Fraction of Area covered | Aggregate rate per AP, single rate | Aggregate rate per AP, multirate | Aggregate rate per AP, multirate, multichannel (for 3 channels & 100 MHz) | Aggregate rate per AP, multirate, multichannel (for 7 channels & 200 MHz) |
|---|---|---|---|---|---|---|---|
| RadioLAN 10 Mb | 8 | 2.511886 | 0.324324 | 3.24324 | 3.24324 | 9.729719 | 22.7027 |
| RadioLAN 20 Mb | 10 | 3.162278 | 0.230886 | 4.617723 | 5.552101 | 16.6563 | 38.8647 |
| RadioLAN 20+RS | 11 | 3.548134 | 0.193372 | 3.867439 | 5.552101 | 16.6563 | 38.8647 |

**Timing and Overhead related parameters**

| Parameter | RadioLAN |
|---|---:|
| aSlotTime | 3 |
| aCCATime | 1.2 |
| aRxTxTurnaroundTime | 1 |
| aTxPLCPDelay | 0.2 |
| aRxTxSwitchTime | 0.1 |
| aTxRampOnTime | 0.5 |
| aTxRFDelay | 0.2 |
| aSIFSTime | 5 |
| aRxRFDelay | 0.2 |
| aRxPLCPDelay | 0.2 |
| aMACProcessingDelay | 0.5 |
| aTxRampOffTime | 1.5 |
| aPreambleLength | 12.8 |
| aPLCPHdrLength | 4.8 |
| aMPDUDurationFactor | 1 |
| aAirPropagationTime | 0.3 |
| aCWmin | 15 |
| aCWmax | 512 |

| Proposal and Rate | 1500B MPDU duration (μsec) | DIFS + backoff (μsec) | 1500B packet duration (μsec) | SIFS (μsec) | ACK packet duration, same rate (μsec) | ACK packet duration, basic rate (μsec) | Efficiency, ACK at same rate | Efficiency, ACK at basic rate |
|---|---:|---:|---:|---:|---:|---:|---|---|
| RadioLAN 10 Mb | 1200 | 30.5 | 1221.6 | 5 | 32.8 | 32.8 | 0.9303046 | 0.9303046 |
| RadioLAN 20 Mb | 600 | 30.5 | 620 | 5 | 25.6 | 32.8 | 0.8809279 | 0.8717129 |
| RadioLAN 20+RS | 600 | 30.5 | 620 | 5 | 25.6 | 32.8 | 0.8809279 | 0.8717129 |