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

Submission Title: [OEM Comments]
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Source: [Bernd Grohmann] Company: [Danfoss A/S]
Address: [E14, DK-6430 Nordborg, Denmark]
Voice: [+45.7488.3802], FAX: [+ +45.7488.4000]
E-Mail: [bernd . grohmann @ danfoss . com]
Re: [IEEE 802.15 TG4b]

Abstract: [This contribution provides comments and summarizes key requirements to the discussion of a 2.4 Ghz derivative PHY for the sub-1-GHz band]

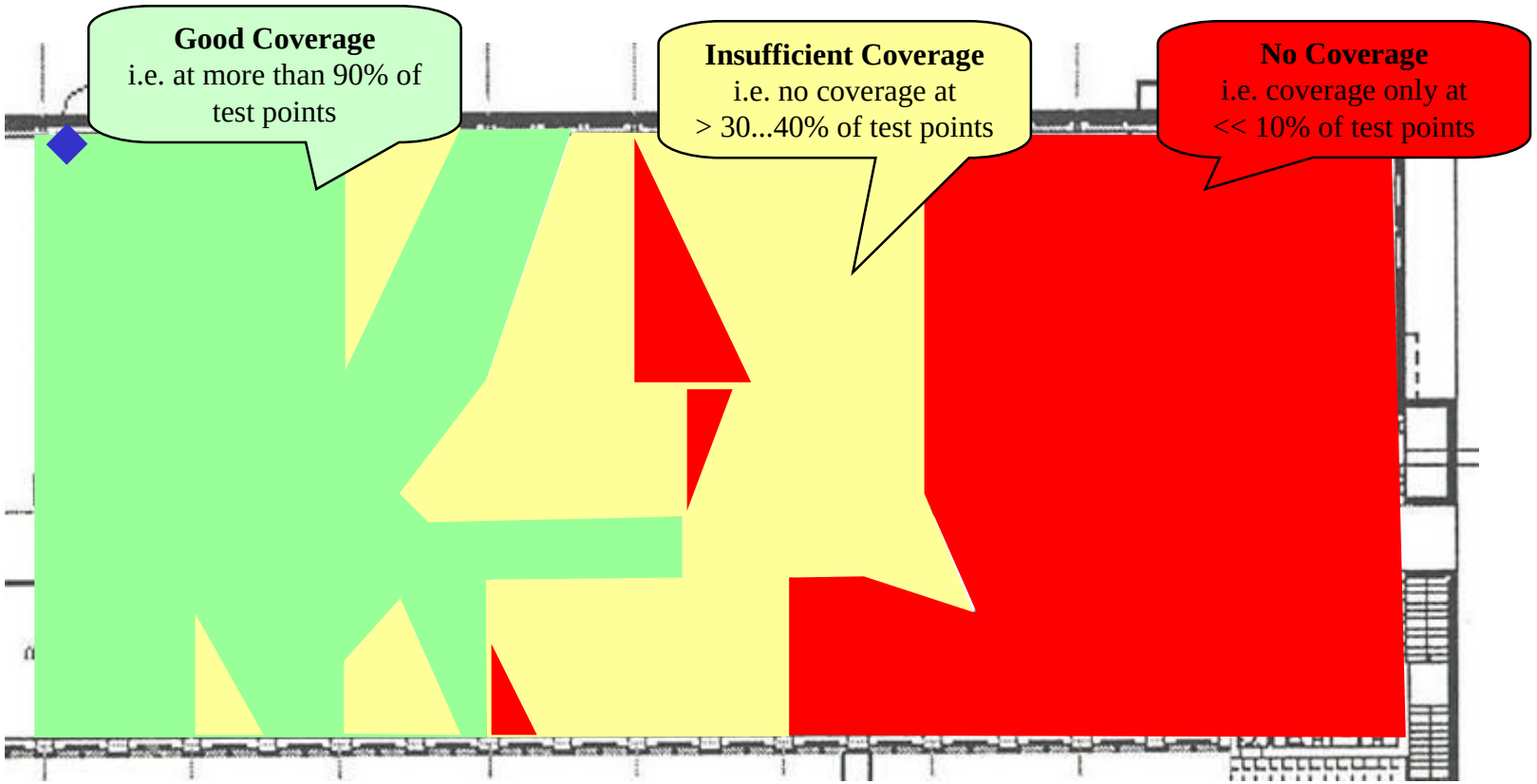
Purpose: [To encourage discussion.]

Presentation content

An OEM's perspective to IEEE802.15 TG4b PHY work

- Experience from target environments
- Rationale for improved sub-1-GHz band support
- Extended European bands
- OEM requirements for TG4b PHY

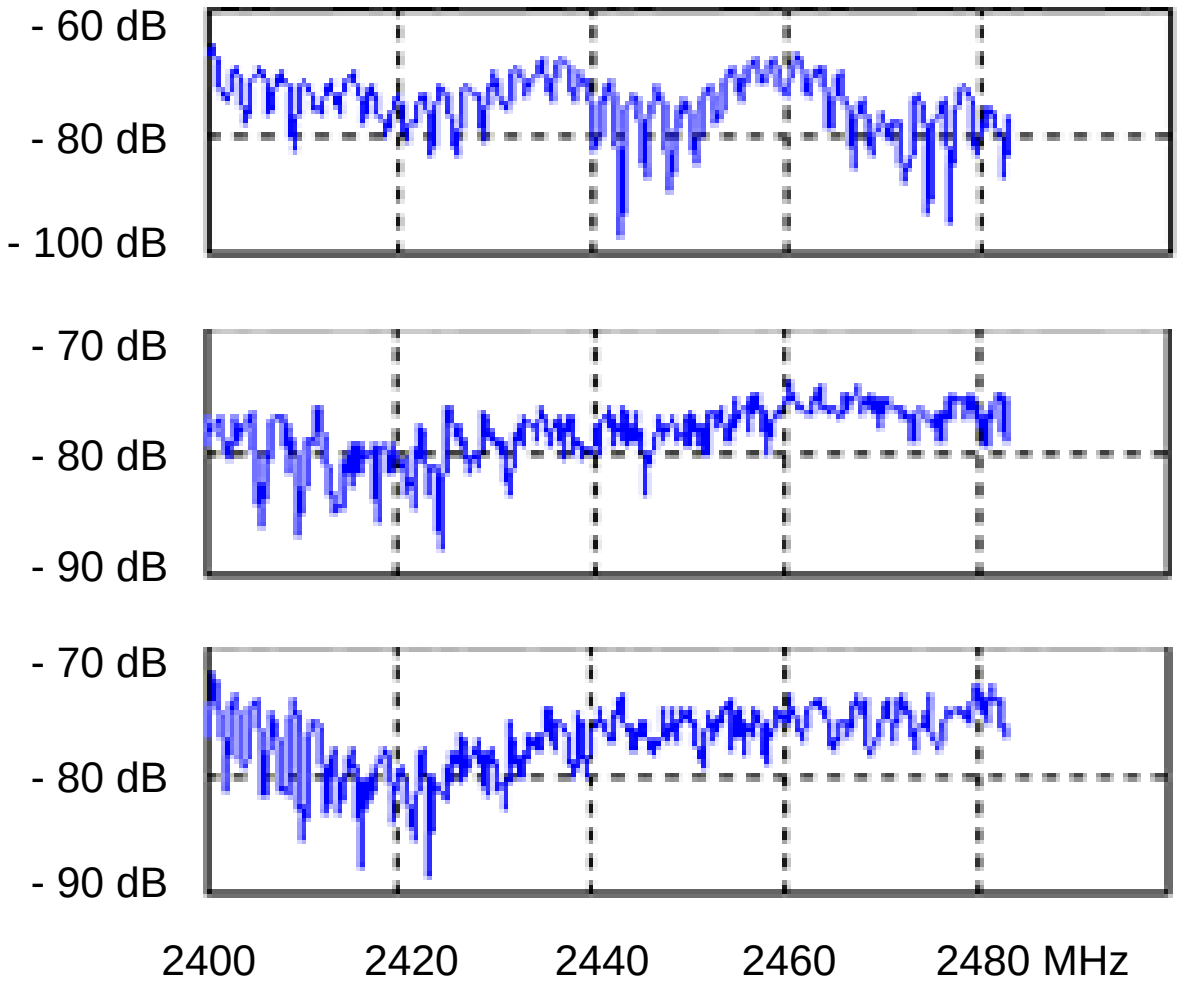
Residential / light commercial environments – Small office building, heating application



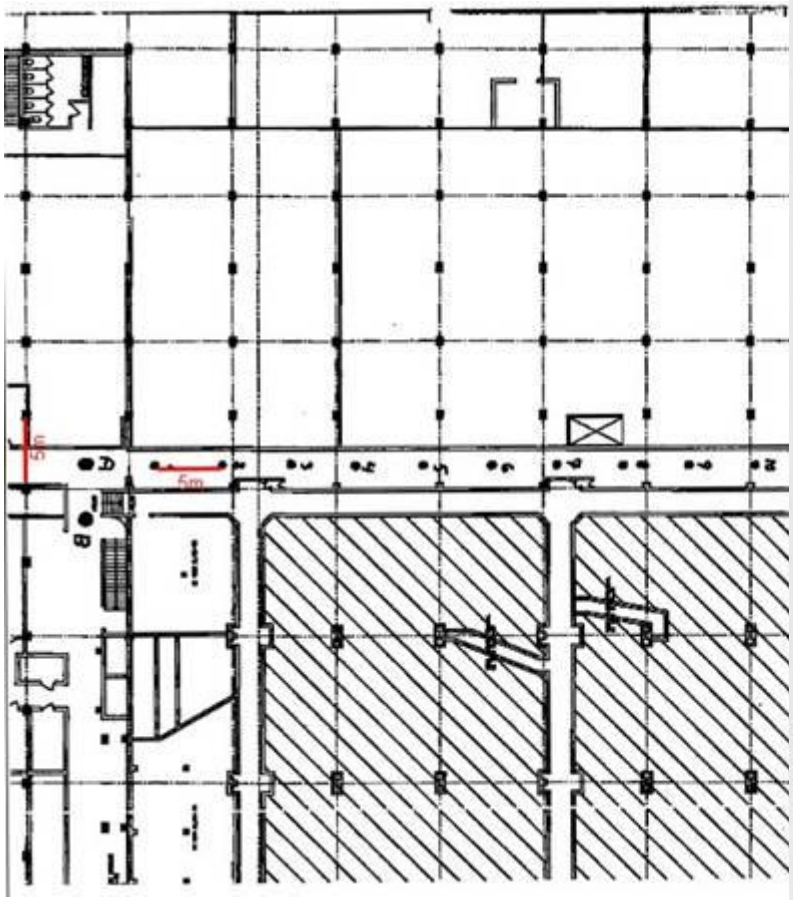
- Test site: Danfoss office (brick building, sheetrock walls)
- Tested RF technology: IEEE802.15.4-2003 (2.4 GHz), 0dBm Tx (Approximation of coverage, PER < 1%)

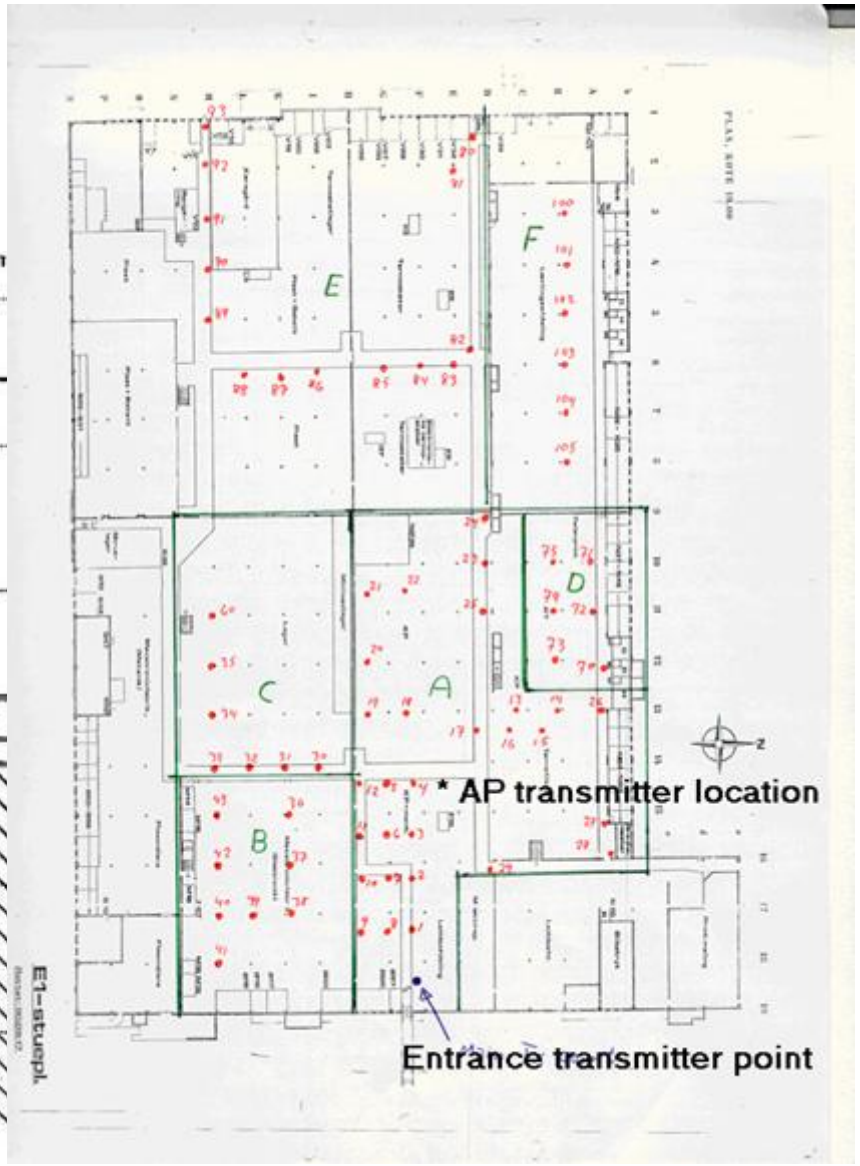
◆ Test transmitter

Residential / Light commercial – Frequency vs. power

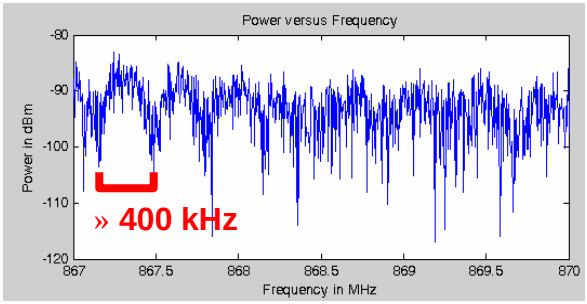


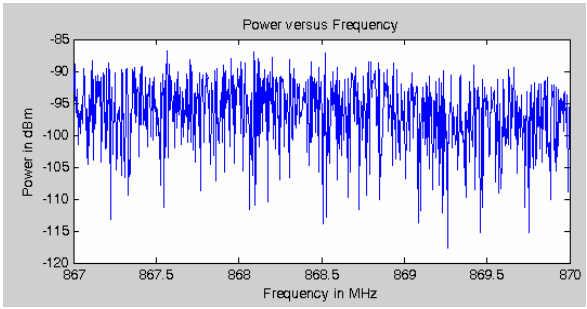
Industrial / Commercial environments

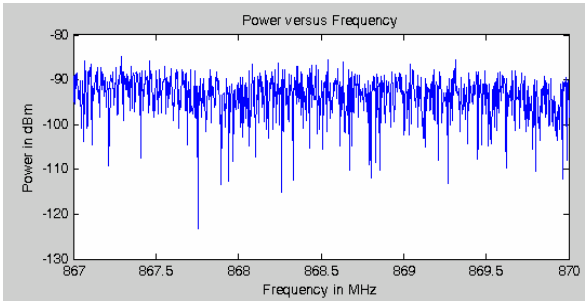


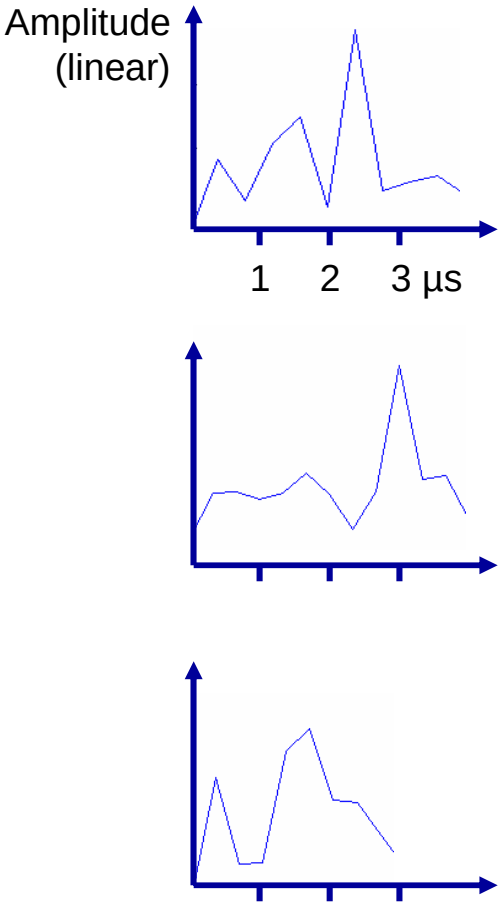


Industrial / Commercial environments









Notes:

- Distance (floorplan) is 20m, 25m, 30m
- Due to antenna bandwidth, measurements used were from 865,25 - 869,75 MHz
- The envelope of the channel response is calculated
- Time resolution of the channel response is about 33ns

Conclusions

- IEEE 802.15.4 is designed for low multipath fading environments and performs there satisfactorily
  - "10m range (indoors) implies worst case path length = 2x10m = 60nS. Proposed system can tolerate a delay spread > 100 ns, so there should be no problem in most applications" [Source: 01229r1P802-15_TG4]
- Especially commercial and industrial environments have significantly higher requirements to MP fading robustness
  - "Application-typical" antenna placement increases challenges
  - "Diffuse exponential model" does not adequately describe such target environments
  - Ability to operate in at least 500-1000 ns frequency selective MP fading is required – without loosing 15-25 dB link budget

Rationale for OEM & customer interest for improved sub-1-GHz band support

- **Actual and perceived high risk of interference in 2.4 GHz band**
  - 2.4 GHz band is crowded already, interference problems already – 2.4 GHz Band will get more crowded (BT, WLAN, WiMedia, Audio etc.)
  - Mobile 2.4 GHz devices "carried around" by people **à** *Uncontrollable*
  - How to guarantee reliable operation for 5+ years ?
    Demanded strongly by our customers already – Risk to market adoption!
- **Higher range** – Factor 2-3 indoor improvement is desired and required
  - Lower attenuation at 868/915 MHz than at 2.4 GHz, passes much better through many relevant materials
  - Currently useable indoor range is largely limited by MP fading robustness
- **Visibly improved indoor coverage**
  - Current 2.4 GHz solution is only barely better than "well-developed" 868/915 MHz narrowband systems in many indoor environments due to MP fading robustness

Our assessment is that for 30-50% of the entire target market volume, the current 2.4 GHz solution in IEEE802.15.4-2003 is not suitable/accepted and an improved 868 / 915 MHz solution would be strongly preferred

Extended European SRD bands in 863-870 MHz – *Status in ECC/CEPT and ETSI*

- **Narrowband channels of 25 / 50 / 100 kHz in 863-870 MHz**
  - LBT (listen before transmit) at Rx threshold of -102 / -99 / -96 dBm e.r.p.
  - Maximum Tx on-time: 1s – Minimum Tx off-time: 100ms
- **Extended bands for DSSS in 863-870 MHz**

Sub-band	Max. radiated power	Bandwidth	Duty Cycle (entire Tx)
865-868 Mhz	25 mW	0.6 Mhz	1% max. or LBT
865-870 Mhz	25 mW	3 Mhz	0.1% max. or LBT
863-870 Mhz	25 mW	7 Mhz	0.1% max. or LBT

LBT: Rx must likely check that all narrowband channels it occupies are free

- Product of Bandwidth x Duty Cycle is not increased unless LBT is applied
  - No wide, unrestricted bands as in the 915 MHz band in the US
- Attractive for TG4b / DSSS with sufficient bitrate (> 200 kbit/s at 1% DC)
  - Permits multiple channels in Europe, e.g. 4x 600 kHz
  - Duty cycly restriction provides protection against interference

Source: ETSI TR 102 313 V1.1.1 (2004-07) ; ECC Report 37

Key requirements for sub-1-GHz band

- **Bitrate over 200 kBit/s**
  - Number of permitted transactions/hr is insuffcient in IEEE802.15.4-2003 868 Mhz
    - 1% duty cycle at 20 kbit/s translates into typically only 600-800 transactions/hr
    - With > 200 kbit/s sufficient number of transactions/hr for our targeted applications
    - Disadvantage of 1% duty cycle limit turns into *protection against interference*
  - Extension from 20/40 kbit/s extends total battery lifetime by 15-40%
- **Improved multipath fading robustness**
  - Achieve PER < 10^{-2} at channels with at least 1 µs delay spread (non-exponential channel models)
  - Improve coverage in "challenging" RF environments – especially commercial, industrial
- **Support of current RF regulatory regimes *plus* enable the use of extended bands**
  - Support 1-2 MHz wide channels in the USA and other countries were they are permitted
  - Support of current 600 kHz band available at 1% duty cycle in Europe today
  - Allow use of extended European bands once they become available
    - Do not expect US-like wide, unrestricted bands
    - Allow addition of additional 600 kHz channels as per current ETSI / ECC report (4/6 channels?)
  - Support of more flexible channel selection method to flexibly add support for more countries
- **Backward compatibility to IEEE802.15.4-2003 (915/868 MHz)**
  - Interoperability when switched to 15.4-2003 mode
  - No fully transparent backward compatibility as in 802.11b vs. 802.11 or 802.11g vs. 802.11b
- **Low cost and low power consumption (!)**

Prioritization of requirements

Residential / Light commercial

- Low cost
- Low power consumption
- RF performance
- Bitrate

Strongly covered already by IEEE802.15.4-2003 2.4 GHz

Commercial / Industrial

- Bitrate
- RF performance
- Low power
- Low cost

Key target for the IEEE802.15 TG4b PHY