**IEEE P802.24**

**Smart Grid TAG**

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| Project | IEEE P802.24 Smart Grid Technical Advisory Group | |
| Title | Link Margin Examples | |
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| Re: | Sub-1GHz white paper contribution | |
| Abstract | Examples of link margin calculations for 902-928 MHz band and 2.4GHz band using the NIST Small City model. | |
| Purpose | Contribution to white paper | |
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Link Margin Calculations comparing Sub-GHz 915 band to 2.4 GHz band

The following calculations compare the link loss difference between a sub-1GHz band at 902-928 MHz with the 2.4 GHz band, keeping all other variables equal. The parameters are typical of a commonly available moderately low data rate radio as is popular in many smart grid and IoT related applications such as metering and remote monitoring. It should be noted that other factors beyond propagation loss, including required data rate, would drive selection of a band. For example, the contiguous spectrum available at 2.4 GHz is much larger than what is available in sub-1GHz bands in many regions, and so maximum data rate achievable may limit use of lower frequencies for applications that require high data volumes.

Example calculations, based on the NIST link model. The “Small City” model was used as this approximates an urban environment.

Conditions:

|  |  |
| --- | --- |
| Transmitter antenna height (m) | 10.0 |
| Receiver antenna height (m) | 3.0 |
| Center frequency in MHz | 915 |
| Environment | Small City |
| Fading mode | shadowing and fading |
| Std. Deviation in dB, *L* | 1.0 |
| Percentage of time, *X* | 90% |
| Desired link margin in dB, *M* | 6.0 |
| Transmit power | 30 dBm |
| Receiver sensitivity | --97 dBm |

Result:

|  |  |  |
| --- | --- | --- |
| Transmit power | 30.0 | dBm |
| Gains | 10.0 | dB |
| Losses | 129.3 | dB |
| Received power | -89.3 | dBm |
| Noise + interference power | -120.9 | dBm |
| Median received SNR | 31.6 | dB |
| Processing gain | 0.0 | dB |
| Median received EbNo | 31.6 | dB |
| Required EbNo | 24.0 | dB |
| Excess | 7.6 | dB |
| Margin | 6.0 | dB |
| SURPLUS | 1.6 | dB |
|  |  |  |
| Desired link reliability | 90 | % |
| Effective link reliability | 62 | % |
|  |  |  |
| Specified link distance | 1.000 | km |
| **Distance for desired reliability** | **1.100** | **km** |

The second example uses exactly the same parameters, but changes the transmit frequency to use the 2.4GHz license exempt band throughout the world. Changing only the frequency, we see the distance to achieve the same 6dB link margin is reduced by nearly half:

|  |  |
| --- | --- |
| Transmit power | 30.0 |
| Gains | 10.0 |
| Losses | 139.8 |
| Received power | -99.8 |
| Noise + interference power | -120.9 |
| Median received SNR | 21.2 |
| Processing gain | 0.0 |
| Median received EbNo | 21.2 |
| Required EbNo | 24.0 |
| Excess | -2.8 |
| Margin | 6.0 |
| SURPLUS | -8.8 |
|  |  |
| Desired link reliability | 90 |
| Effective link reliability | 27 |
|  |  |
| Specified link distance | 1.000 |
| **Distance for desired reliability** | **0.589** |