# IEEE P802.11
# Wireless LANs

## Addressing some of the BRAN-related issues

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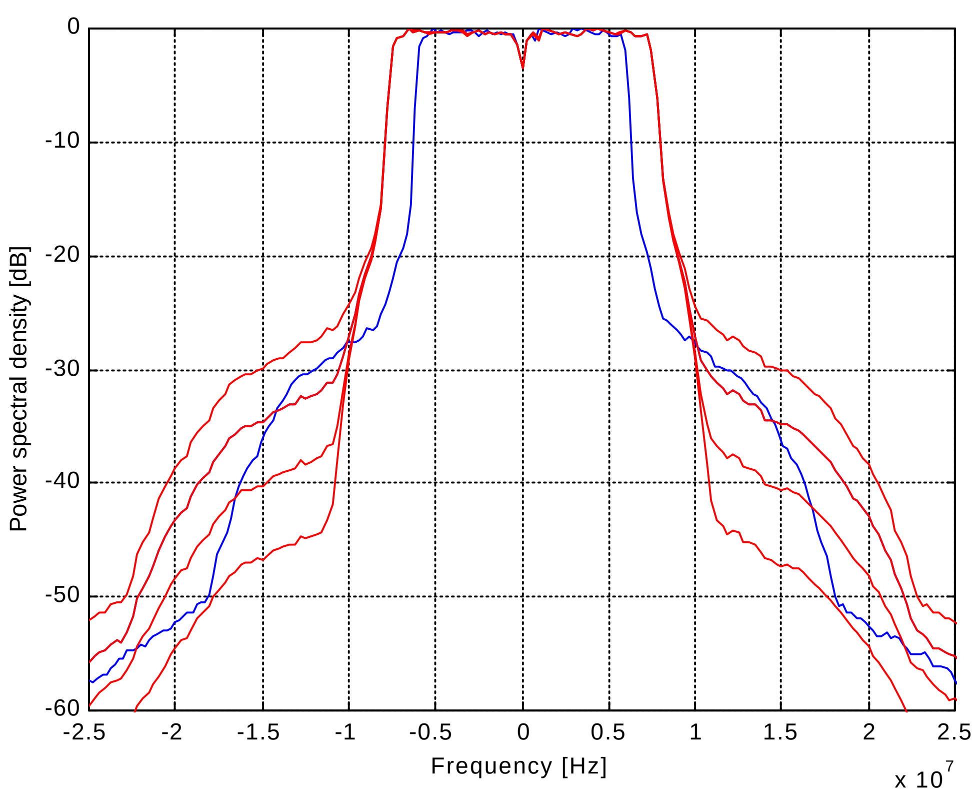
## Abstract

Some of the issues discussed with BRAN are addressed here quantitatively to support decisions in 802.11. Issues of channel spacing, FFT size and number of data subcarriers are considered.

### Channel Width Implications

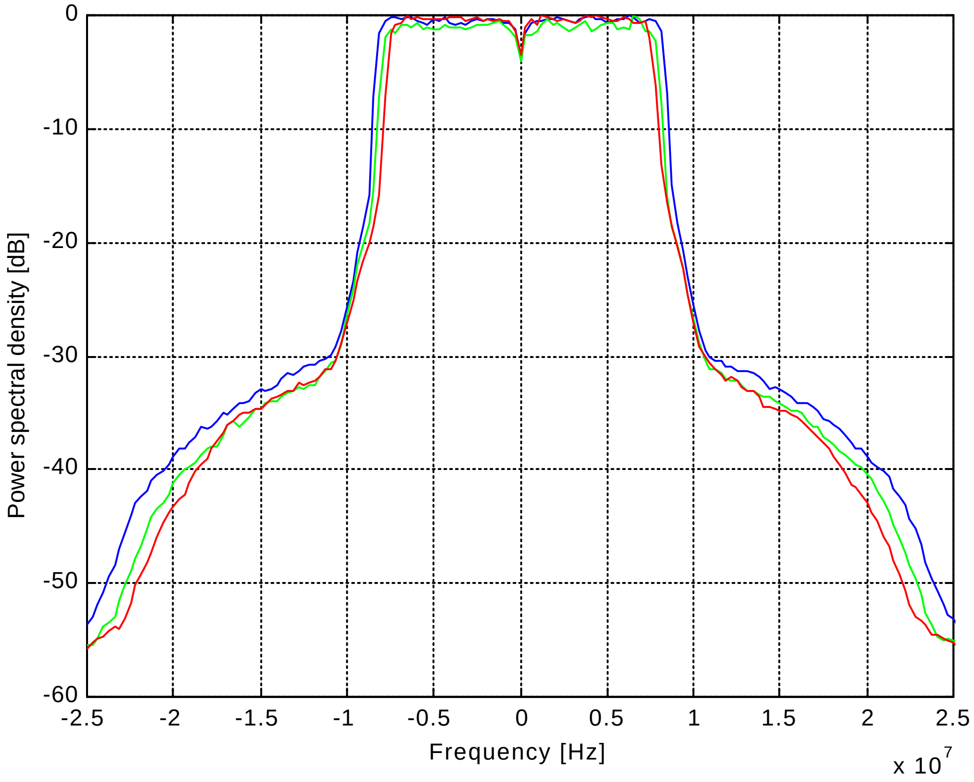
Increasing the channel spacing of 802.11a std from 15 MHz to 20 MHz was discussed with BRAN as an agreed common parameter. The benefit is an increased instantaneous data rate. The penalty is that an increased transmission bandwidth also widens the intermodulation "skirt", and larger backoff is required. The following figure compares the current 15.83 MHz sampling rate spectrum with the newly proposed 20 MHz sampling rate, when same utilization (48 out of 64 lines) is used.




Blue Fs=15.8Mhz 64 pts FFT / 48 lines. Backoff=-5dB.
Red Fs=20Mhz 64 pts FFT / 48 lines. Backoff=-5, -7, -9, -11dB.

Figure 1: Power spectrum versus sampling raet and backoff.

Note that at 20 MHz frequency offset for 20 MHz sampling rate third intermodulation is still dominant while for 15.83 MHz sampling rate higher order intermodulation dominates the performance. As a result there is a substantial (5-6 dB) degradation in PA backoff required to pass the FCC restricted band regulations. In order to avoid this problem, the bandwidth of the signal needs to be reduced to about 13 MHz and thus the advantage of higher channel spacing is wasted. Note that using 128 size FFT instead of 64 (to be discussed later) is irrelevant to the backoff problem. Increasing the number of utilized lines (to increase spectral efficiency) makes the problem worse, as is illustrated in the following figure:




Red- 64 pts FFT/ 48 lines
Green- 64 pts FFT/ 50 lines
Blue- 64 pts FFT/ 52 lines

Figure 2: Power spectrum versus number of utilised subcarriers; Backoff=-7 dB.

The possible ways of action are:

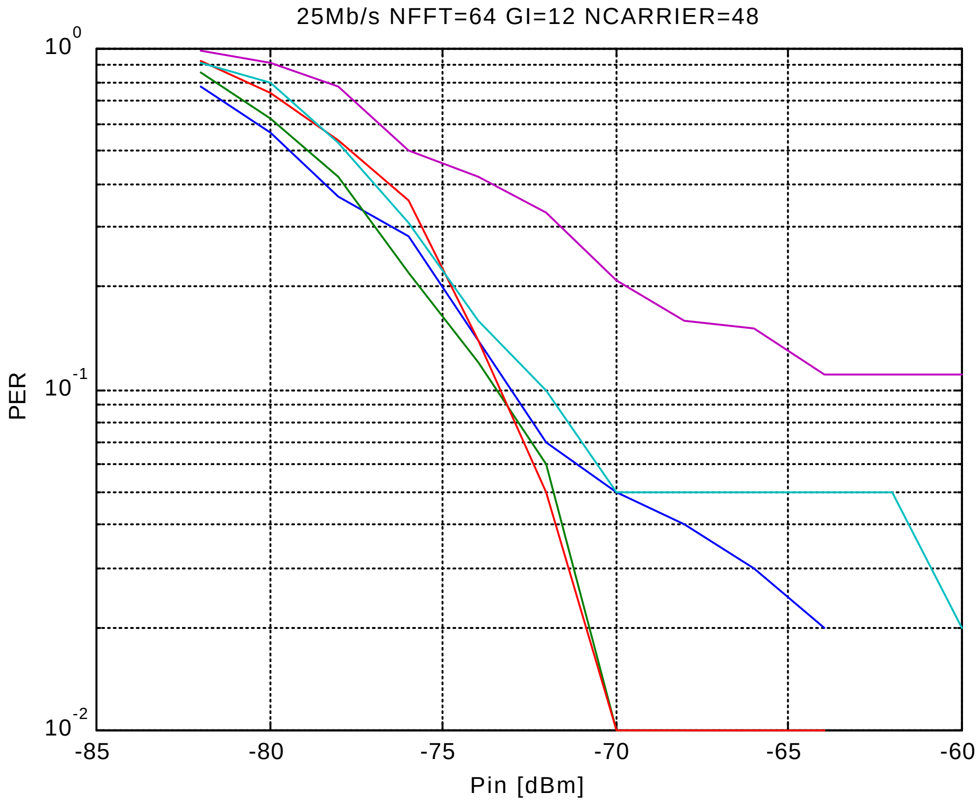
1) Retaining the 15 MHz spacing and reopening the issue with BRAN. Note that their out-of-band requirements are more relaxed and this might become a contentious issue.
2) Accept the loss and use larger backoff at close-to-edge channels.
3) Give up one channel and increase spacing from the end to, say, 25 MHz
4) Give less power to outer subcarriers, effectively narrowing the bandwidth
5) Mandate use of peak-to-average reducing techniques
6) Hope that FCC will relax the regulations or try asking them to do so

In our view, we should stick to the 20 MHz channel spacing which we agreed upon with BRAN and MMAC, even if we loose one channel due to increased intermodulation skirt width. Alternatively, we can retain 20 MHz spacing from the edge and pay the increased backoff when utilising the extreme channels.

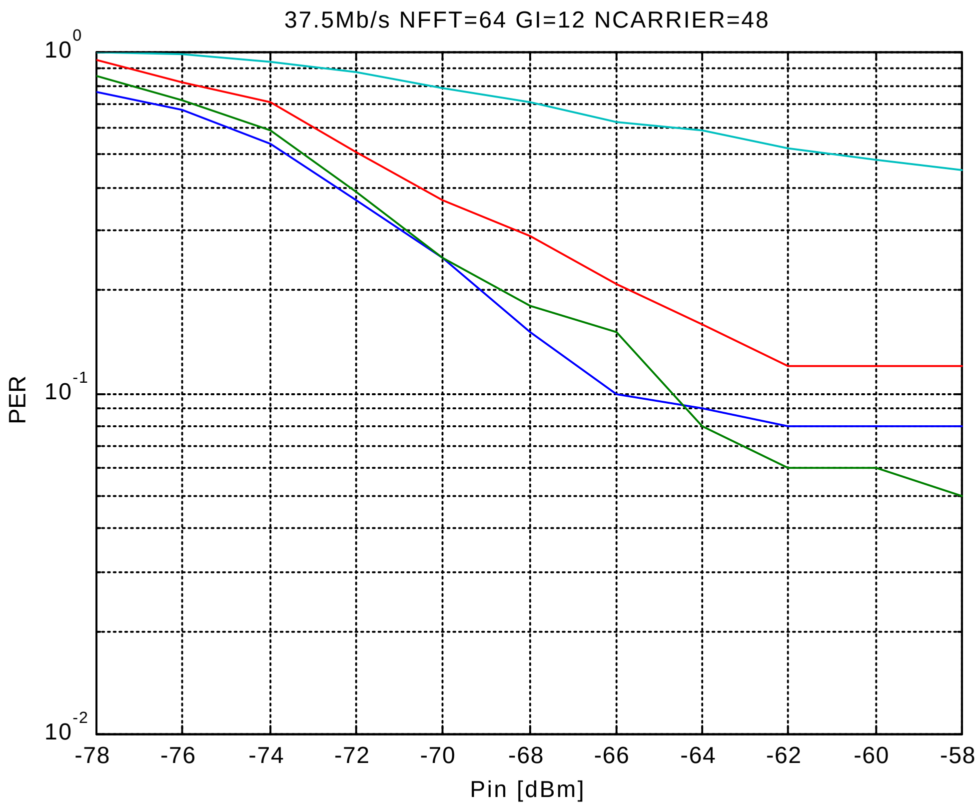
**The 128 vs. 64 point FFT**

The advantages of increased FFT size are improved robustness to multipath, lower overhead (guard vs. FFT time) and more pilot carriers (5 pilots instead of 3 for higher diversity). The main disadvantage is worse robustness in phase noise, slightly more waist in last OFDM symbol, more decoding latency, more implementation complexity. The phase noise sensitivity degrades 3-4 dB, but still the oscillator requirements are manageable.

Option 1: NFFT=64, GI=12

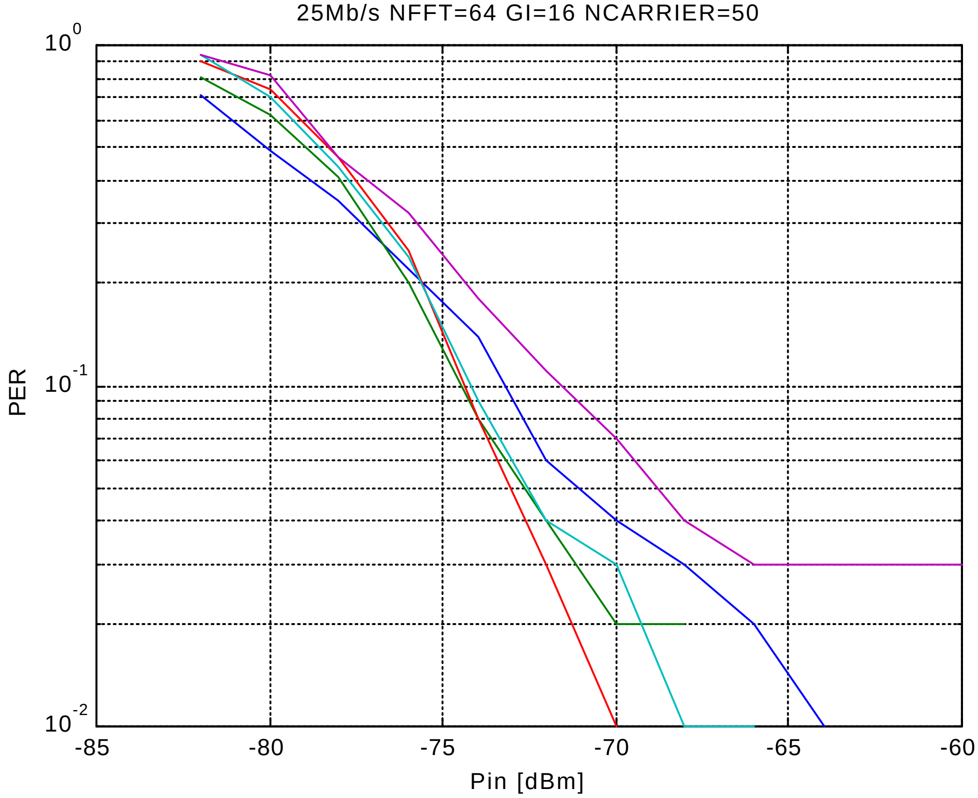



Color legend : blue –25nS; green-50nS; red-100nS; L.blue-150nS; violet -200nS

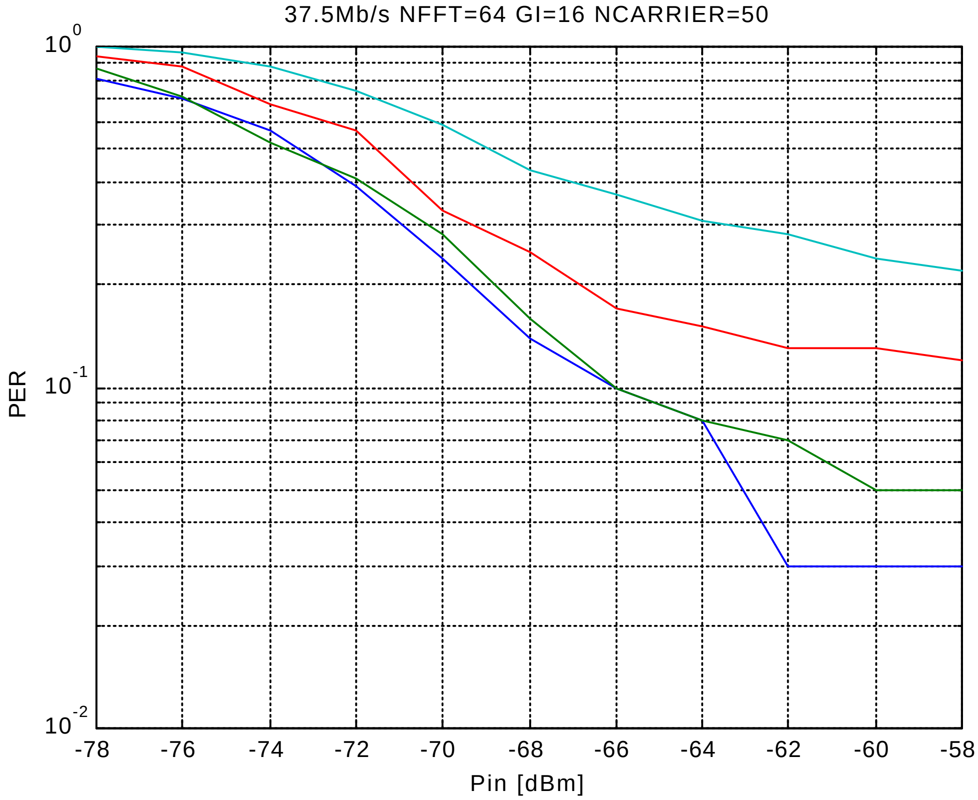



Color legend : blue –25nS; green-50nS; red-100nS

Option 2: NFFT=64, GI=16

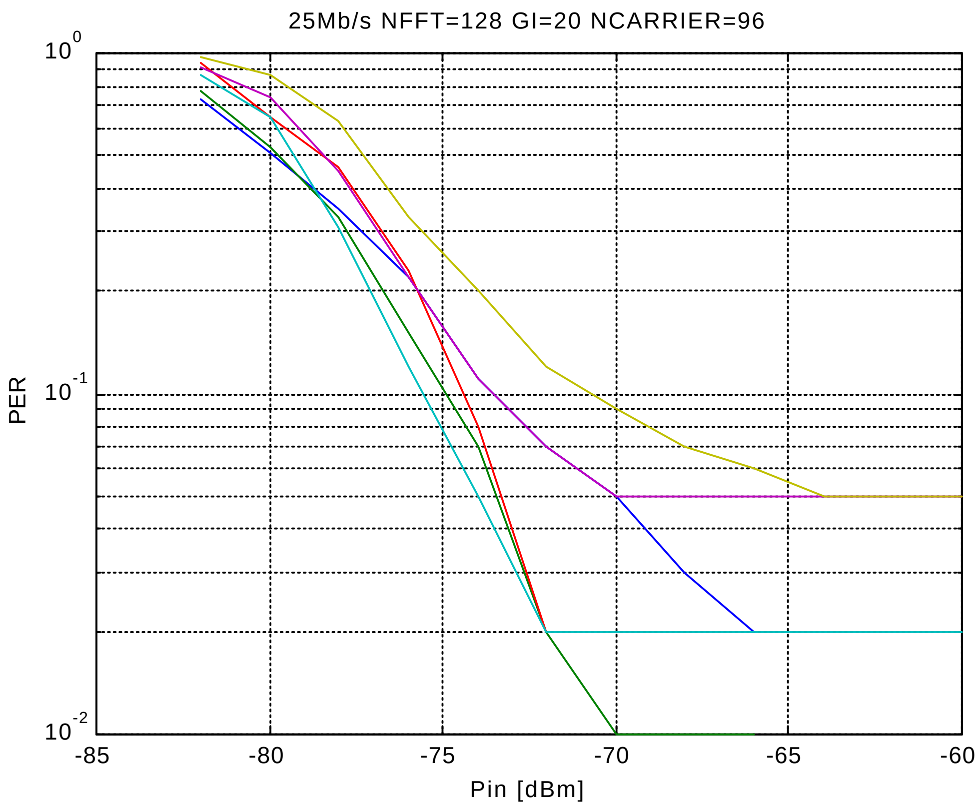



Color legend : blue –25nS; green-50nS; red-100nS; L.blue-150nS; violet 200nS

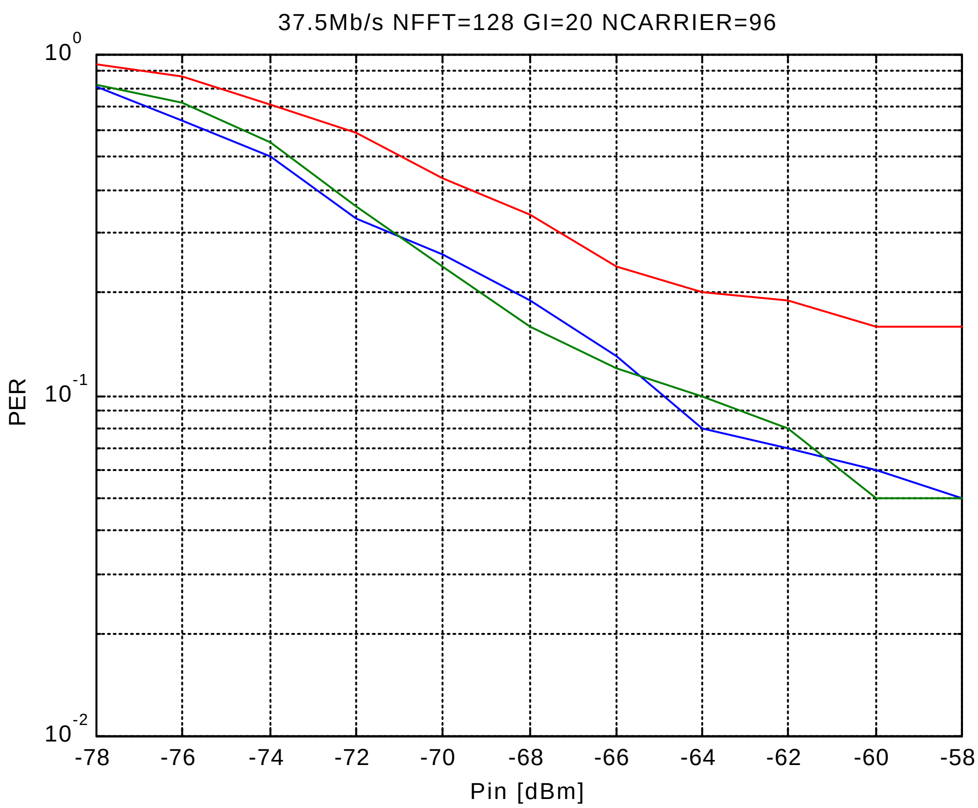



Color legend : blue –25nS; green-50nS; red-100nS; L.blue-150nS;

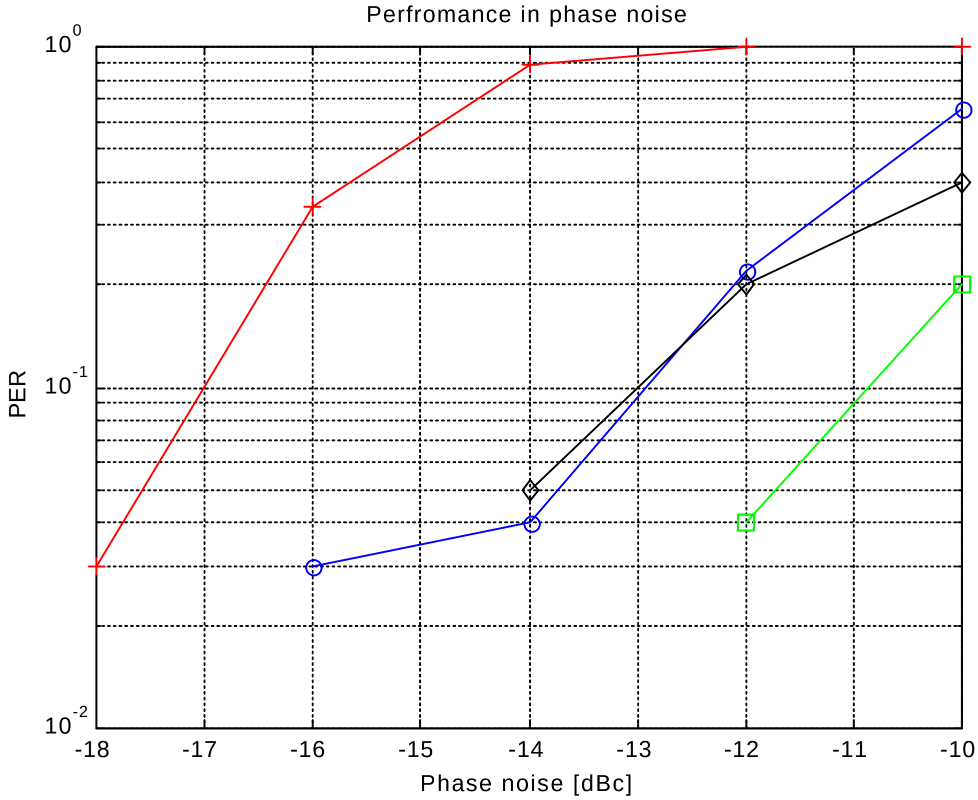
Option 1: NFFT=128, GI=20




Color legend : blue –25nS; green-50nS; red-100nS; L.blue-150nS; purple 200nS yellow-250nS




Color legend : blue –25nS; green-50nS; red-100nS; L.blue-150nS; purple 200nS




legend: green square- 25Mb/s NFFT=64
black diamond- 37.5Mb/s NFFT=64
blue circle- 25Mb/s NFFT=128
red cross - 37.5Mb/s NFFT=128

It is possible to gain about 10% in rate due to lower overhead, and gain some 20% in delay spread tolerance. In our view this is a viable improvement.

Note that the AWGN performance is unchanged when the FFT length is increased. The preamble can also remain at same length, with the two repetitions of 64 long sequence replaced with a single 128 sequence.

**Number of utilised FFT lines**

As mentioned before, even with 48 out of 64 lines we need to reconsider the distance of first channel from the end. Once we've done that, we can consider 50 or 52 subcarriers and gain 4%-8% in rate. The price is sharper filter at the transmitter. We consider it a justifiable change.

In case 128 long FFT the power spectra are essentially same when 96, 100 or 104 out of 128 subcarriers are considered.

We recommend to consider 100 out 128 combination.

**Summary**

We recommend the following changes:

1) Accept the 20 MHz channel spacing with 20 MHz discance between the edge of the band and the center of the channel closest to it. Increase of this distance at expense of one channel may be considered.
2) We recommend aligning the sampling clock rate with channel spacing, i.e. using 20 MHz sampling rate.
3) We recommend increasing the FFT size to 128 for improved multipath tolerance and reduced overhead, at expense of more stringent phase noise requirements.

4) We recommend to increase the number of information carrying subcarriers from 48 to 50 in the case of NFFT=64, or to 100 in case of NFFT=128.
5) In case NFFT is increased to 128, use 5 pilot subcarriers.