QAM RADIO RECEPTION IN PRESENCE OF INTERFERENCE AND NOISE

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ABSTRACT : Transmission and reception of digitally modulated microwave (MW) and millimeter-wave (MMW) radio signals are widely investigated [1,2,3,4]. This paper addresses the problem of digital MW/MMW radio reception and demodulation in the simultaneous presence of additive Gaussian white noise (AGWN) and radio-frequency interference (RFI) [5,6]. A new representation of receiver interference immunity is shown. Then for QAM reception, we present simulation results and we give physical explanation of bit error rate (BER) degradation due to interferer signals.

General block diagram of dual-downconversion MW/MMW digital radio receivers is shown in Fig.1. In the absence of interferer signals the BER is mainly determined by the signal-to-noise (*S/N*) ratio [1,2,3,6]. The *BER(S/N)* function has the well-known *erfc(x)* curve shape as shown by the lowest curve in Fig.2. The *BER* is deteriorated when interferer signals appear in the frequency band of the desired signal. At a given received signal level (*RSL*) the BER degrades as the level of the interferer signal increases. In Fig.2. measured BER degradation curves are shown as a function of *RSL* and signal-to-interferer (*S/I*) power ratio. Fig.2 indicates the usual representation of BER degradation caused by co-channel RFI. Similar curves are obtained for sinusoidal CW or for like-modulated interferers. But for each different interference frequency a new set of *BER(RSL)* curves should be plotted.

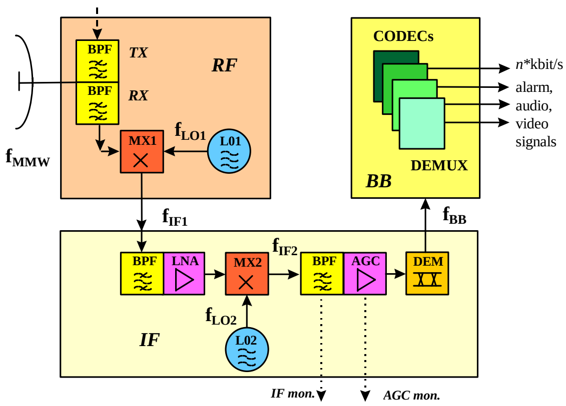

Figure 1. Block diagram of a typical dual-downconversion MW/MMW digital receiver

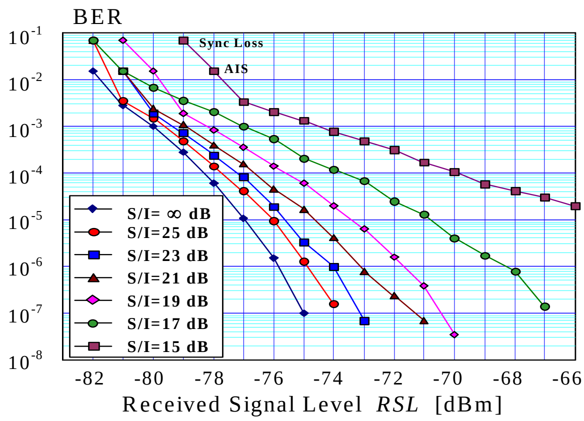

Figure 2. Measured co-channel interference of a 38 GHz 8 Mbit/s digital receiver

In Fig.3 curves of Fig.2 are represented in another way : for a given *BER* level (e.g. 10^{-6}) *S/I* is plotted as a function of *RSL* [3,4,6]. These curves exhibit two asymptotes. As the *RSL* is increased lower *S/I* ratios are tolerated meanwhile a constant *BER* is maintained. But even for very high *RSL* values a threshold *S/I* level remains, which is always essential for the demodulation. It is denoted the demodulator threshold and its value depends on the modulation mode used and on the quality of the receiver. On the other hand, if we decrease the *RSL*, at the receiver sensitivity threshold the correct demodulation will be distorted by errors, even for extremely good *S/I* ratios since AGWN is always present in the channel. In [6] we presented a new representation and a test method for the RFI sensitivity characterization of MW/MMW digital receivers. The interfering signal frequency f_I is tuned over the frequency band of interest around the reception (RX) frequency of the receiver under test. The interferer signal power is increased at each interference frequency until a predefined *BER* value is not achieved (typically *BER*=10^{-6}). Measured *S/I* contours of 15 GHz 4-QAM receivers are plotted in Fig.4. Channel capacities of 16, 8, 4 and 2 times 2 Mbit/s have been tested, respectively. The curves are drawn for the *S/I* ratios degrading the error free link to *BER*=10^{-6} due to sinusoidal CW interference. Measured points are normalized to the midband *S/I* ratio. Applying higher interferer levels within the RX band, the reception becomes faulty. However, outside the reception channel the receiver tolerates interferer levels of 70 dB greater than the wanted signal. Applying the presented method, we performed RFI sensitivity measurements of several MW/MMW FSK and 4-QAM receivers operating in the frequency bands of 1.5, 3.5, 15, 18, 23, 26 and 38 GHz. In addition to co-channel and adjacent channel RFI tests, image rejection and spurious reception properties of the receiver under test can be traced as well. It is worth to compare Fig.2-3 to Fig.4. Curves of Fig.4 recall the frequency response shape of bandpass filters. In fact, all the frequency selective elements within the radio chain (Fig.1) have their influence on the shape of the measured curve. Its width is determined mainly by the IF stage and the transmitter spectral characteristics. Fig.4 gives a better understanding of digital receiver immunity and selectivity.

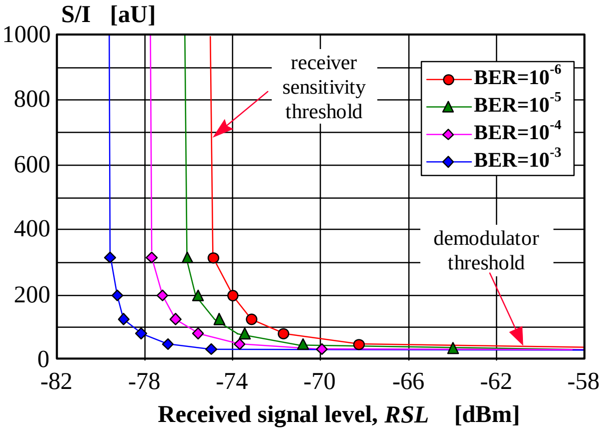

Figure 3. Required *S/I* resulting in a $BER=10^{-x}$ as a function of *RSL* in a MMW digital radio receiver

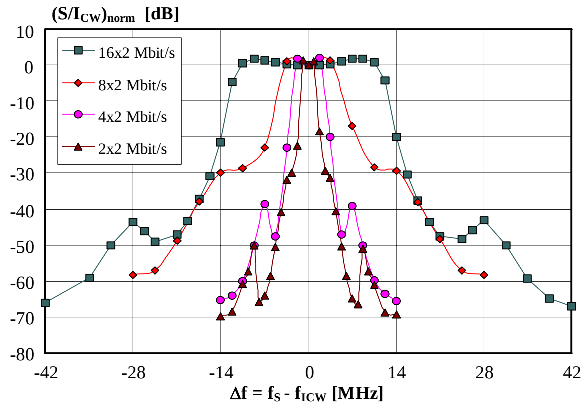

Figure 4. Normalized signal-to-interferer ratios resulting in $BER = 10^{-6}$ of a 15 GHz 4-QAM digital receiver

Finally, using Monte-Carlo method of a communication system analysis software [7] we modelled RFI of a 4-QAM receiver. Simulated results show good agreement with measured ones. We plotted interference immunity and constellation diagrams of the 4-QAM receiver. Fig.5 shows digital reception corrupted only by AGWN, while in Fig.6 sinusoidal interference is also introduced. In our final paper we will explain this result by phasor representation of the interferer signal rotating in the signal space. We show also a mathematical method developed to estimate *BER* degradation.

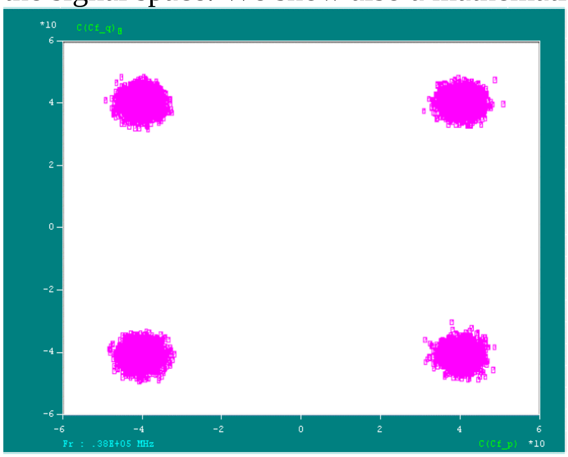

Figure 5. Simulated constellation diagram of 4-QAM signal corrupted only by AGWN

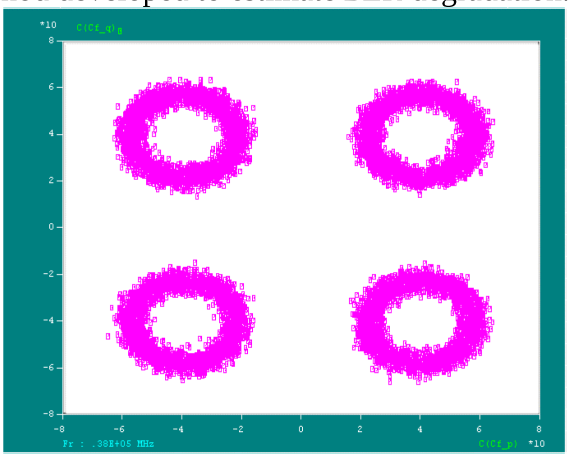

Figure 6. Constellation diagram of 4-QAM signal corrupted by sinusoidal CW interference and AGWN

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