FEC POTENTIAL IN CASE OF NARROW BAND INTERFERENCE

submission to IEEE 802.4L
Through-The-Air Token Bus Physical Layer

prepared by

Kiwi Smit

NCR

INTRODUCTION

ıis paper discusses the impact of FEC (Forward Error Correction), in combination with a QPSK (Differential Quadrature Phase Shift Keying) transceiver, on the BER (Bit Error Rate). ıe transceiver operates in an ideal environment, except for the fact that it is exposed to a ıgle tone interferer.
section 2 the properties of the BER are derived in case no FEC is used. Section 3 describes e effect of FEC on the BER. In section 4 the conclusions are drawn.

BER FOR A DQPSK TRANSCEIVER EXPOSED TO A SINGLE TONE INTERFERER.

1 Signal description

ıe input y of the DQPSK decoder in the receiver is considered as a vector in the IQ-plane (I ıd Q denoting the in-phase and quadrature components of the baseband signal). The vector y ınsists of two components; a signal component y_s and an interference component y_i; so for y e following equation holds:

$$y(n) = y_s(n) + y_i(n) \qquad [0]$$

he index n denotes the n th symbol sampling moment.
or the two components of y, where the IQ-plane is considered to be the complex plane, the ıllowing expressions hold:

$$y_s(n) = z_s \exp(j(\Theta(n)+\Phi_s)) \qquad [1]$$

with $j = \sqrt{-1}$
z_s length of signal vector
$\Theta(n)$ information bearing phase
Φ_s initial phase

$$y_i(n) = z_i \exp(j(\Omega.n+\Phi_i)) \qquad [2]$$

with z_i length of interferer vector
Ω phase shift during one symbol period;
$\Omega = 2\pi f_i/f_s$ with f_i frequency of interferer and f_s symbol frequency
Φ_i initial phase

Note that in the signal description the vector lengths are constant. In reality they are a function ıf time due to quantization noise, AGC control etc.

2.2 DQPSK decoding.

For the DQPSK decoder output u(n) the following relation holds:

$$u(n) = y(n) \cdot [y(n-1)]^{*} \qquad (\,* = \text{complex conjugate}) \qquad [3]$$

Substituting the equations [0] through [2] into [3] delivers:

$$\begin{aligned} u(n) &= [y_s(n) + y_i(n)] \cdot [y_s(n-1) + y_i(n-1)]^{*} \\ &= z_s^2 \exp(j(\Theta(n)-\Theta(n-1)) + z_i^2 \exp(j\Omega) + \\ &\qquad z_s z_i \exp(j(\Theta(n)-\Theta(n-1)+\Omega) \end{aligned} \qquad [4]$$

Let

$$\Theta(n)-\Theta(n-1) = \alpha(n) \qquad [5]$$

with $\alpha(n) \in [\pi/4, 3\pi/4, 5\pi/4, 7\pi/4]$, depending on the dibit that has been sent.

The discrete stochastic variables $\alpha(n)$ and $\alpha(m)$ are for every pair {n,m | n not equal m} independent, identically distributed. All four possible outcomes of $\alpha(n)$ are equiprobable.

A new variable x is introduced and defined as follows:

$$x = z_s/z_i \qquad [6]$$

Substituting [5] and [6] into [4] delivers:

$$u(n) = z_i^2 \, [\, x^2 \exp(j\alpha(n)) + \exp(j\Omega) + x \exp(j(\alpha(n)+\Omega)) \,] \qquad [7]$$

desired component (first term); interferer components (remaining terms)

As can be seen from equation [7] the interferer component is a function of the parameter Ω, the variable x and the stochastic variable $\alpha(n)$.

Bit error probability

ven Ω, the BER curve (BER as a function of SIR (Signal to Interference Ratio)) can be
culated from equation [7]. Here only some general properties of these curves will be derived.
r sufficiently high values of x the bit error rate wile be zero. If x drops below a certain
eshold, which depends on Ω, P_b will instantaneously change to a value of at least 1/8. There
values of Ω for which P_b changes to 1/4 .
e change of P_b to a value of at least 1/8 can be seen as follows:
ppose that one out of four symbols is misdetected, such that the misdetected symbol contains
e erroneous bit. This leads to $P_b = 1/8$.
general the BER curve is a staircase like function, with step heights equal to 1/8 or 1/4.
e SIR (Signal to Interference Ratio) at the input of the decision unit is defined as:

$$SIR = 20*\log(x) \quad [8]$$

figure 2 an example is given of a BER curve, with the SIR given in dB's. In this example
lds $\Omega = 1.2\pi$

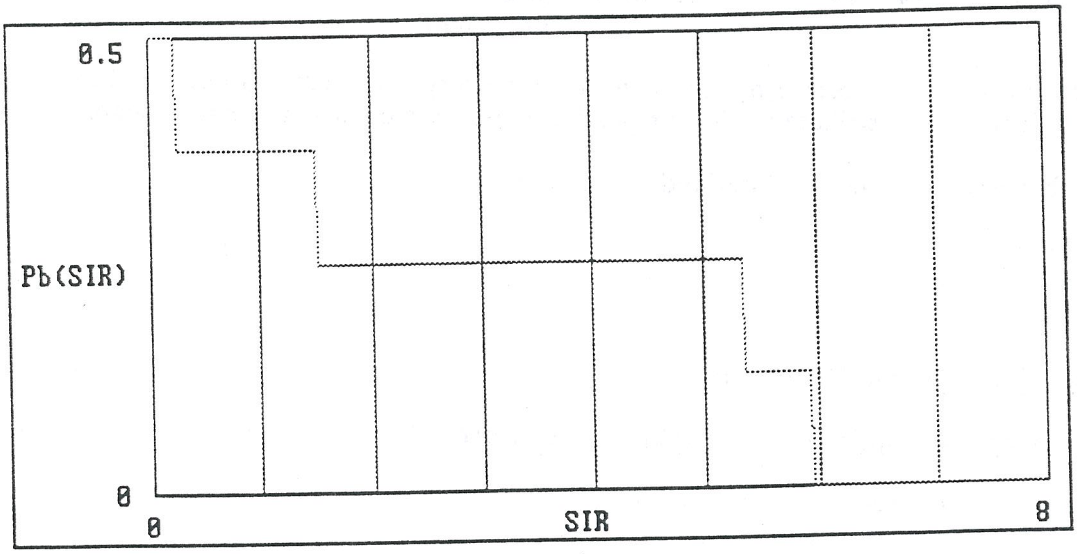

Figure 2

3 IMPACT OF FEC ON THE BER CURVE.

There does not exist a hard decisions FEC scheme that is able to transform a bit error rate of 0.25 into a significantly lower value. A thresholding phenomenon exists for the coding gain. At sufficiently high bit error rates the FEC loses its effectiveness and actually makes the situation worse. Only hard decision schemes are of practical interest, due to the relative ease of implementation.

4 CONCLUSION.

For a DQPSK transceiver operating in a narrow band interference environment, FEC is not an appropriate tool for improvement of the BER curve.