TSG-RAN WG1#17 TSGR1#17(00)1396
Stockholm, Sweden, 20th-24th Oct 2000
Agenda Item: Adhoc#24, HSDPA
Source: Motorola

Performance Comparison of Hybrid-ARQ Schemes

Introduction

Automatic-Repeat-Request (ARQ) schemes are used in packet data communication system. The term "Hybrid ARQ" can be used to describe any combined FEC+ARQ scheme in which unsuccessful attempts are used in FEC decoding instead of being discarded. Chase combining (also called H-ARQ-type-III with one redundancy version) involves the retransmission by the transmitter of the same coded data packet. The decoder at the receiver combines these multiple copies of the transmitted packet. Another form of "Hybrid ARQ" is called incremental redundancy. In this scheme, instead of sending simple repeats of the coded data packet, progressive parity packets are sent in each subsequent transmission of the packet. The decoder then combines all the transmissions and decodes the packet at a lower code rate. In this contribution, simulation results are presented for two methods for "Hybrid ARQ". Using these link results, a system with adaptive modulation and coding (AMC) can be shown to have nearly identical throughput for each method. The Chase combining method is much simpler in terms of memory, processing, and signaling requirements, and is therefore preferred.

Method-1 (Chase Combining)

The simplest form of Hybrid ARQ scheme was proposed by Chase [1]. The basic idea in Chase's combining scheme (also called H-ARQ-type-III with one redundancy version) is to send a number of repeats of each coded data packet and allowing the decoder to combine multiple received copies of the coded packet weighted by the SNR prior to decoding. This method provides diversity gain and is very simple to implement.

Method-2 (Incremental Redundancy)

Incremental redundancy is another H-ARQ technique wherein instead of sending simple repeats of the entire coded packet, additional redundant information is incrementally transmitted if the decoding fails on the first attempt. Incremental redundancy is called H-ARQ-type-II, or H-ARQ-type-III if each retransmission is restricted to be self-decodable. In this contribution Method-2 was implemented for the MCS levels shown in Table 1.

Table 1. MCS Level for Method-2

MCS	Modulation	Turbo Code Rate
7	64 QAM	3/4
6	16 QAM	3/4
5	16 QAM	1/2
3	QPSK	3/4
2	QPSK	1/2

The Turbo codes used in the hybrid ARQ system consists of a parallel concatenation of two R=1/3 systematic and recursive convolutional encoders as shown in Figure 1. The overall code rate of the turbo code entering the puncturing circuit is 1/6. For each input stream, six output streams are formed: the input stream x itself, two parity streams produced by the first convolutional code y_1 and y_2 interleaved input stream x' and the second parity streams z_2 and z_3 produced by the second convolutional code. The puncturing block after the encoder is used to form (for example) R=3/4, R=2/3 and R=1/2 codes by puncturing the parity bits. As an example, for R=1/2 codes alternate parity bits are sent over the channel (x, y_1, x, z_2, x, y_1,…). In case of Method-2 using R=1/2 code the following algorithm was implemented in the simulator:

1. In case of even order re-transmission, the following set of bits were transmitted : (x, y_1, x, z_2, x, y_1,…).
2. In case of odd order transmission, the following set of bits were transmitted : (x, z_1, x, y_2, x, z_1,…).
3. The very first transmission is decoded as an R=1/2 code and subsequent re-transmissions are decoded as an R=1/3 code. It may be noted that the information bits in each re-transmission are added symbol-wise to the corresponding stored bits.

The following algorithm was implemented for Method-2 using a R=3/4 turbo code.

1. In case of even order re-transmission, the following set of coded bits were transmitted for every three information bits : (x, x, x, y_1, x, x, x, z_1, x, x, x, y_1, x, x, x, z_1,……).
2. In case of odd order re-transmission, the following set of bits were transmitted for every three input bits : (x, x, x, y_2, x, x, x, z_2, x, x, x, y_2, x, x, x, z_2,……).
3. The very first transmission is decoded as an R=3/4 code and subsequent re-transmissions are decoded as an R=3/5 code. It may be noted that the information bits in each re-transmission are added symbol-wise to the corresponding stored bits.

Figure 2 to Figure 10 to compares the performance of Chase combining vs. Incremental Redundancy for different MCS levels and at various values of vehicle speeds. The following conclusions are drawn from the figure:

1. For QPSK with a low code rate, IR benefits over Chase are not significant.
2. The differential performance difference between IR and Chase is larger in a static channel than in a fading channel.
3. For higher code rate (e.g. ¾) and higher order modulation IR performs better than Chase combining at low geometries. However, the regions where IR has better performance will not be selected by the AMC algorithm, yielding no net throughput improvement for Method-2.
4. Other IR schemes, especially Type-II Hybrid-ARQ where each transmission is not self decodable, has the potential of providing significant performance gains over Chase combining. These schemes are currently under investigation.

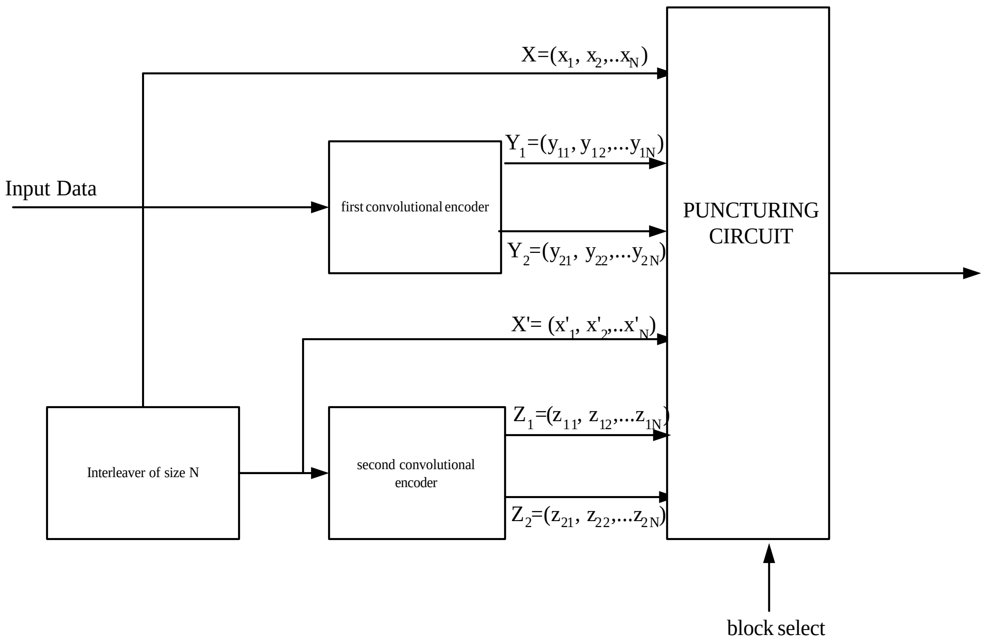

Figure 1 . Block diagram of a Turbo Encoder.

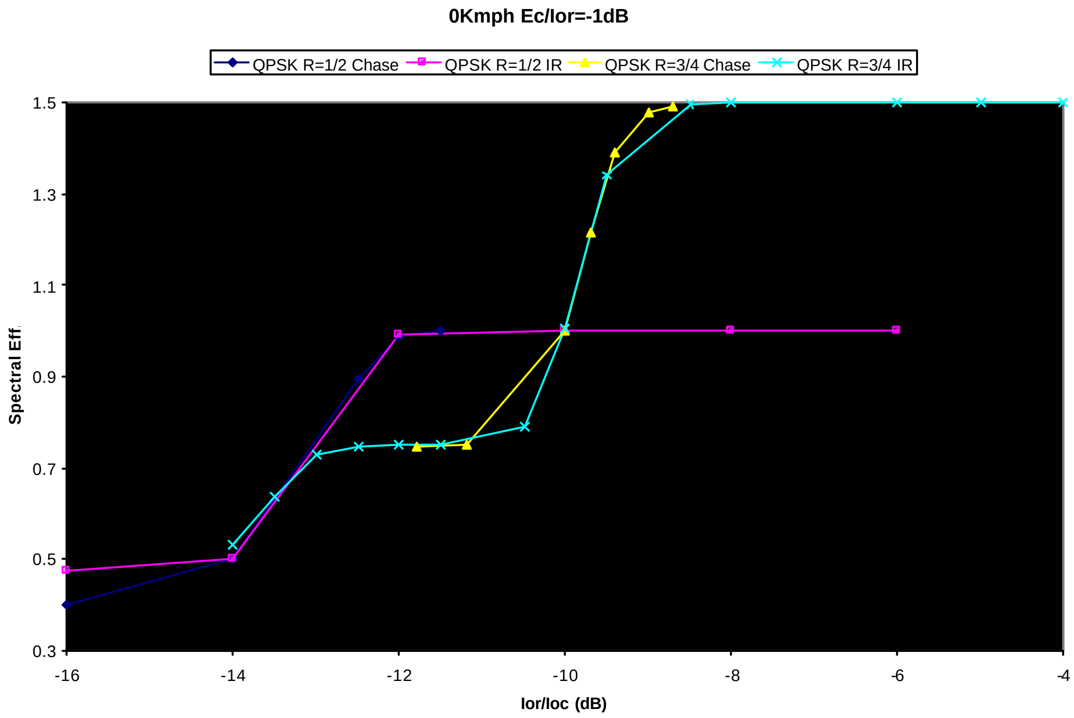

Figure 2. 0Kmph QPSK

Figure 3. 0Kmph 16-QAM

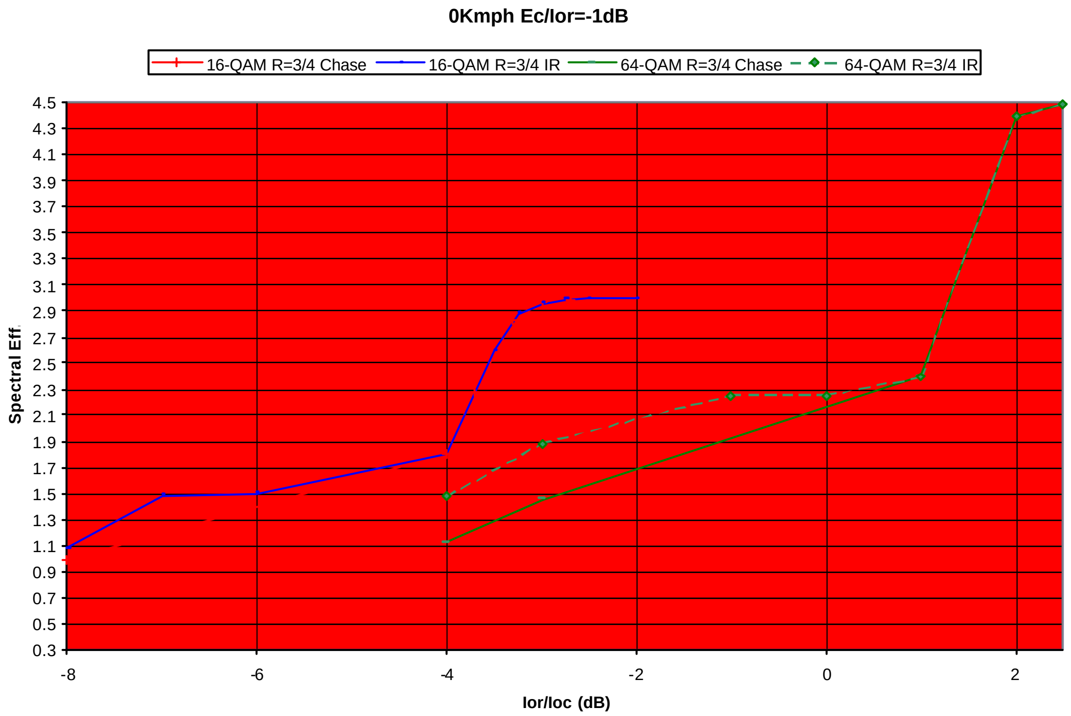

Figure 4. 0Kmph 64-QAM

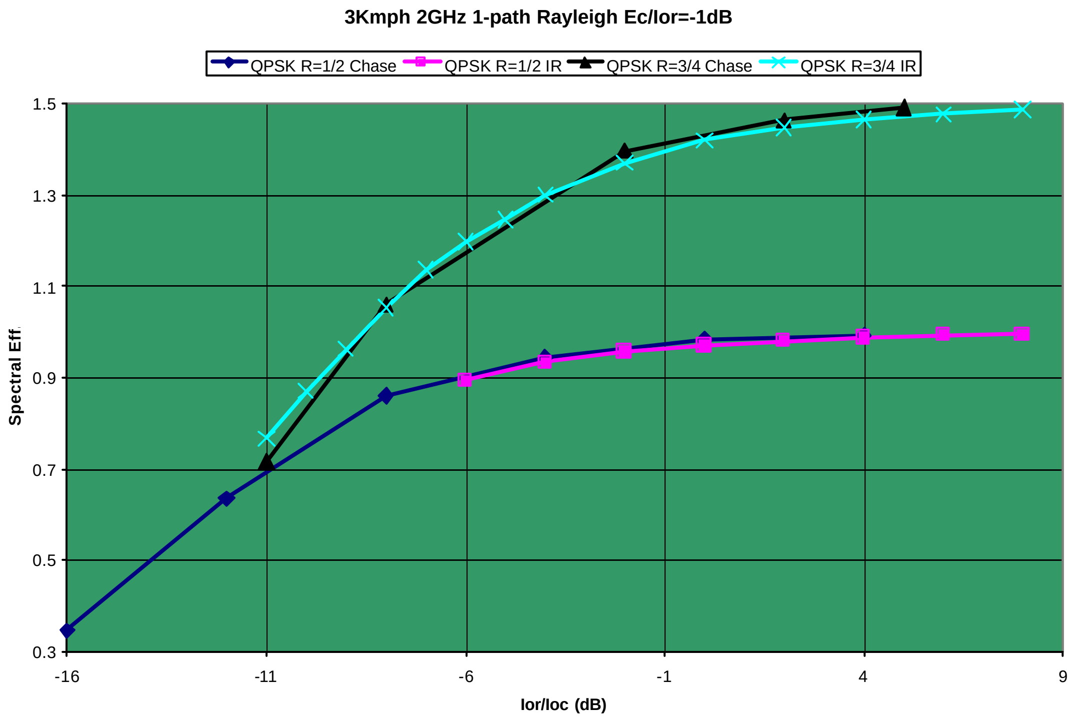

Figure 5. 3Kmph QPSK

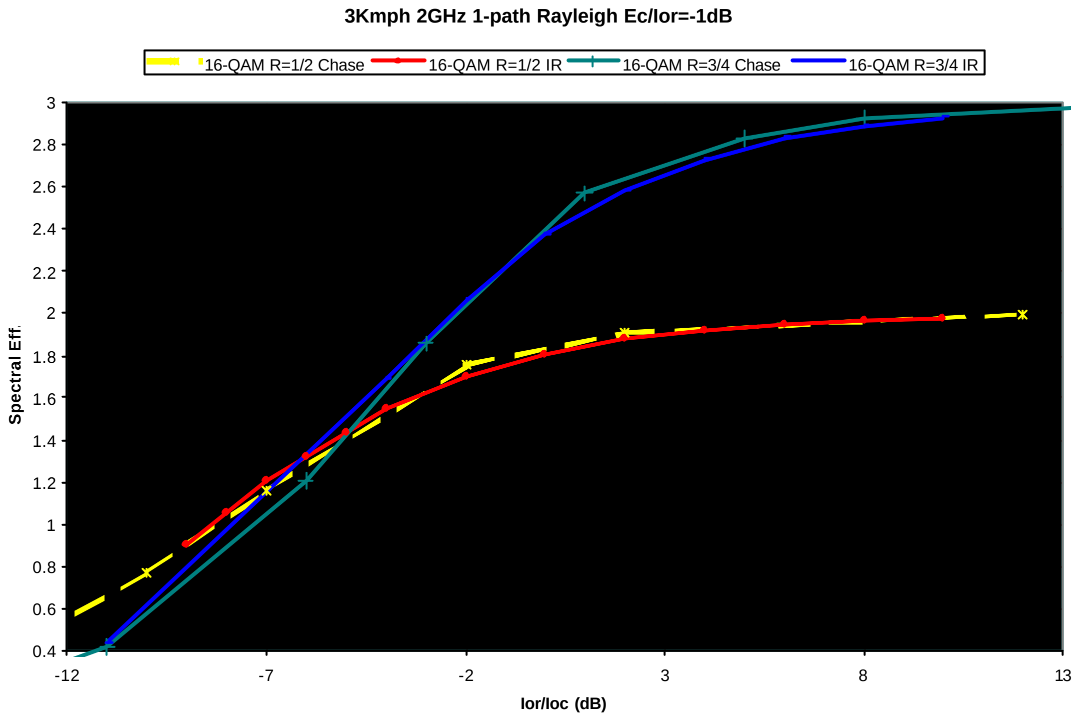

Figure 6. 3Kmph 16-QAM

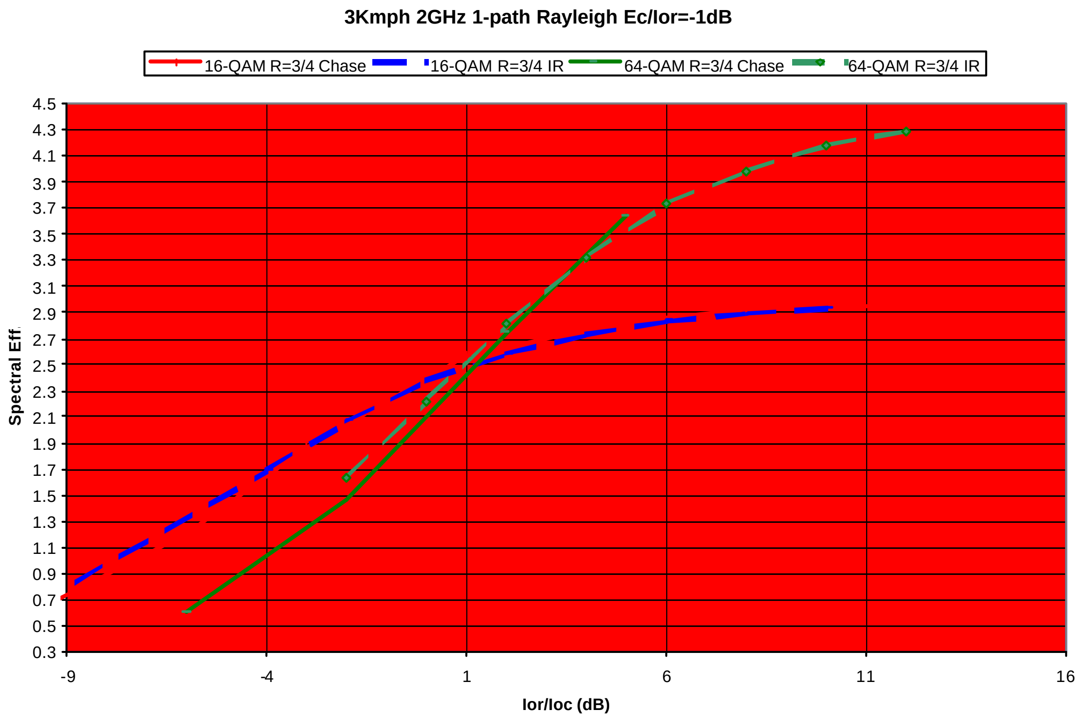

Figure 7. 3Kmph 64-QAM

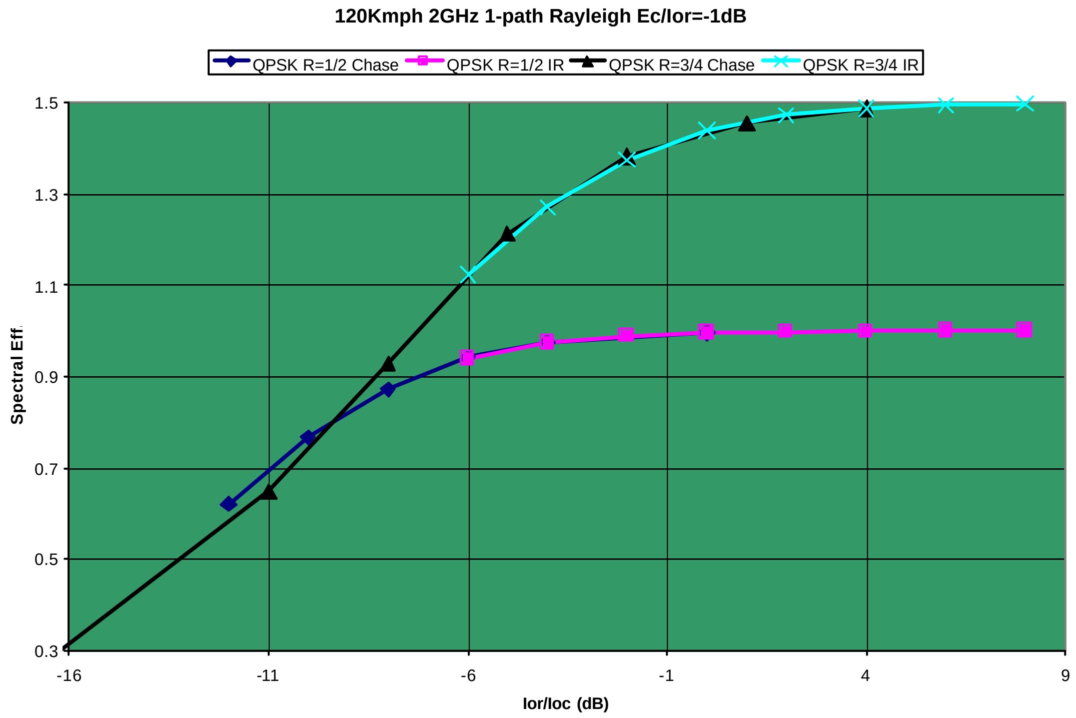

Figure 8. 120Kmph QPSK

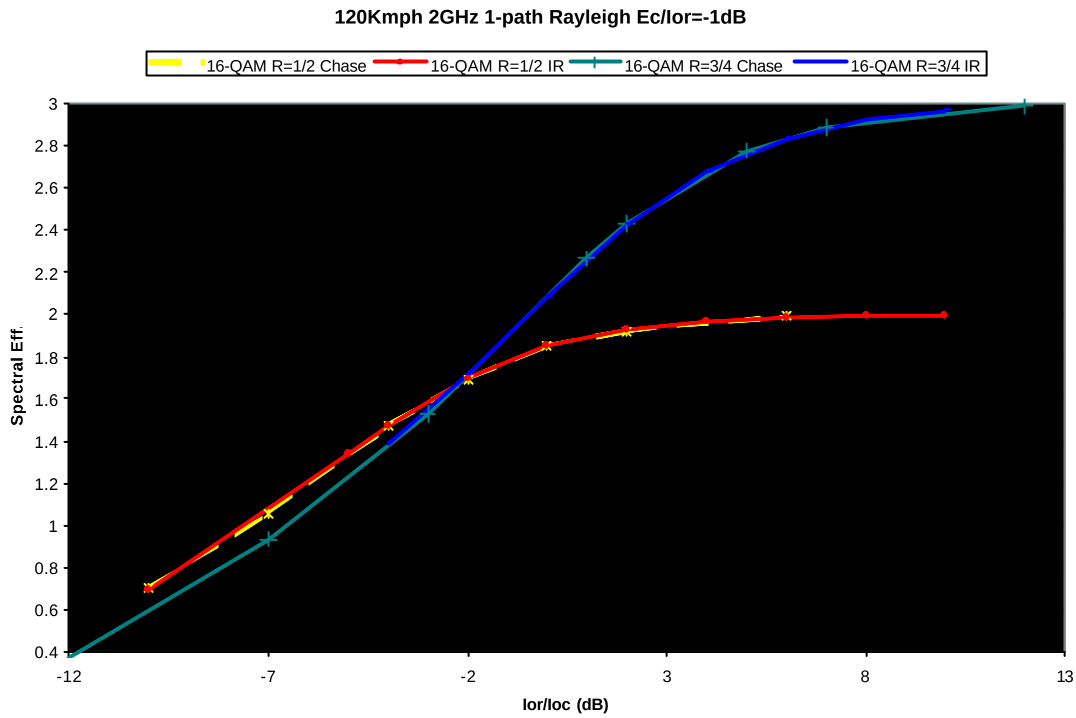

Figure 9. 120Kmph 16-QAM

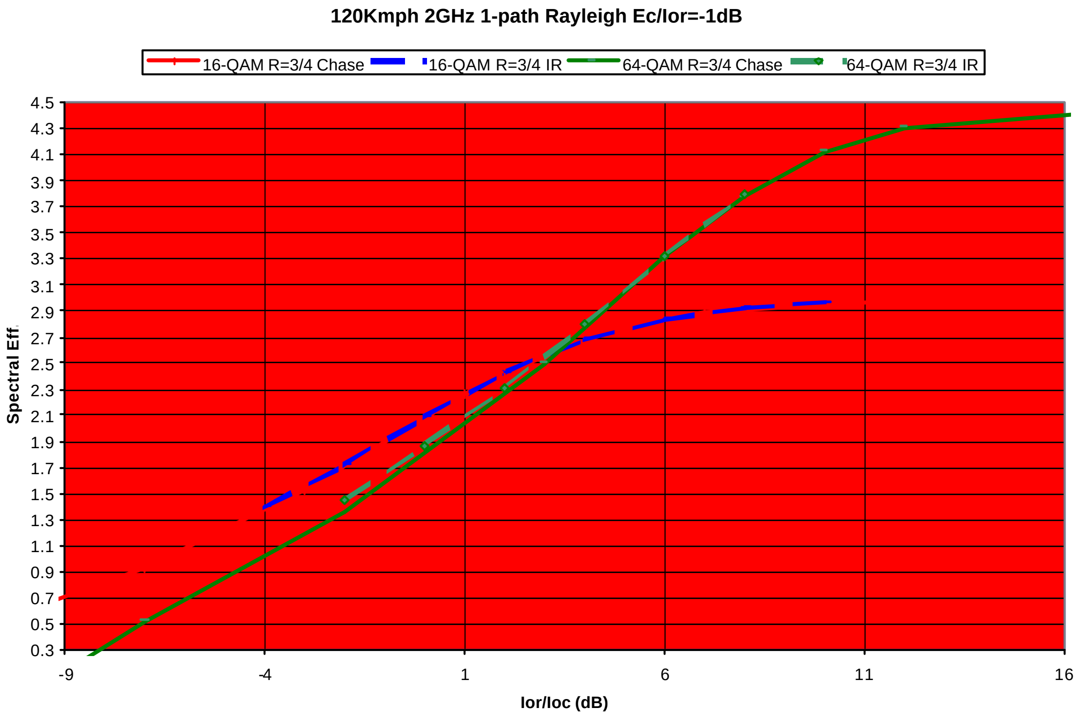

Figure 10. 120Kmph 64-QAM

References

[1] D. Chase, "Code Combining: A maximum-likelihood decoding approach for combining an arbitrary number of noisy packets," *IEEE Trans. on Commun*., Vol. 33, pp. 593-607, May, 1985.

[2] TSGR1#16(00)1316, “TR on HSDPA”