

## IEEE 802.16.3 Turbo Product Code Performance Under Multipath Channels

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Purpose:

The purpose of this presentation is to provide the TG3 working group with information regarding the system CODEC

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# TG3 and Turbo Product Codes

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# Turbo Product Codes

- TPCs are readily integrated into multicarrier and single carrier frameworks
- TPCs Provide high performance combined with high spectral efficiency
- TPCs have been selected in TG1
- Off the shelf chips and cores available
- TPC technology is consistent with both SS and BS target costs

Cont...

# Turbo Product Codes (cont)

- The code proposed have been selected by both SC and MC ad-hoc groups for TG3
- Based on recent voting, TPCs have been selected for inclusion in TG4
- Provide outstanding performance
- Offer high flexibility

# TPC – 2D Encoding Operation

- Choose coding parameters  $n, k$
- Choose component codes,  $x$  and  $y$
- Choose Code Parameters  $(n, k)$
- Choose Component Codes  $(n_x, k_x) \dots$
- Shorten Component Codes by 's' as required

$$(n, k) = (n_x - s_x, k_x - s_x) \times (n_y - s_y, k_y - s_y) \dots$$

# Note on Component Codes

- Component Codes based on extended Hamming Codes (Hamming Code+1 bit parity)

Extended Hamming Code	Hamming Code	Gen Poly
(8,4)	(7,4)	$x^3 + x + 1$
(16,11)	(15,11)	$x^4 + x + 1$
(32,26)	(31,26)	$x^5 + x^2 + 1$
(64,57)	(63,57)	$x^6 + x + 1$
(128,120)	(127,120)	$x^7 + x^3 + 1$
(256,247)	(255,247)	$x^8 + x + 1$

## 2D TPC Coding Example

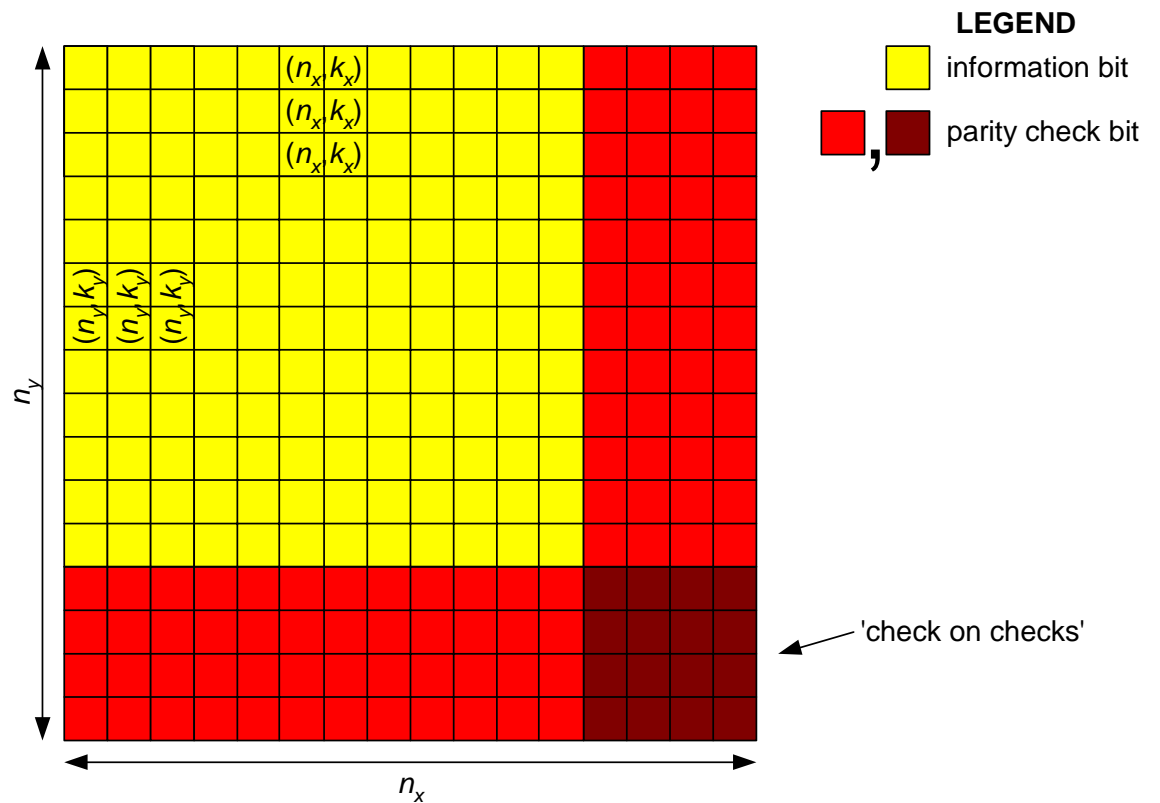
- TPC Code Required: **(2304,1681)**
- Choose Component Codes (use  $\sqrt{n}$ )
- Extended Hamming Code **(64,57)**
- Shorten Code by 16, to make **(48,41)** code
- **(48,41) x (48,41) = (2304,1681)**

# 2D Visualization

Resultant code is:

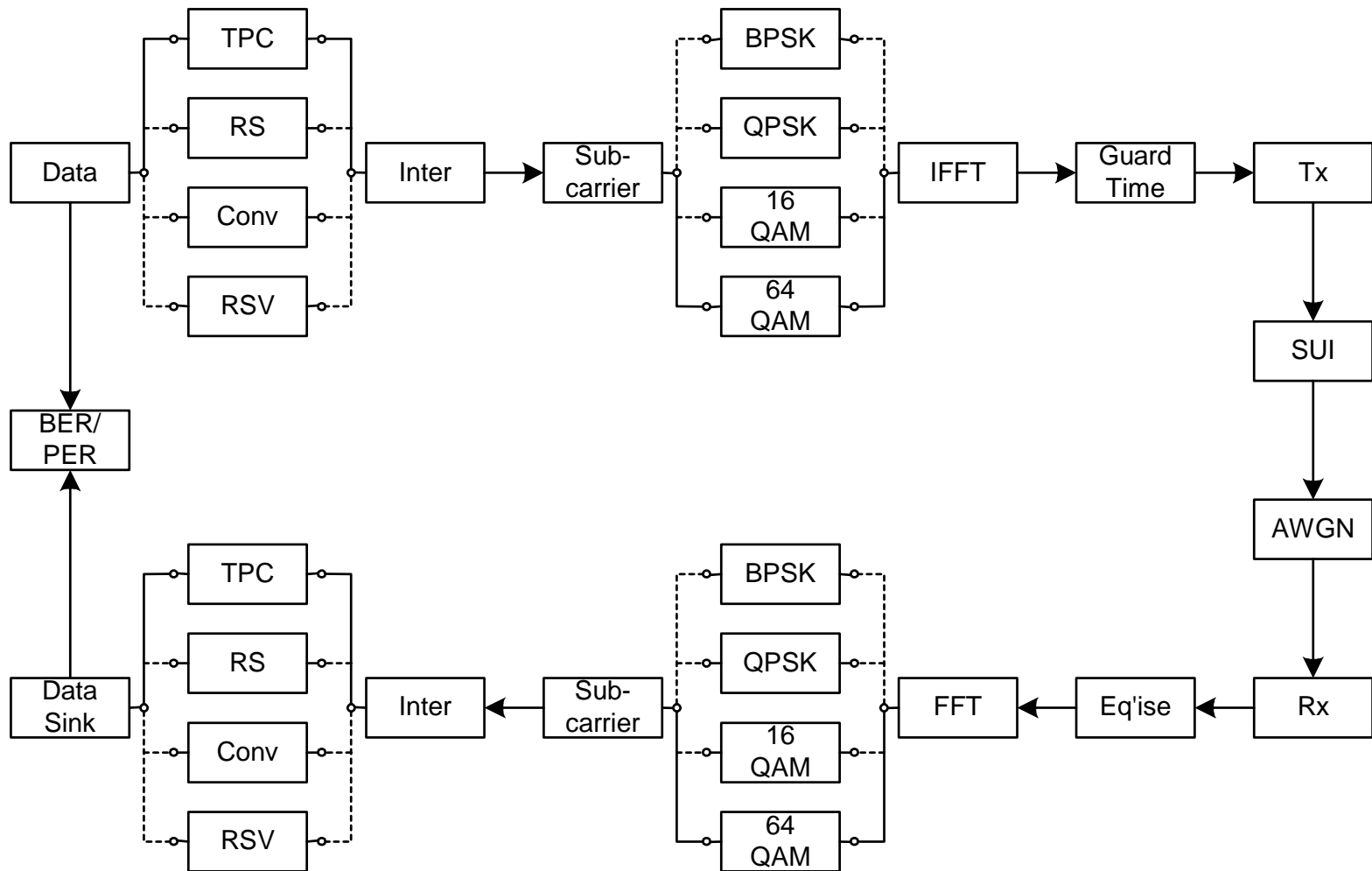
- $(n_x, k_x) \times (n_y, k_y) = (n, k)$

$$\text{rate} = \frac{k_x \times k_y}{n_x \times n_y} = \frac{k}{n}$$





# Signal Path



# Channel Model

<b>SUI 1</b>			
Delay/s	0	4.00E-07	8.00E-07
K Direct	16	0	0
K Omni	4	0	0
Power (dB) Direct	0	-21	-32
Power (dB) Omni	0	-15	-20
Doppler (Hz)	0.4	0.4	0.4

<b>SUI 4</b>			
Delay/s	0	2.00E-06	4.00E-06
K Direct	0	0	0
K Omni	0	0	0
Power (dB) Direct	0	-10	-20
Power (dB) Omni	0	-4	-8
Doppler (Hz)	0.2	0.2	0.2

<b>SUI 2</b>			
Delay/s	0	5.00E-07	1.00E-06
K Direct	8	0	0
K Omni	2	0	0
Power (dB) Direct	0	-18	-27
Power (dB) Omni	0	-12	-15
Doppler (Hz)	0.2	0.2	0.2

<b>SUI 5</b>			
Delay/s	0	5.00E-06	1.00E-05
K Direct	0	0	0
K Omni	0	0	0
Power (dB) Direct	0	-11	-22
Power (dB) Omni	0	-5	-10
Doppler (Hz)	2	2	2

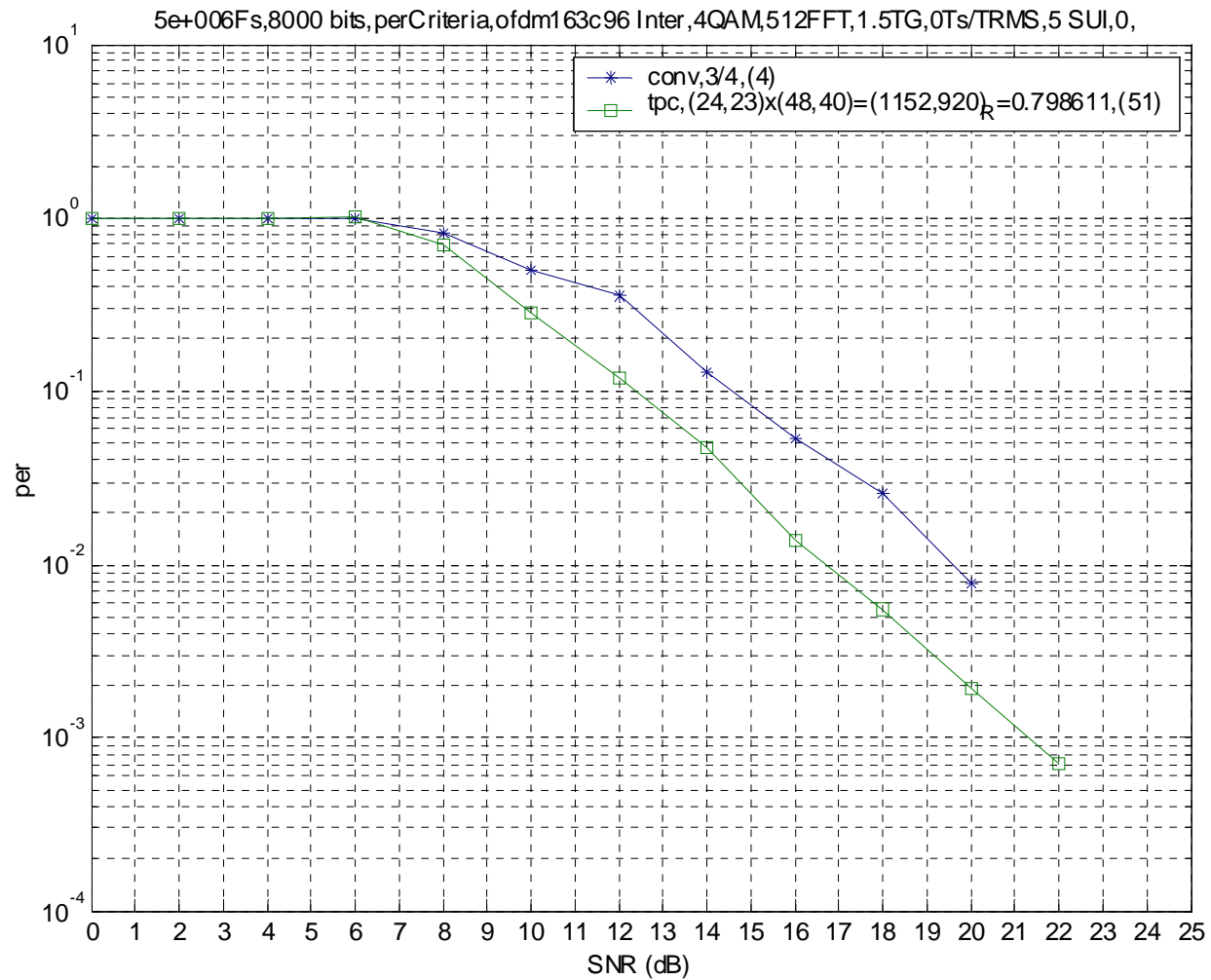
<b>SUI 3</b>			
Delay/s	0	5.00E-07	1.00E-06
K Direct	3	0	0
K Omni	1	0	0
Power (dB) Direct	0	-11	-22
Power (dB) Omni	0	-5	-10
Doppler (Hz)	0.4	0.4	0.4

<b>SUI 6</b>			
Delay/s	0	1.40E-05	2.00E-05
K Direct	0	0	0
K Omni	0	0	0
Power (dB) Direct	0	-16	-26
Power (dB) Omni	0	-10	-14
Doppler (Hz)	0.4	0.4	0.4

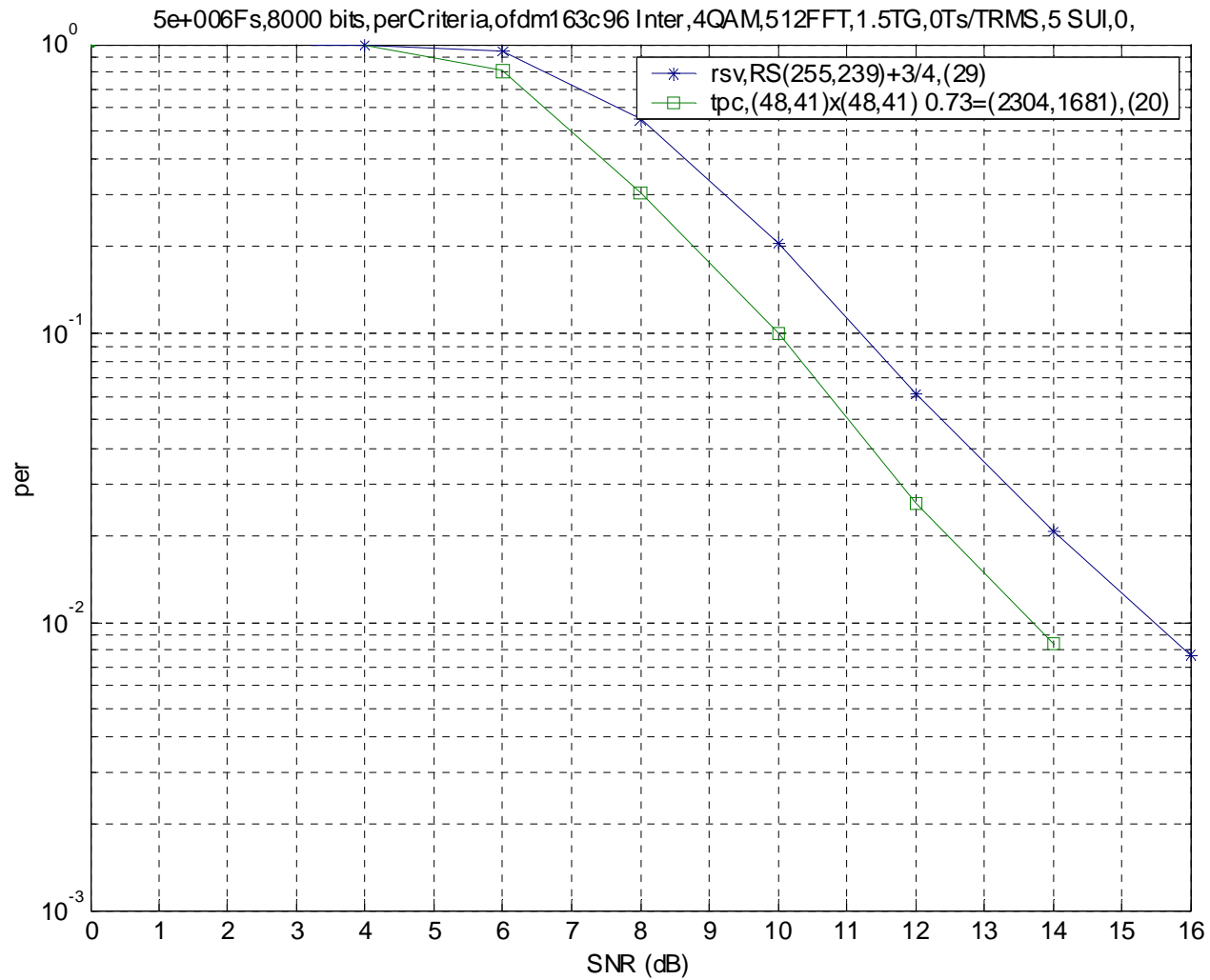
# Simulation Assumptions

- Monte-Carlo Simulation, based on min errors
- Modulation QPSK, 16 QAM, 64 QAM with Gray code mapping
- Channel Model SUI 5
- 64, 512, 1024, 2048 point FFT
- Zero power penalty due to pilot/overhead transmission
- Coding: Turbo Product Coding, RSV
- Optimally weighted LLR soft metric derivation for TPC/Viterbi Decoder
- All Simulation employ channel interleaving as per proposed OFDM 16.3 method
- 1 Packet contains 8000 information bits

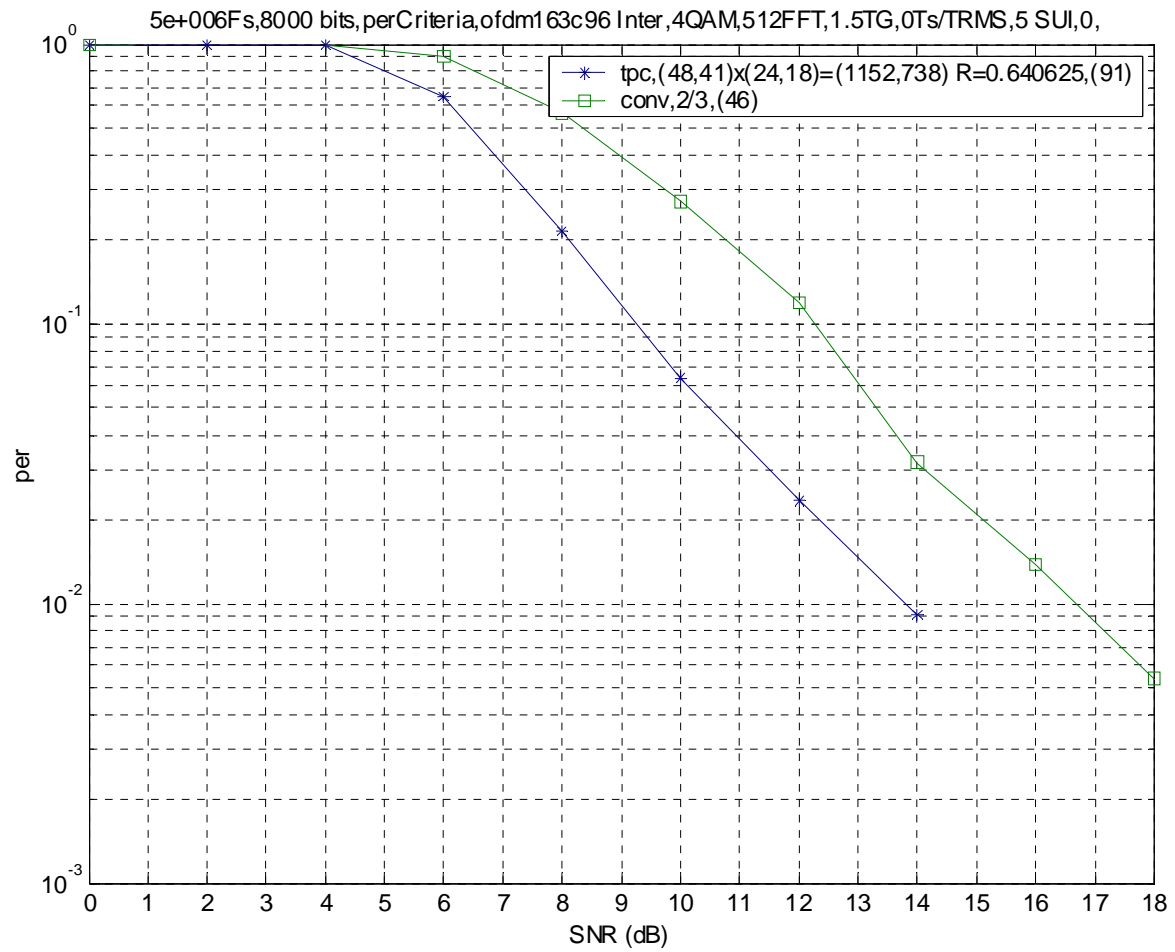
# OFDM Results



# OFDM Results



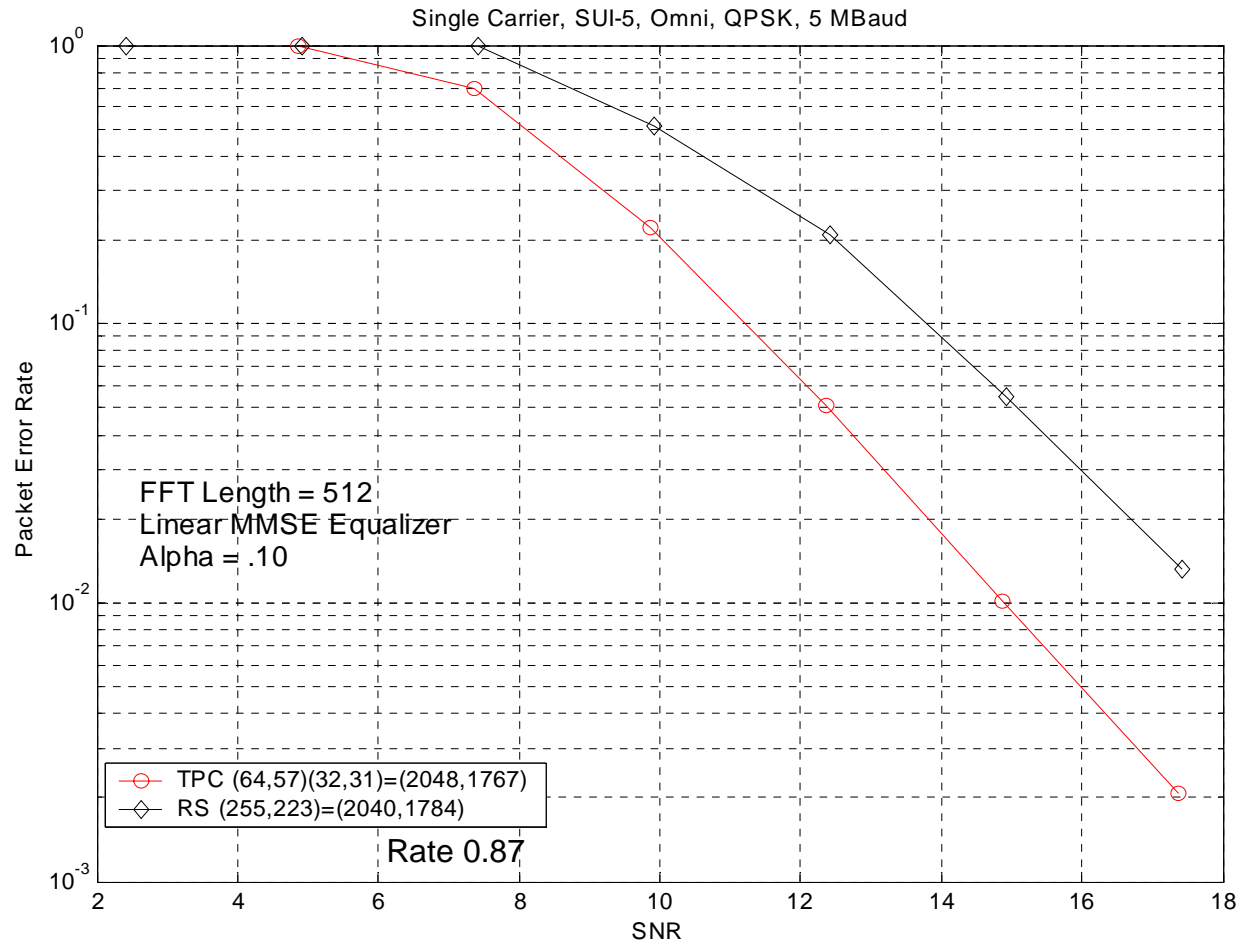
# OFDM Results



# Simulation Assumptions

- Monte-Carlo Simulation, based on min errors
- Modulation QPSK, 16 QAM, 64 QAM with Gray code mapping
- Channel Model SUI 5, Omni Directional
- 64, **512**, 1024, 2048 point FFT
- Zero power penalty due to overhead transmission
- Coding: Turbo Product Coding, RSV
- Optimally weighted LLR soft metric derivation for TPC
- All Simulation employ channel interleaving as per proposed OFDM 16.3 method
- 32 Tap FIR, sampled 4 samples per symbol
- Roll off factor of 0.10
- Minimum Mean Squared Error, Linear
- Perfect State Information Assumed
- Packet contains 1767 bits

# SC+FDE Results





# Conclusion

- TPCs are readily integrated into multicarrier frameworks
- TPCs Provide high performance combined with high spectral efficiency
- TPCs have been selected TG1 & poss. TG3
- Off the shelf chips and cores available
- TPC technology is consistent with both SS and BS target costs

Cont...

# 16 QAM Performance in a Rayleigh Channel

