

# Analysis of EMC Performance vs. Modulation Schemes

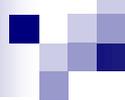
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# Contributors & Supporters

## Contributors

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# Outline

## ■ Objective

- To study the transient BER performance under the BCI test during the induced interference

## ■ Simulation

- Time domain simulations
- EMC Considered in the simulations
  - Immunity: Mode Conversion
  - Emission: TX PSD Mask

## ■ PAM Modulations Comparison

## ■ Conclusions

# Transient Performance vs. Modulation Schemes

- Simulation Based on 15m Insertion Loss baseline
- 1.1Gsps, 694Msps and 550Msps symbol rate for PAM2, PAM3 and PAM4 simulations, respectively
- EMI Interference referred to the input
  - 110mVpp, 100mVpp, 75mV or 50mVpp

# BER vs. EMC Consideration

## ■ Immunity Simulation Consideration

- BCI: 200mVpp referred to input equivalent to BCI 200mA rms
- 106dBuA(200mA) BCI current required for BER of  $10^{-10}$  from “EMC ad hoc BCI limit line survey, bunzt\_3bp\_01\_1113.pdf”

# Transient Performance vs. Modulation Simulations

## ■ Modulation Schemes

- Comparison PAM2, PAM3 and PAM4
- SNR requirement (BER of  $10^{-10}$ )
  - 15.9, 20.2 and 22.9dB for PAM2, PAM3 and PAM4

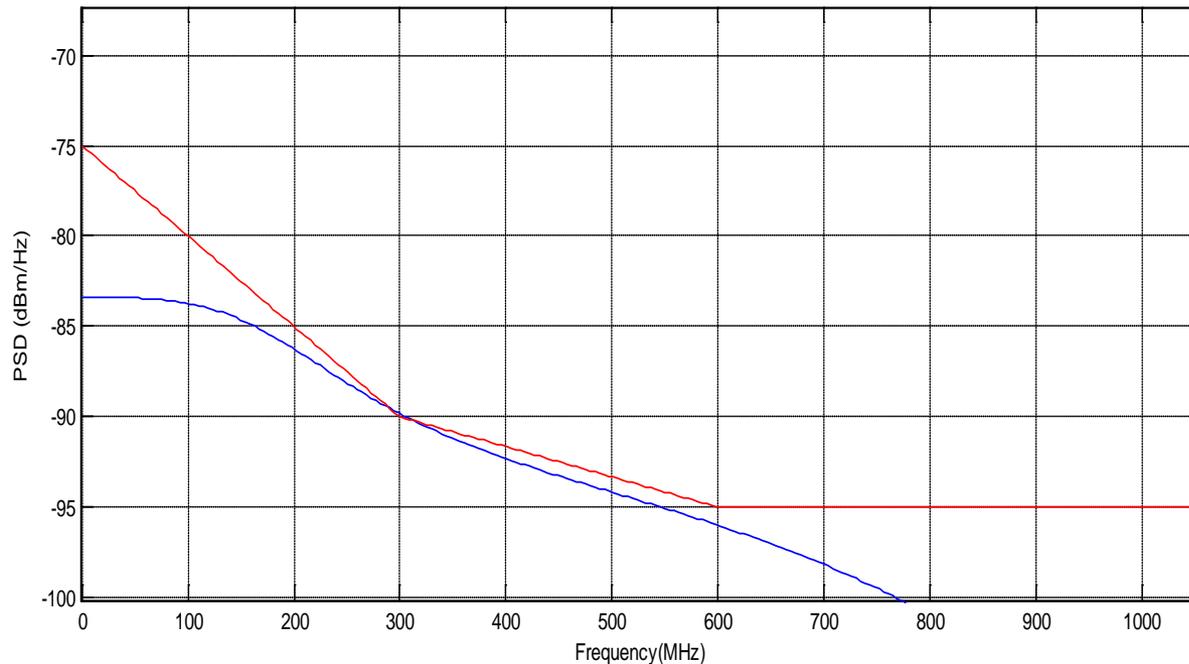
## ■ Simulations

- Baseline (Channel, EMC)
- TX peak amplitude (-0.5V to +0.5V)

# TX PSD Mask

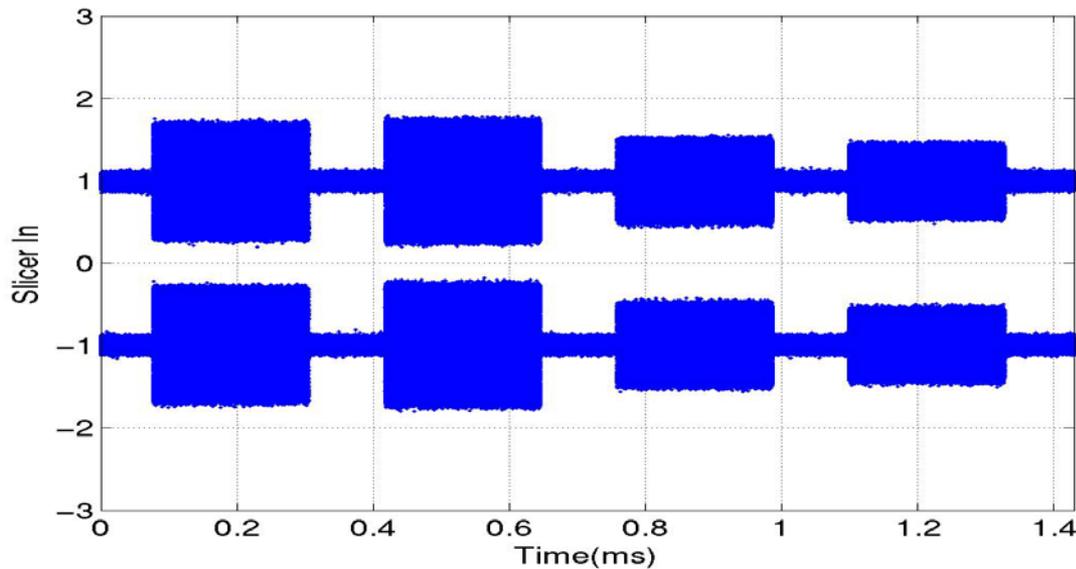
## ■ PAM2, PSD Mask

- The blue curve: PAM2 TX PSD
- The red curve: TX PSD Mask from [EMCnoise ad hoc f2f 3bp 01 0716.pdf](#)



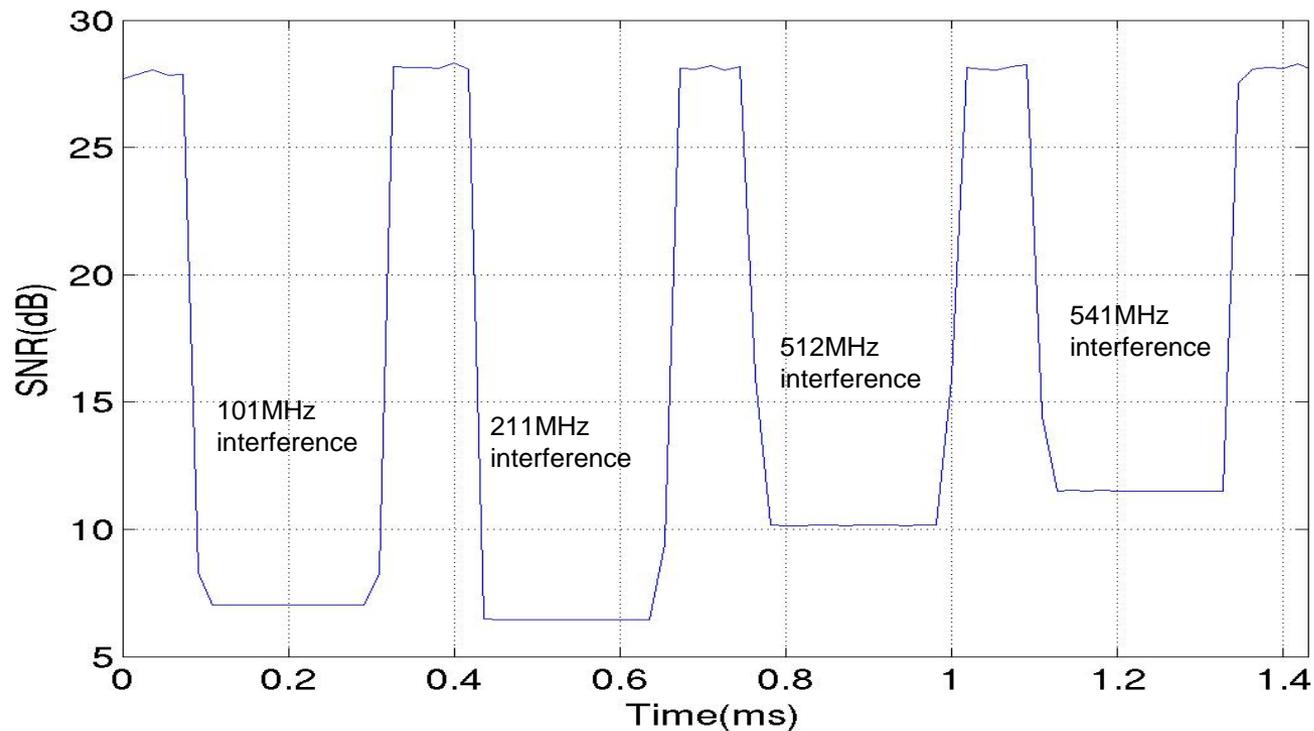
# Simulation Case: PAM2

- Eye Diagrams (100mVpp Narrowband Tone)
  - Interference Frequency (MHz):
    - 101, 211, 512 and 541
    - Adaptation loops freezed during induced interference

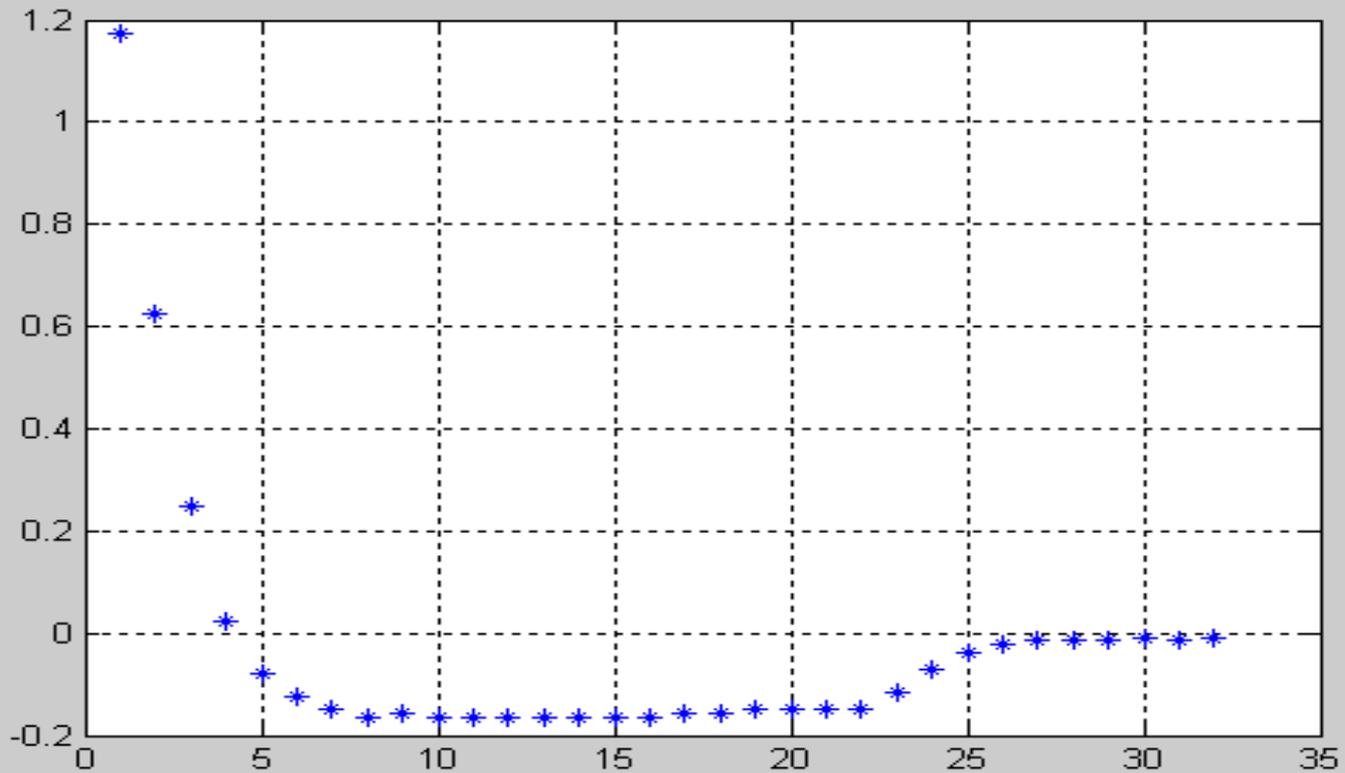


# Simulation Case: PAM2

- PAM2, SNR, 100mVpp Interference

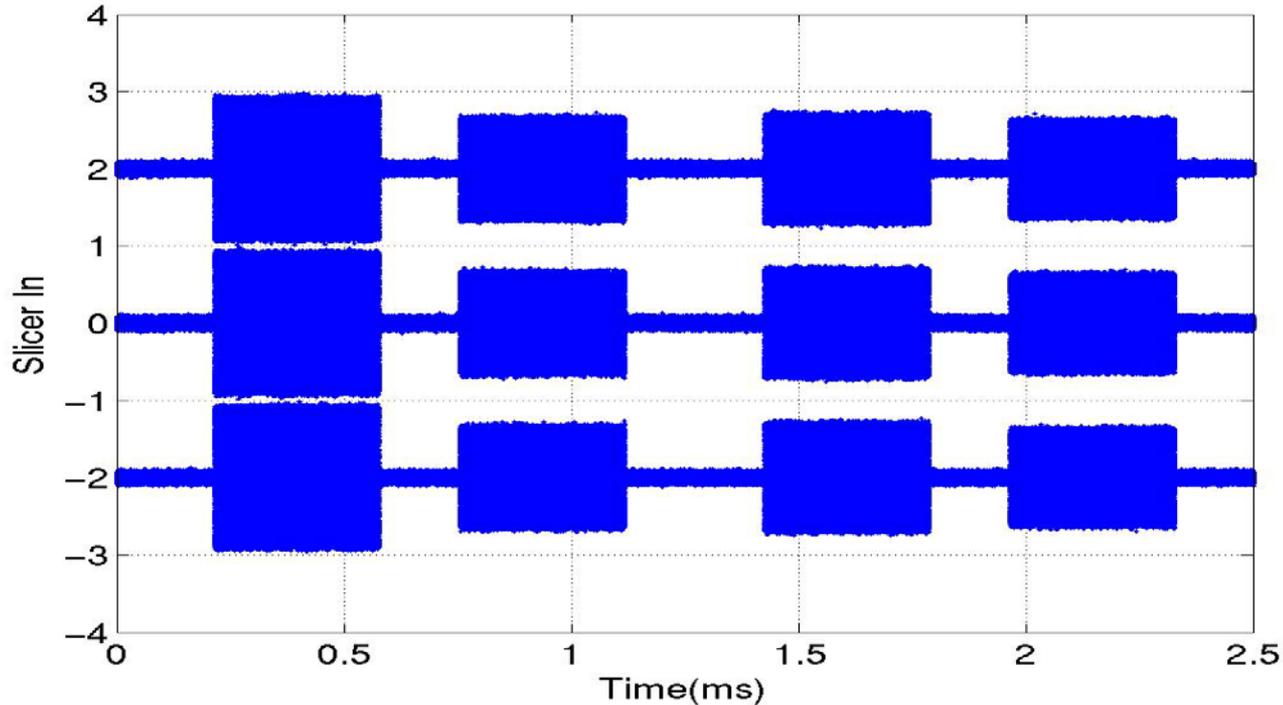


# PAM2 DFE Taps



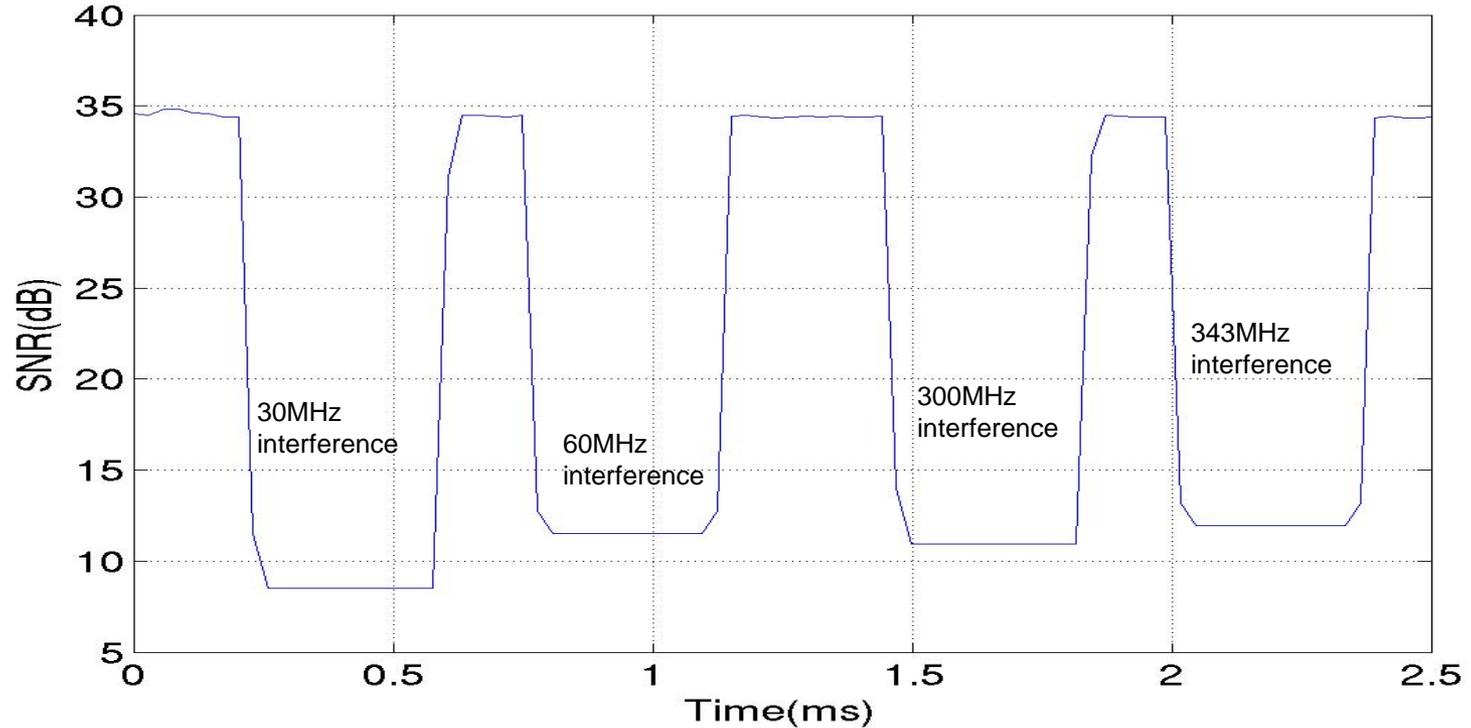
# Simulation Case: PAM3

- PAM3, 75mVpp interference
  - Interference Frequency (MHz):
    - 30, 60, 300 and 343
    - Adaptation loops freezed during induced interference



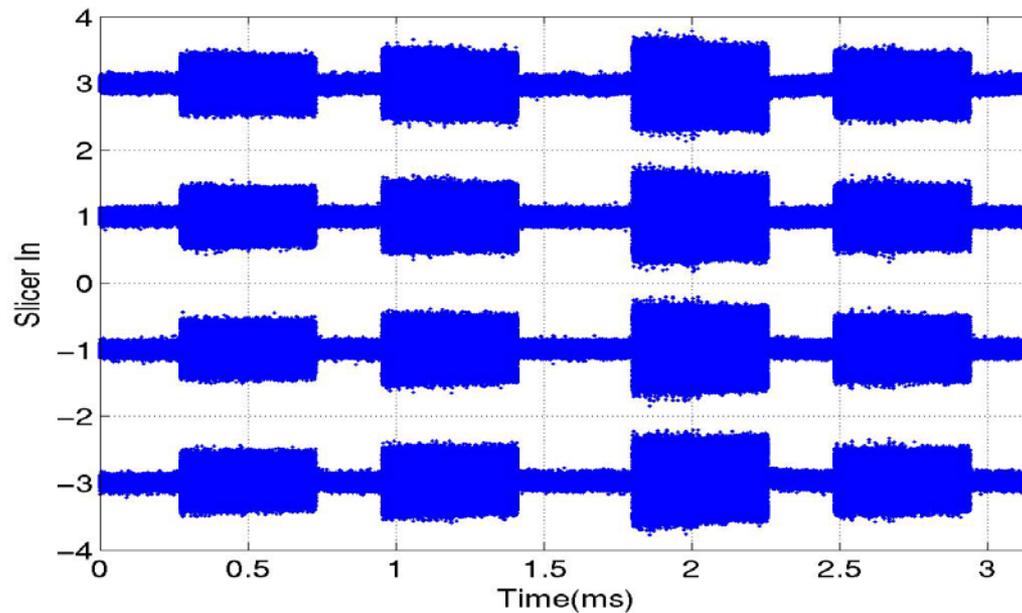
# Simulation Case: PAM3

- PAM3 SNR, 75mVpp interference



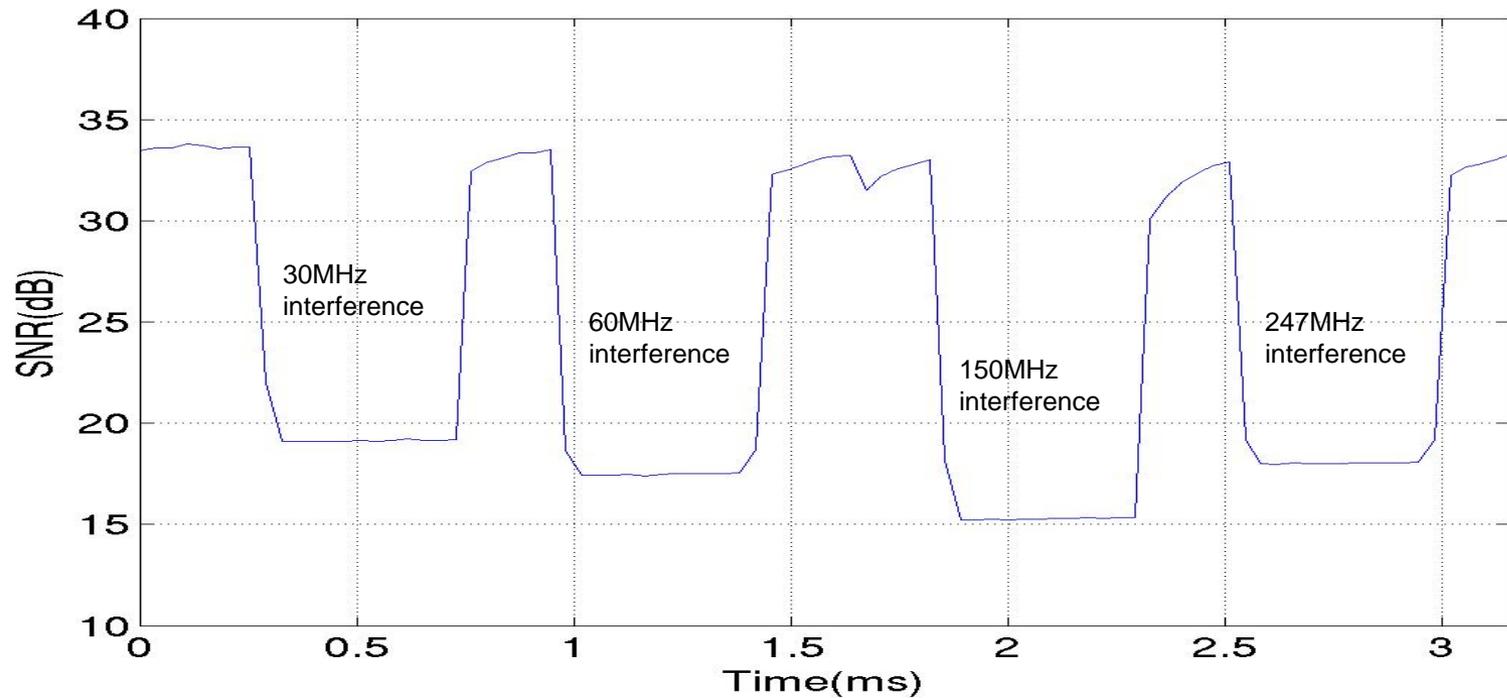
# Simulation Case: PAM4

- PAM4, Eye Diagram (50mVpp Interference)
  - Interference Frequency (MHz):
    - 30, 60, 150 and 247
    - Adaptation loops freezed during interference induced



# Simulation Case: PAM4

- PAM4 SNR, 50mVpp interference



# Transient Performance Comparison on Modulation Scheme

- 200mVpp referred to input equivalent to BCI 200mArms

Modulation	PAM2	PAM3	PAM4
BCI(120mA) (15m)	fail	fail	fail
BCI(110mA) (15m)	pass	fail	fail
BCI (100mA) (15m)	pass	fail	fail
BCI (75mA) (15m)	pass	pass	fail
BCI (50mA) (15m)	pass	pass	pass
Max BCI Current (15m cable)	110mA	75mA	60mA
Max BCI Current (10m cable)	160mA	95mA	85mA
Max BCI Current (2m cable)	320mA	190mA	160mA

# Conclusions

- 100mVpp Interference
  - Only PAM2 passes immunity test
- 75mVpp Interference
  - PAM2 & PAM3 passes Immunity test
- 50mVpp Interference
  - PAM2, PAM3 & PAM4 passes immunity test with enough margins
- Effect of Insertion Loss
  - Less insertion loss, better EMC immunity performance
  - Much better EMC Immunity performance at shorter cable lengths

# Conclusions -continued

- Transient Immunity Performance determined by Forward Gain
- Error Propagation Issue
  - Equalizer optimized for suppressing narrow band interference resulting in Large DFE taps
- PAM2 Best for the Transient Interference Performance
  - Potential Issue for PAM2 (possible 512MHz Broadband Cellular Phone Interference -- xiaofeng\_3bp\_01\_1113.pdf)



# Thank You!