Analysis of the Impact of Crosstalk in High-speed Serial Links

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Agenda

- Introduction
- Crosstalk Contributors in High-Speed Serial Links
- Analysis of the Impact of Crosstalk in BGA area
- Summary

Why Crosstalk?

- 10Gbps and even more higher speed channels need to be designed. So, crosstalk is inevitable.
  - Signal rise time （Tr）in 10Gbps+ system is very small ,Which produces more high frequency components.
  - 10Gbps+ Interconnect System is very Sensitive with Impedance Mismatch , e.g., BGA fanout areas, Connectors, Pindrills and other Vias. Crosstalk from reflected aggressor signals and reflected crosstalk will further degrade the victim signal.
- The Crosstalk in High-speed Serial links must be carefully analyzed to meet the BER performance requirement.

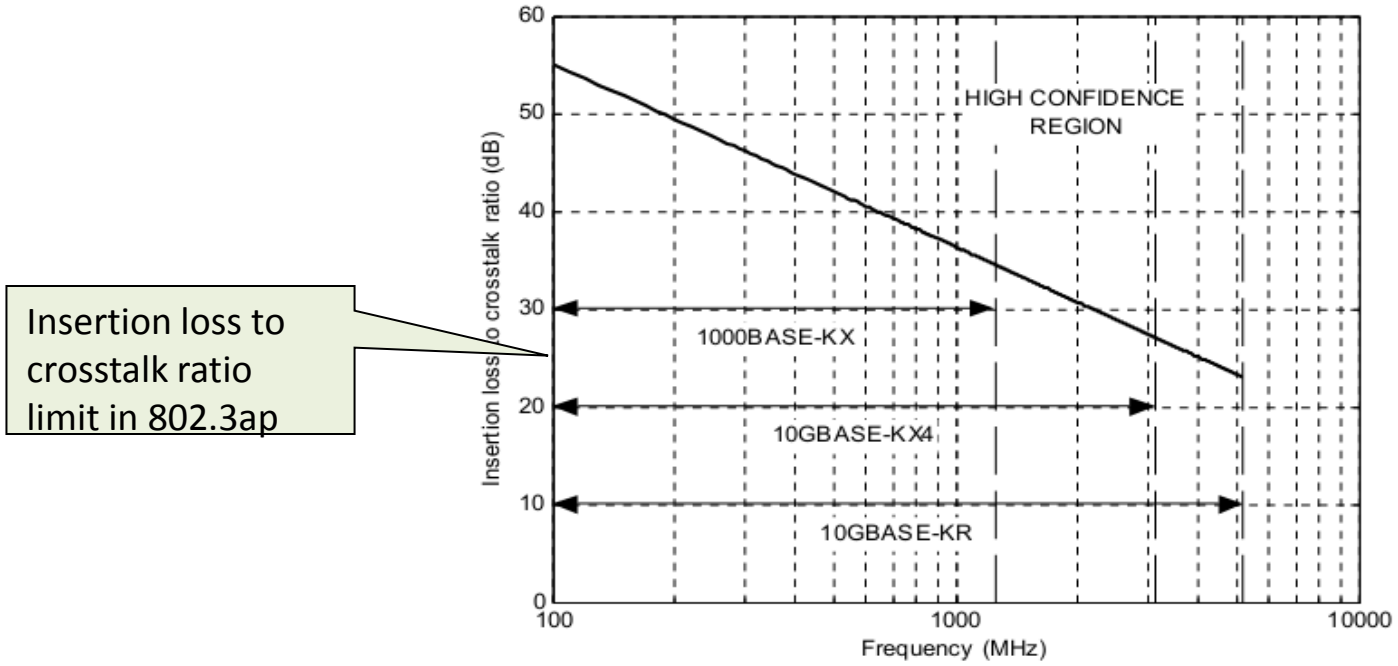
Definition of Crosstalk in SerDes System

Crosstalk is usually subdivided to two parts. It is described in IEEE802.3ap as followed :

- Far-end crosstalk(FEXT) coming from data traveling in the same general direction as the channel of interest.
- Near-end crosstalk(NEXT) originating from a channel with a transmitter near the receiver of the channel of interest.

Crosstalk Requirement in IEEE 802.3ap

- Most of standards specify the requirement of crosstalk.
- In IEEE 802.3ap, it is specified as Insertion loss to crosstalk ratio（ICR）.



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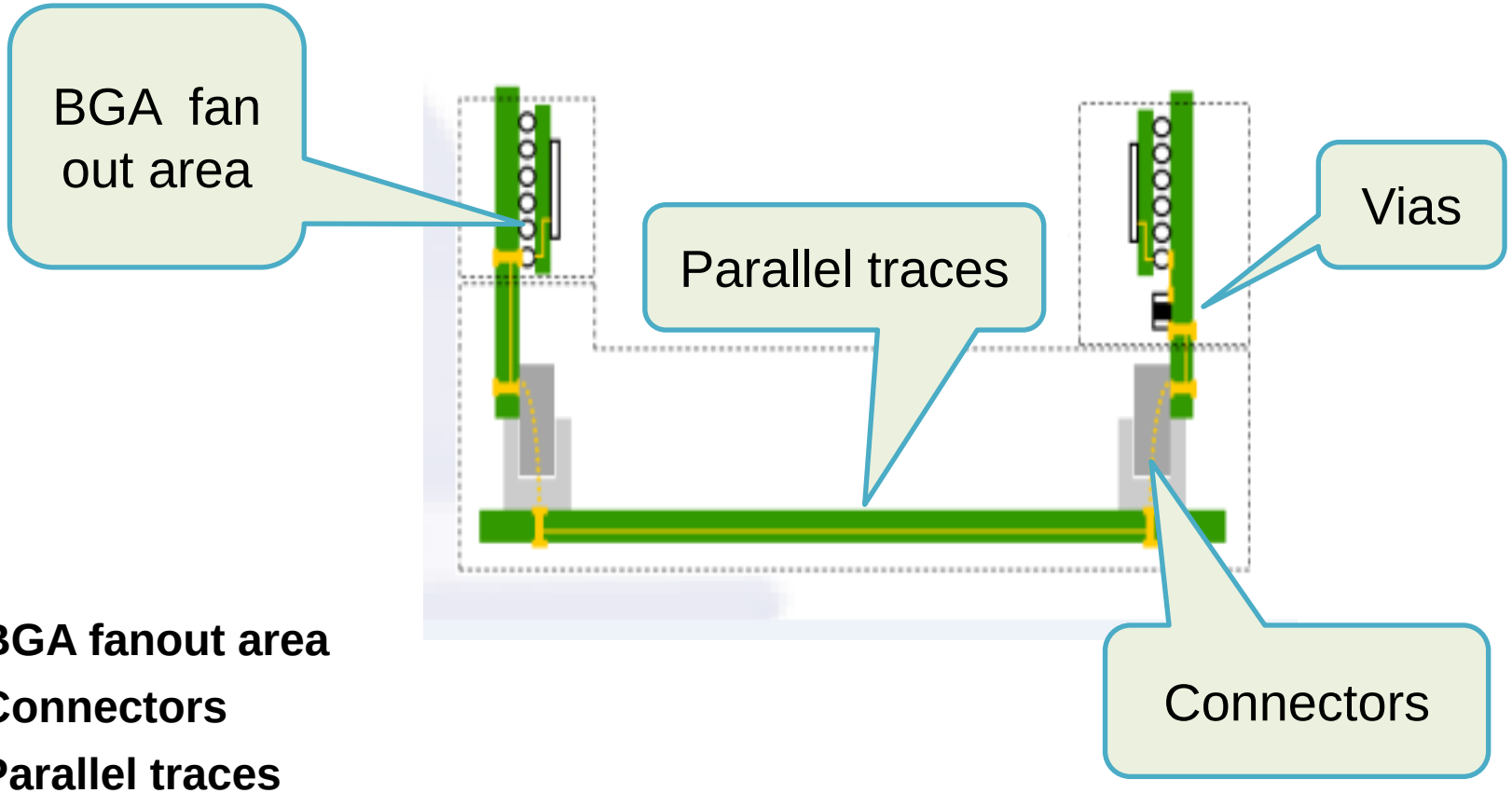
Crosstalk Contributors in High-Speed System



- **BGA fanout area**
- **Connectors**
- **Parallel traces**
- **Other Vias in channel**

Crosstalk Contributors in High-Speed System

■ **BGA fanout area**

Pay attention to BGA fanout area .The fanout patterns of differential pairs affect the crosstalk .

■ **Connectors**

Connectors are often the key contributor to crosstalk. Estimate TX/RX partition and pindrill to optimize the crosstalk performance.

■ **Parallel traces**

Find the longest parallel trace and carefully analyze the crosstalk to ensure the routing rules are suitable.

■ **Other Vias in channel**

The Vias for capacitors will cause crosstalk ,so keep appropriate distance between Vias of differential pairs.

Why do we focus on Crosstalk in BGA Area

- We often focus on the crosstalk caused by connectors, connectors' pindrills and parallel traces.
- We paid few attention to crosstalk in BGA area in the past.
- BGA area is also an important part needed to be carefully analyzed.
- In the rest of this paper, we will look into the impact of BGA area.

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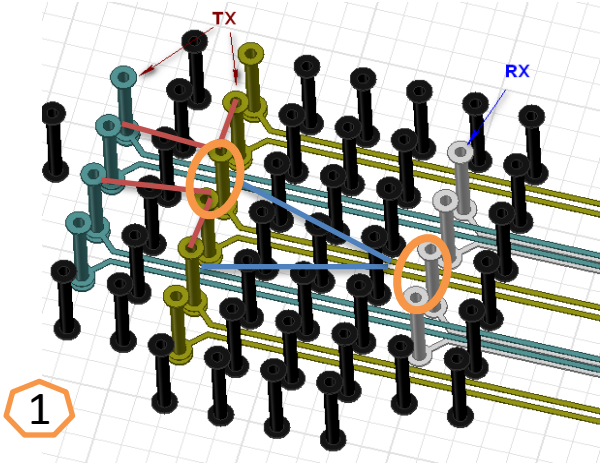
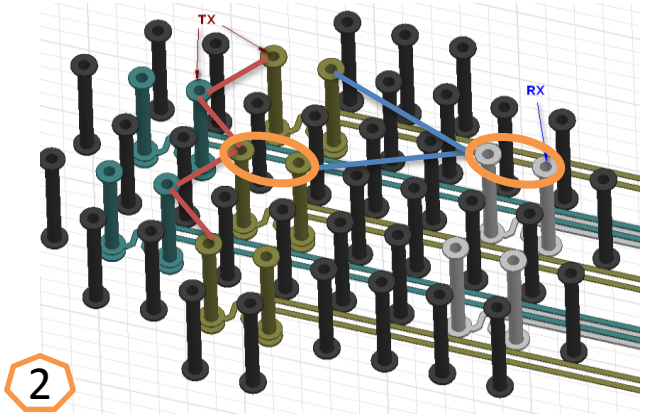
Modeling for Crosstalk Analysis

In BGA fanout area，There are Three samples and their primary differences:

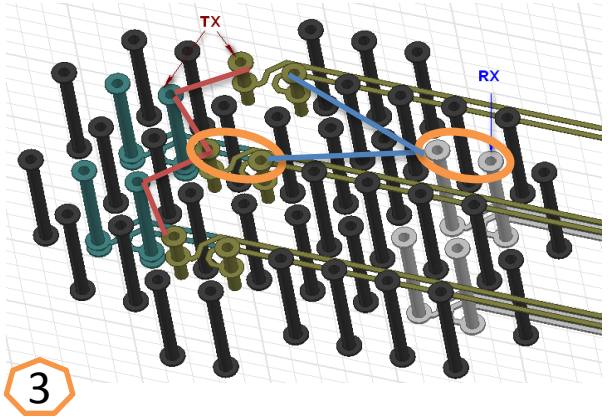
- Fanout pattern
- Distance between pairs
- Via length



Long Via, Fanout Pattern 1



Long Via, Fanout Pattern 2

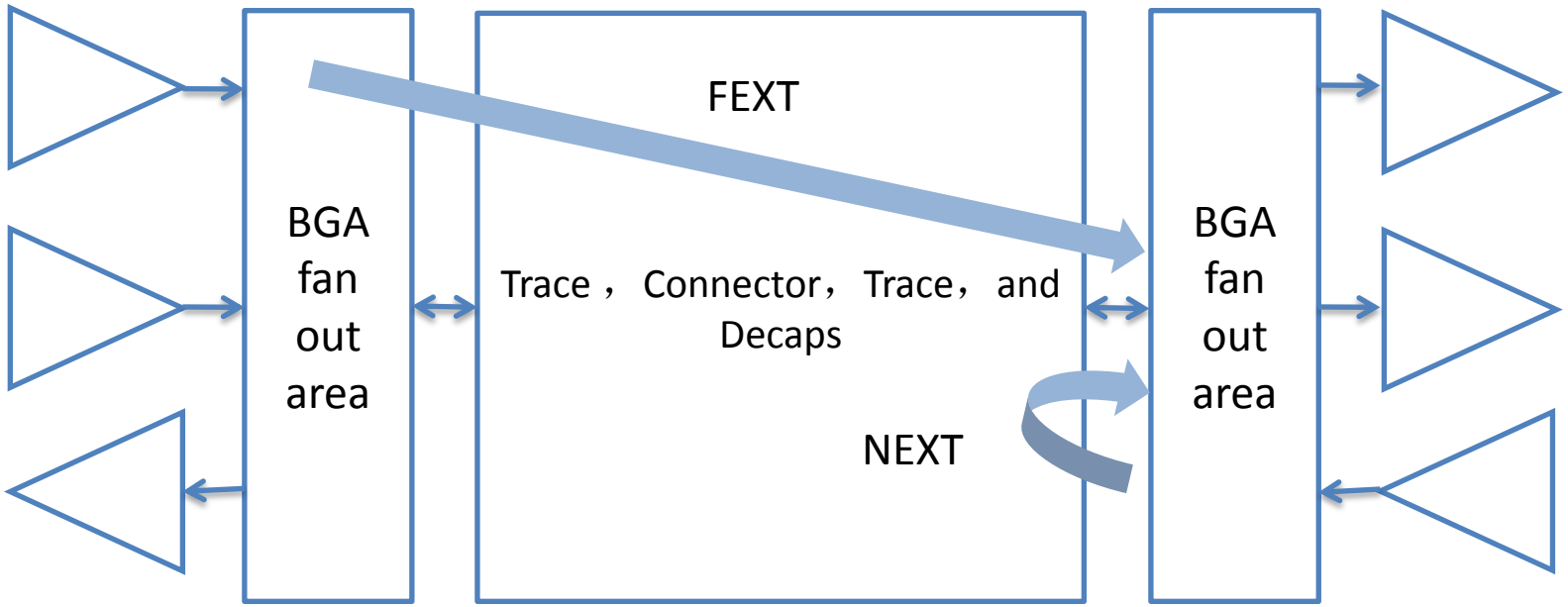


Short Via, Fanout Pattern 3

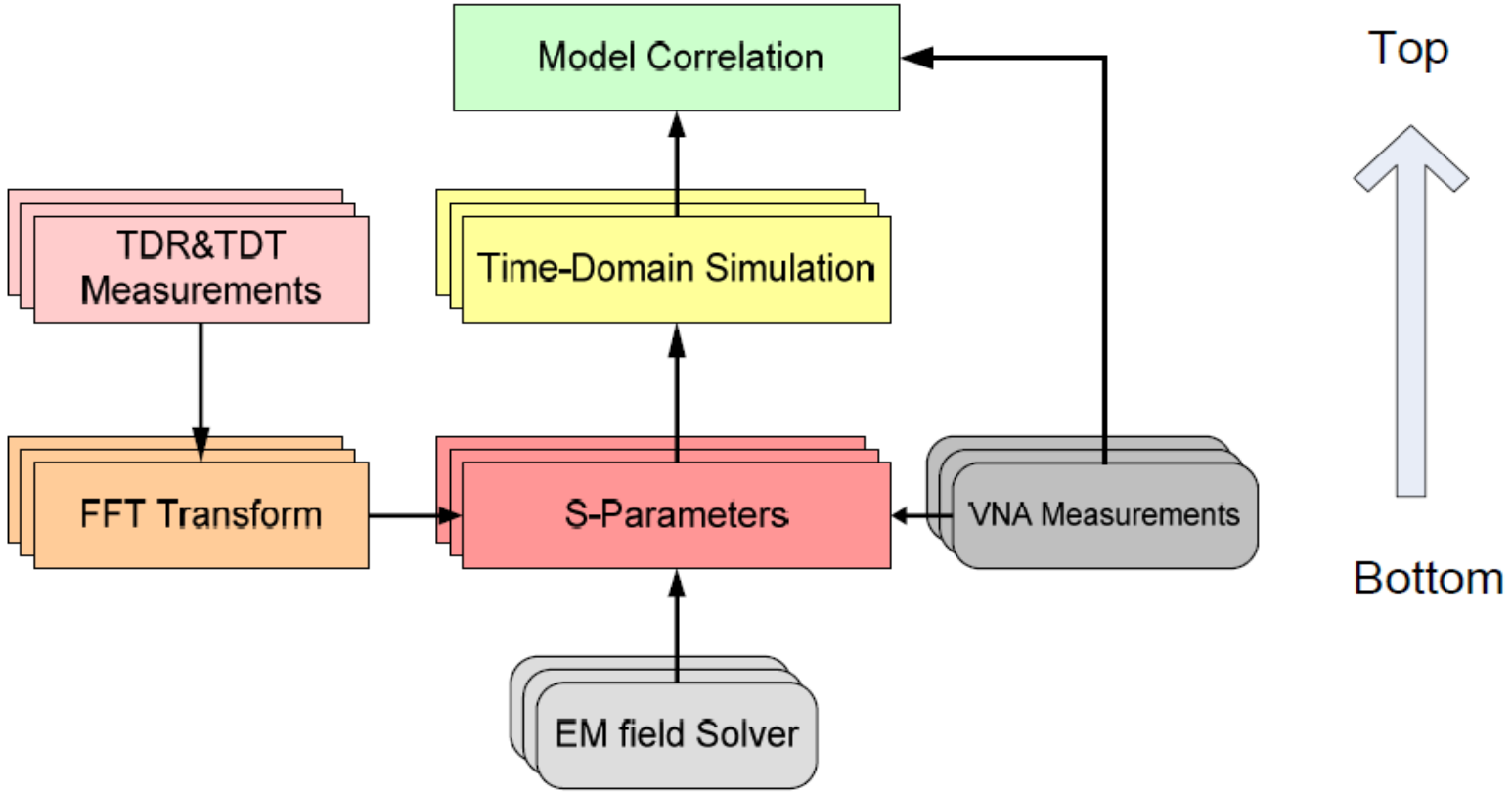
Modeling for Crosstalk Analysis

There are three serial links in model:

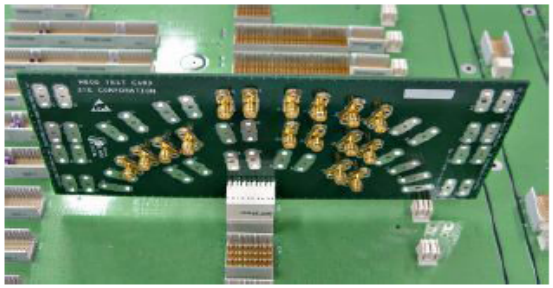
- Victim's channel ,aggressor channel for NEXT and aggressor channel for FEXT.
- S4p files for NEXT and FEXT.
- 40-inch length trace，3W space，a certain connector model.



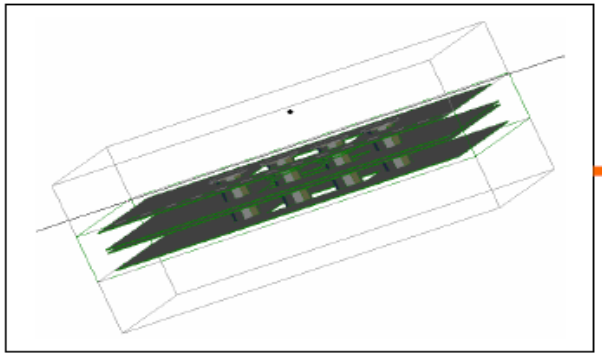
Using S-Parameters for Crosstalk Analysis



Using S-Parameters for Crosstalk Analysis



Measurement setup



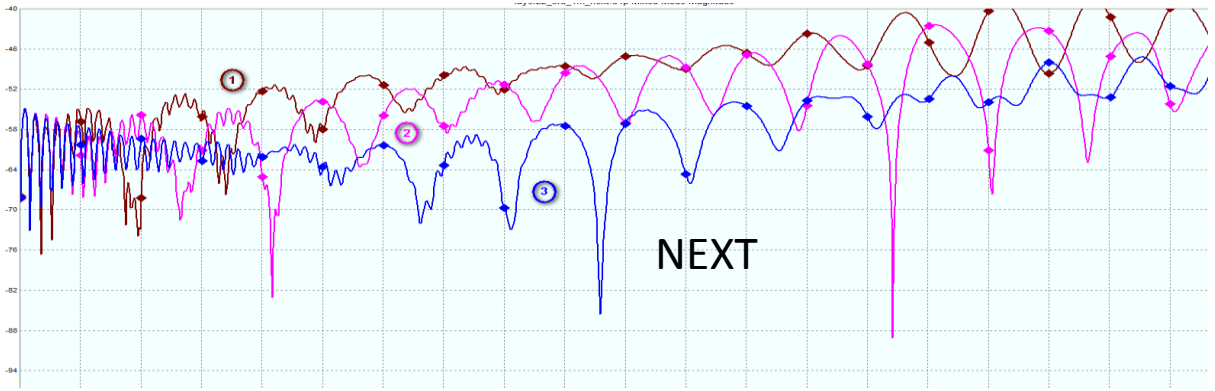
3D EM Solver Modeling

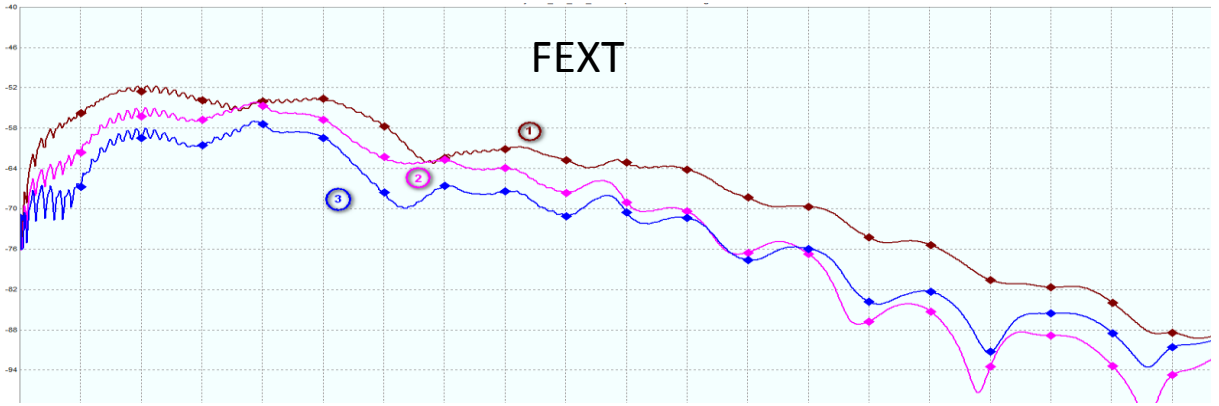
S-Parameter touchstone file

```
! FILE NAME
! DATE 10/20/05  22:27
! CORRECTED  DATA
# GHz  S     MA    R  50.00
 0.010000000 3.217487E-02  25.539 1.433922E-02  73.163 7.022051E-04 -164.797 9.721752E-01  -14.501
        1.437112E-02  73.522 8.342298E-02  21.247 9.721735E-01  -14.643 1.031352E-03  152.923
        6.869677E-04 -166.566 9.750083E-01  -14.799 3.180707E-02  24.806 1.426077E-02  73.110
        9.757603E-01  -14.762 1.043164E-03  148.597 1.442420E-02  73.191 3.261170E-02  27.190
 0.019987500 4.338055E-02  24.741 2.759167E-02  60.757 1.264493E-03  172.773 9.619784E-01  -28.320
        2.753260E-02  60.598 5.663544E-02  -7.471 9.629115E-01  -28.078 8.262120E-04  130.485
        1.252529E-03  171.672 9.652648E-01  -28.414 4.342042E-02  20.989 2.762920E-02  60.190
        9.660442E-01  -28.600 8.369133E-04  130.697 2.751868E-02  59.706 4.591656E-02  22.958
 0.029975000 5.279364E-02  19.352 3.940318E-02  47.550 1.777378E-03  145.369 9.554404E-01  -42.013
        3.933148E-02  47.604 3.671105E-02  -9.347 9.577851E-01  -41.765 7.441007E-04  136.632
        1.751164E-03  143.245 9.584093E-01  -42.077 5.350023E-02  13.120 3.941780E-02  46.306
        9.575923E-01  -42.330 7.423362E-04  133.941 3.934892E-02  46.433 5.596628E-02  14.271
 0.039962500 6.059968E-02  11.269 4.905304E-02  34.608 2.323297E-03  117.191 9.492754E-01  -55.661
        4.906615E-02  34.594 3.431321E-02  15.544 9.519293E-01  -55.371 1.174888E-03  136.972
        2.295646E-03  114.989 9.529339E-01  -55.758 6.189575E-02  3.980 4.901626E-02  33.024
        9.517830E-01  -55.968 1.161010E-03  136.920 4.896336E-02  33.055 6.299231E-02  3.407
 0.049950000 6.662585E-02  1.555 5.628981E-02  21.659 2.841726E-03  90.468 9.434645E-01  -69.209
        5.633547E-02  21.883 5.111281E-02  22.288 9.453543E-01  -68.928 1.940923E-03  116.840
        2.788556E-03  88.049 9.454238E-01  -69.373 6.795117E-02  -5.423 5.627455E-02  19.599
        9.449649E-01  -69.579 1.899390E-03  117.875 5.611407E-02  19.671 6.618402E-02  -7.747
 0.059937500 7.025610E-02  -9.871 6.094978E-02  8.924 3.319784E-03  63.903 9.380775E-01  -82.793
        6.093212E-02  8.964 6.989614E-02  11.224 9.395743E-01  -82.342 2.770354E-03  88.655
        3.227467E-03  61.858 9.384965E-01  -82.888 7.212381E-02  -15.124 6.077348E-02  6.385
        9.384112E-01  -83.188 2.774367E-03  89.391 6.085816E-02  6.319 6.634015E-02  -18.404
 0.069925000 7.160252E-02  -22.097 6.273439E-02  -3.632 3.720456E-03  37.930 9.326985E-01  -96.370
        6.272058E-02  -3.522 8.357295E-02  -6.331 9.355087E-01  -95.783 3.570472E-03  57.951
        3.599259E-03  36.141 9.323274E-01  -96.278 7.376438E-02  -24.634 6.278425E-02  -6.705
        9.336231E-01  -96.646 3.602008E-03  58.589 6.281382E-02  -6.657 6.448640E-02  -28.081
 0.079912500 7.081175E-02  -34.685 6.182219E-02  -16.100 4.040125E-03  12.437 9.270003E-01 -109.843
        6.178188E-02  -15.966 8.959131E-02  -26.534 9.309905E-01 -109.271 4.262746E-03  27.041
        3.903036E-03  11.300 9.269238E-01 -109.574 7.376363E-02  -34.289 6.182057E-02  -19.660
        9.282665E-01 -110.146 4.314952E-03  26.898 6.182886E-02  -19.667 6.259895E-02  -35.944
```

Modeling for Three Fanout Patterns

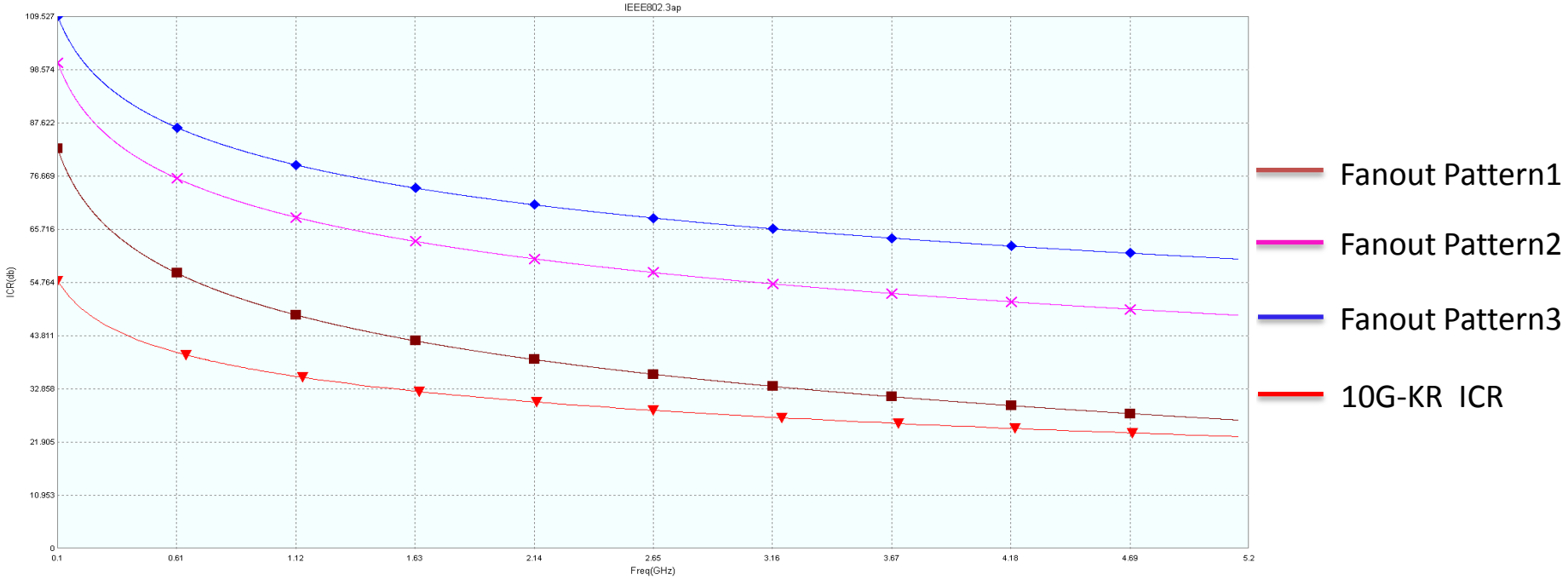
- Exchange the BGA fanout area model with former three samples, and we get three different results for system NEXT and FEXT.





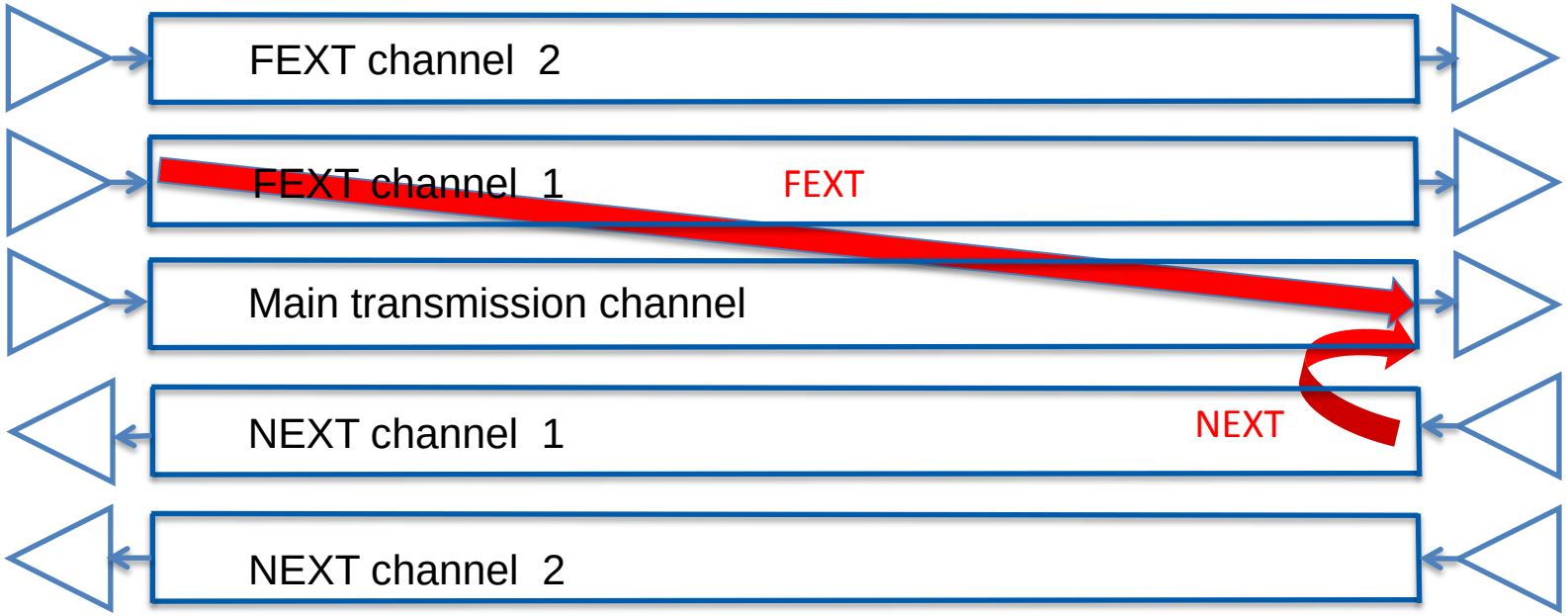
ICR Simulation for Three Fanout Patterns

- Three ICR Simulation Results compare with ICR Requirement in IEEE 802.3ap.



SNR & BER Simulation for Three Fanout Patterns

- Crosstalk Simulation Setup
  - Time domain simulation with SerDes buffer models.
  - 10.3125Gbps,64B66B.
  - Crosstalk phase assumed to be worst-case aligned signal.



Comparisons of Simulation Results

Sample Channel	Eye Height	Eye Width	SNR	BER
Fanout Pattern1 without crosstalk	16.37%	0.35UI	21.9	7.2E-36
Fanout Pattern2 without crosstalk	16.35%	0.35UI	21.9	5.4E-36
Fanout Pattern3 without crosstalk	16.42%	0.35UI	21.9	6.3E-36
Fanout Pattern1 with 1 time crosstalk	15.65%	0.35UI	21.6	1.2E-33
Fanout Pattern2 with 1 time crosstalk	15.95%	0.35UI	21.8	9.8E-35
Fanout Pattern3 with 1 time crosstalk	16.22%	0.35UI	21.8	3.0E-35
Fanout Pattern1 with 2 times crosstalk	14.92%	0.35UI	21.3	2.0E-31
Fanout Pattern2 with 2 times crosstalk	15.64%	0.35UI	21.6	1.8E-33
Fanout Pattern3 with 2 times crosstalk	16.05%	0.35UI	21.8	1.0E-34

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Summary

- The crosstalk in BGA fanout area is not negligible but very important in 10Gbps+ SerDes links ,we need to select an optimized pattern for BGA fanout to improve the system performance.
- Connectors & pindrills, parallel traces and Vias are also very important parts to be analyzed.
- With carefully look into these crosstalk, we will do better work in serial links design.

Bringing you Closer

Thanks!

ZTE中兴