

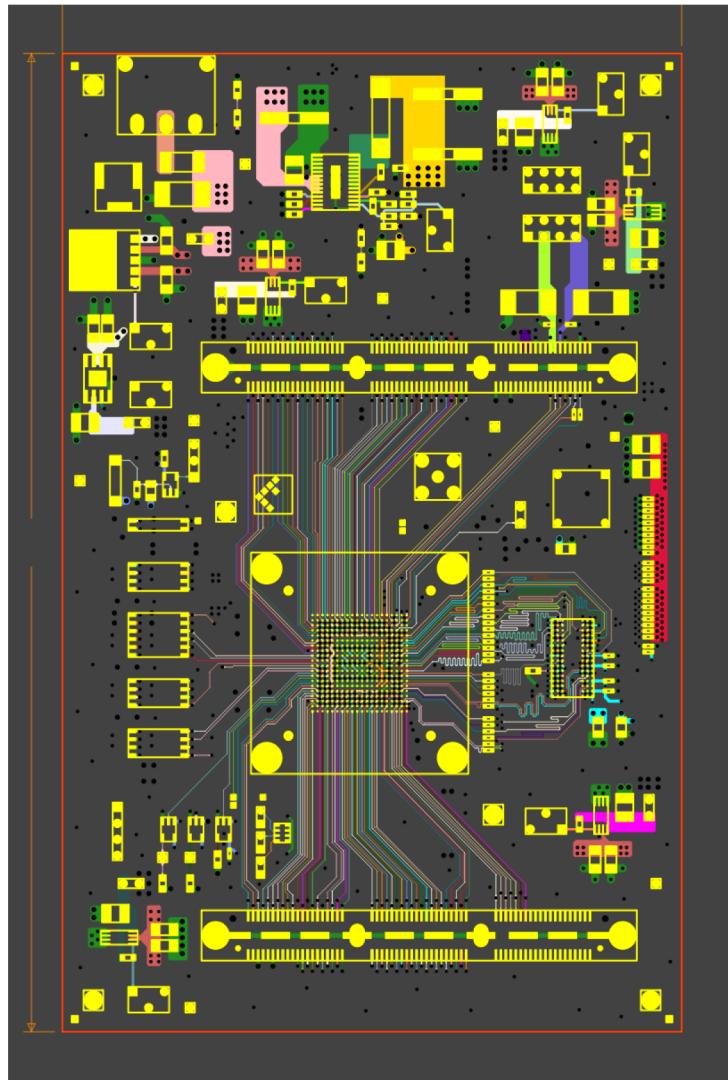
DDR4 仿真验证报告

2018年6月4日

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设计摘要

| 设计信息 | |
|------------------------|----------------------------|
| 名称 | PCB_DDR4_ONBOARD_2V0-0313a |
| 版图格式 | ODB |
| PCB尺寸(mm^2) | 155x100 |
| 器件总数 | 386 |
| 电路板层数 | 6 |
| DDR信息 | |
| DDR类型 | DDR4 |
| DDR电压(v) | 1.2V |
| DDR控制芯片 | XCKU115-1FLVD1924I: U1 |
| DDR内存芯片 | MT40A1G16HBA-083E: U2 |
| 时钟频率 | 1200MHz |
| 通道数目 | 1 |
| 数据字节数 | 2 |



叠层信息

| 类型 | 名称 | 厚度(mm) | 介电常数(ϵ_r) | 损耗因数(δ) |
|------------|-------|--------|----------------------|------------------|
| Metal | I1 | 0.04 | | |
| Dielectric | LD_I1 | 0.21 | 4.2 | 0.02 |
| Metal | I2 | 0.04 | | |
| Dielectric | LD_I2 | 0.33 | 4.2 | 0.02 |
| Metal | I3 | 0.04 | | |
| Dielectric | LD_I3 | 0.23 | 4.2 | 0.02 |
| Metal | I4 | 0.04 | | |
| Dielectric | LD_I4 | 0.33 | 4.2 | 0.02 |
| Metal | I5 | 0.04 | | |
| Dielectric | LD_I5 | 0.21 | 4.2 | 0.02 |
| Metal | I6 | 0.04 | | |

服务摘要

| 服务项目 | 服务范围 | 报告 |
|---|---|----------------------|
| 阻抗计算 | 数据信号: DQ/DQS 控制信号: Clk, CAS, RAS, WE 地址信号: Clk, Adr, BA | 阻抗表格 |
| 传输线建模 | 以上所有Net | 串扰, Delay/Skew 和眼图报告 |
| Tx/Rx I/O 缓存模型 | Driver strength, timing characterization | I/O 缓存模型报告 |
| 串扰仿真 | 对串扰的仿真分析 | 串扰报告 |
| Delay and skew 仿真 | 对delay/skew的仿真分析 | 时序报告及眼图 |
| Eye diagram and DDR3L compliance checking | 眼图的生成以及验证 | 眼图及其规范 |

| 现象 | 建议 |
|----|----|
| | |
| | |
| | |

仿真验证报告详细结果

- 信号特性阻抗
- 串扰分析
- Clock/DQS 波形图
- DQ信号时序
- Address/Command 信号时序

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信号特性阻抗

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DQ特性阻抗

| Byte | Net名 | 层 | 阻抗(Ω) (最小值，最大值) | 长度(mm) (最小值，最大值) | 宽度(mm) (最小值，最大值) |
|------|--|----------------|---|---|---|
| 0 | NET276, NET324 NET289, NET355 NET311, NET347 NET297, NET364 NET294, NET368 NET313, NET363 NET314, NET341 NET296, NET337 | I1 I3 I6 | I1=(49.2, 49.2) I3=(53.6, 53.6) I6=(49.2, 49.2) | total=(42, 46) I1=(1.435, 31.706) I3=(16.634, 26.242) I6=(2.026, 25.630) | I1=0.127 I3=0.178 I6=0.127 |
| | NET303, NET333 NET308, NET369 | I1 I6 | I1=(49.2, 49.2) I6=(49.2, 49.2) | total=(50, 51) I1=(17.481, 32.355) I6=(1.061, 1.594) | I1=0.127 I6=0.127 |
| 1 | NET279, NET367 NET310, NET335 NET280, NET332 NET288, NET370 NET278, NET330 NET292, NET357 NET302, NET336 NET312, NET354 | I1 I6 I3 | I1=(29.0, 49.2) I6=(49.2, 49.2) I3=(53.6, 53.6) | total=(43, 46) I1=(0.566, 29.415) I6=(1.981, 24.275) I3=(19.334, 19.334) | I1=(0.127, 0.305) I6=0.127 I3=0.178 |
| | NET270, NET360 NET271, NET342 | I1 I6 | I1=(49.2, 49.2) I6=(49.2, 49.2) | total=(47, 47) I1=(6.414, 22.738) I6=(18.038, 18.568) | I1=0.127 I6=0.127 |

Address信号特性阻抗

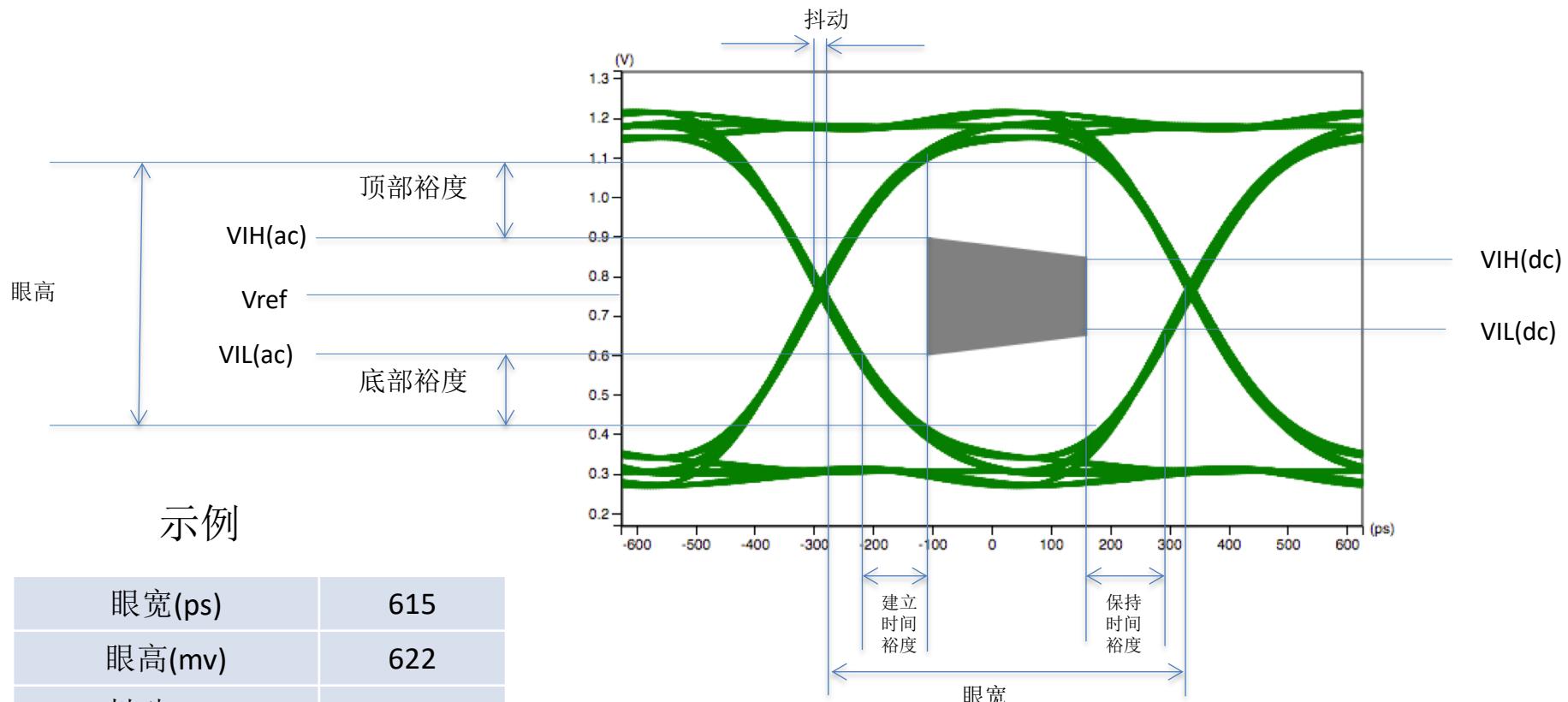
| Net名 | 层 | 阻抗(Ω) (最小值，最大值) | 长度(mm) (最小值，最大值) | 宽度(mm) (最小值，最大值) | 终端电阻 |
|--|----------------|---|--|----------------------------------|------|
| NET295, NET356 NET277, NET327 NET273, NET338 NET316, NET351 NET291, NET334 NET306, NET352 NET309, NET358 NET298, NET359 NET318, NET365 NET305, NET322 NET290, NET328 NET300, NET343 NET282, NET362 NET269, NET321 NET284, NET346 NET299, NET348 NET281, NET320 | I1 I3 I6 | I1=(49.2, 49.2) I3=(53.6, 54.4) I6=(49.2, 49.2) | total=(61, 83) I1=(1.435, 42.003) I3=(9.423, 37.817) I6=(1.009, 32.776) | I1=0.127 I3=0.178 I6=0.127 | 39.0 |
| NET036, NET265 | I1 I6 | I1=(49.2, 49.2) I6=(20.0, 49.2) | total=(55, 55) I1=(2.871, 2.871) I6=(2.000, 50.311) | I1=0.127 I6=(0.127, 0.508) | 39.0 |
| NET035, NET265 | I1 I6 | I1=(49.2, 49.2) I6=(20.0, 49.2) | total=(51, 51) I1=(2.871, 2.871) I6=(2.000, 46.963) | I1=0.127 I6=(0.127, 0.508) | 39.0 |

| Net名 | 层 | 阻抗(Ω) (最小值，最大值) | 长度(mm) (最小值，最大值) | 宽度(mm) (最小值，最大值) | 终端电阻 |
|----------------|----|--------------------|--|---------------------|------|
| NET285, NET339 | l1 | l1=(49.2, 49.2) | total=(61, 61) | l1=0.127 | 39.0 |
| | l3 | l3=(53.6, 54.4) | l1=(26.917, 26.917) | l3=0.178 | |
| | l6 | l6=(49.2, 49.2) | l3=(8.887, 8.887) | l6=0.127 | |
| | l1 | l1=(49.2, 49.2) | l6=(4.715, 4.715) | l1=0.127 | |
| | l6 | l6=(49.2, 49.2) | l1=(1.435, 1.435) l6=(19.098, 19.098) | l6=0.127 | |
| NET304, NET325 | l1 | l1=(49.2, 49.2) | total=(83, 83) | l1=0.127 | 39.0 |
| | l3 | l3=(53.6, 54.4) | l1=(31.954, 31.954) | l3=0.178 | |
| | l1 | l1=(49.2, 49.2) | l3=(21.898, 21.898) l1=(29.460, 29.460) | l1=0.127 | |

差分特性阻抗

| Net Names | 层 | 阻抗(Ω) (最小值, 最大值) | 长度(mm) (最小值, 最大值) | 宽度(mm) (最小值, 最大值) | 间距 |
|----------------------------------|----------|------------------------------------|---|----------------------|------------------|
| NET035, NET265 NET036, NET265 | I6 | (89.7, 89.7) | (2.000, 50.311) | (0.1, 0.5) | 0.2 |
| NET308, NET369 NET303, NET333 | I1 | (89.7, 95.8) | (17.481, 32.355) | 0.1 | (0.2, 0.4) |
| NET271, NET342 NET270, NET360 | I1 I6 | I1=(89.7, 89.7) I6=(89.7, 89.7) | total=(24, 47) I1=(6.414, 22.738) I6=(18.038, 18.568) | I1=0.127 I6=0.127 | I1=0.2 I6=0.2 |

时序变量定义



示例

| | |
|------------|-----|
| 眼宽(ps) | 615 |
| 眼高(mv) | 622 |
| 抖动 (ps) | 55 |
| 顶部裕度(mv) | 192 |
| 底部裕度(mv) | 201 |
| 建立时间裕度(ps) | 115 |
| 保持时间裕度(ps) | 130 |

仿真驱动模型



| 驱动 | DQS | DQ | 接收 | DQS | DQ |
|-----------------|-----------------------|-----------------------|------------|-------------------|------------------|
| Impedance (ohm) | 39.1 | 39.1 | ODT (ohm) | 43.0 | 43.0 |
| 上升时间(ps) | 134 | 134 | IBIS 模型 | DQS_IN_ODT40_3200 | DQ_IN_ODT40_3200 |
| 驱动下降时间(ps) | 139 | 139 | | | |
| IBIS Models | HP_POD12_S_OUT40_IN40 | HP_POD12_S_OUT40_IN40 | | | |

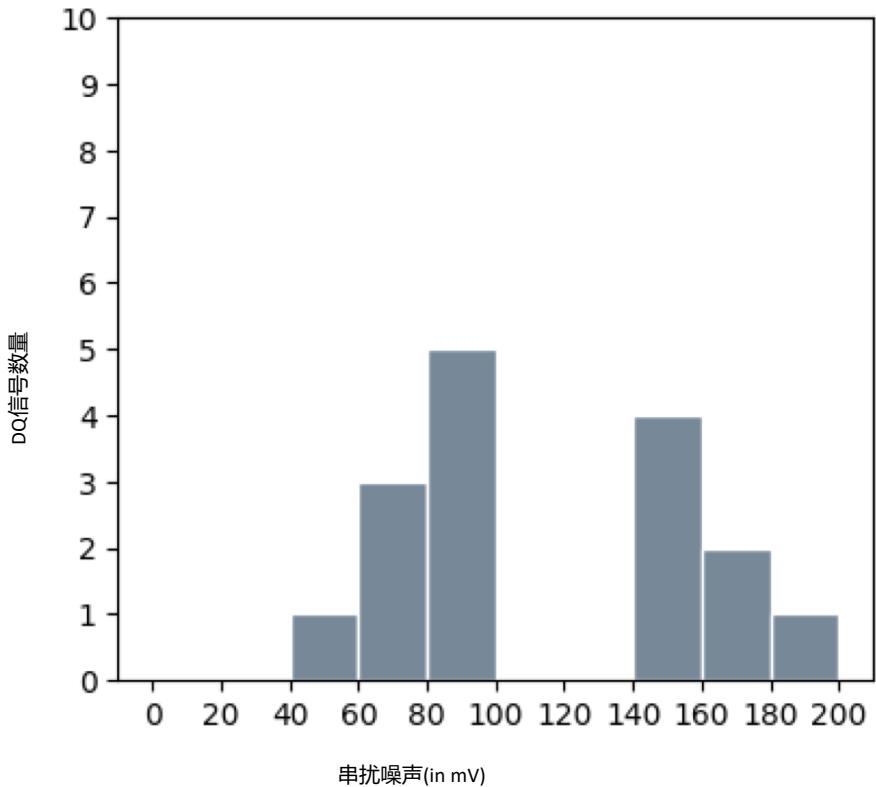


| 接收 | DQS | DQ | 驱动 | DQS | DQ |
|------------|-----------------------|-----------------------|-----------------|-------------|------------|
| ODT (ohm) | 38.0 | 38.0 | Impedance (ohm) | 36.6 | 36.6 |
| IBIS 模型 | HP_POD12_S_OUT40_IN40 | HP_POD12_S_OUT40_IN40 | 上升时间(ps) | 77 | 77 |
| | 0 | 0 | 驱动下降时间(ps) | 68 | 68 |
| | | | IBIS Models | DQS_40_3200 | DQ_40_3200 |

串扰分析

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串扰分析摘要



DQ串扰柱状图

| Net Names | 串扰值(mV) |
|-----------|---------|
| NET302 | 194 |
| NET310 | 173 |
| NET280 | 169 |
| NET289 | 150 |
| NET278 | 145 |
| NET312 | 143 |
| NET314 | 143 |
| NET292 | 97 |
| NET311 | 92 |
| NET296 | 92 |

影响最大前10位

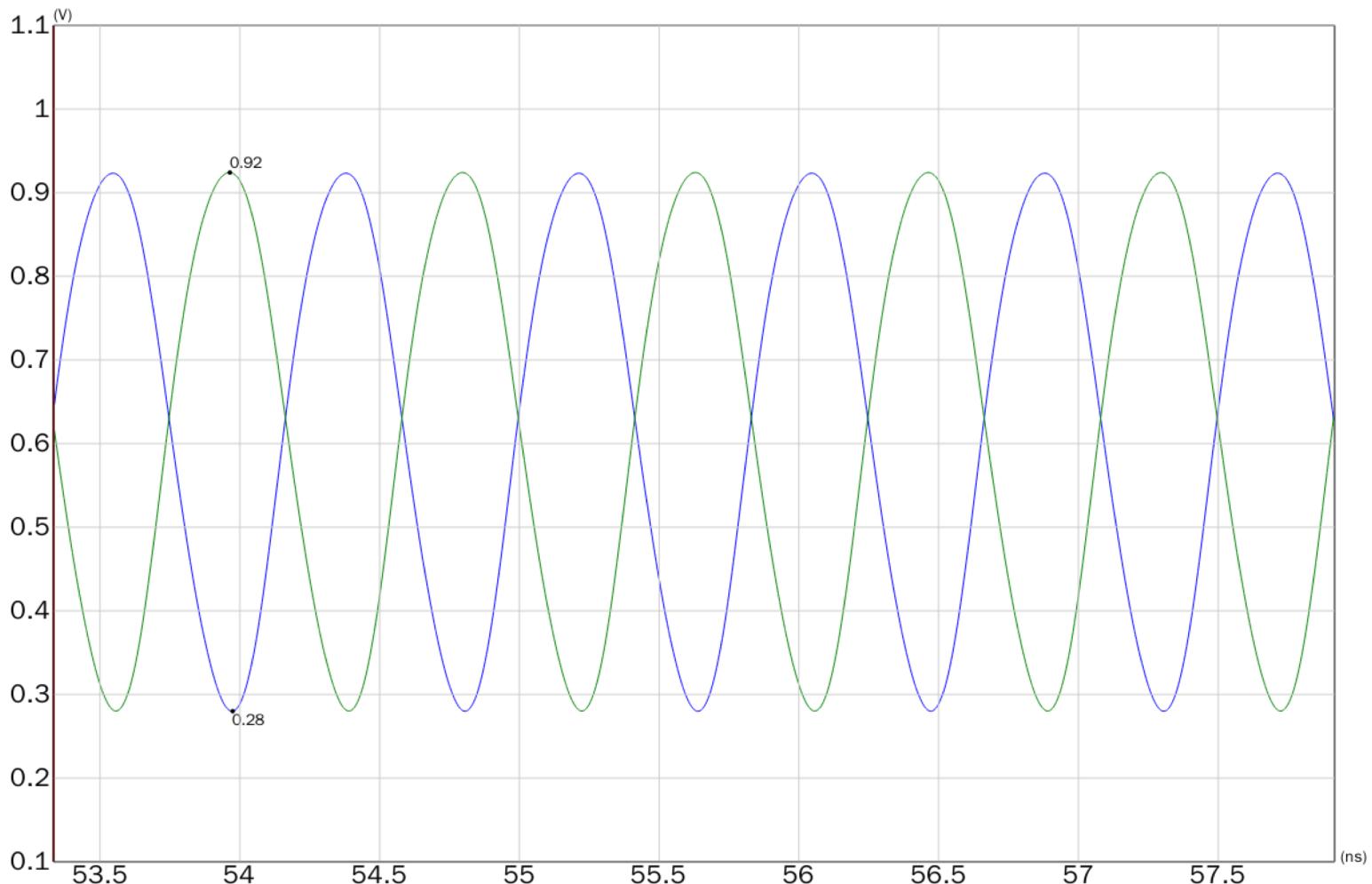
DQ串扰分析 - Byte [0, 1]

| Byte | Net Names | 近端Xtalk(mv) | 远端Xtalk(mv) |
|------|-----------|-------------|-------------|
| 0 | NET276 | 24.48 | 64.44 |
| | NET289 | 51.95 | 150.11 |
| | NET311 | 45.67 | 92.24 |
| | NET297 | 44.16 | 66.90 |
| | NET294 | 41.51 | 90.47 |
| | NET313 | 30.62 | 84.72 |
| | NET314 | 52.32 | 142.87 |
| | NET296 | 45.10 | 92.00 |
| 1 | NET279 | 27.19 | 47.25 |
| | NET310 | 53.64 | 173.28 |
| | NET280 | 48.22 | 168.72 |
| | NET288 | 30.69 | 65.80 |
| | NET278 | 48.36 | 144.94 |
| | NET292 | 30.50 | 97.44 |
| | NET302 | 56.70 | 194.34 |
| | NET312 | 51.88 | 143.35 |

Clock & DQS 信号波形图

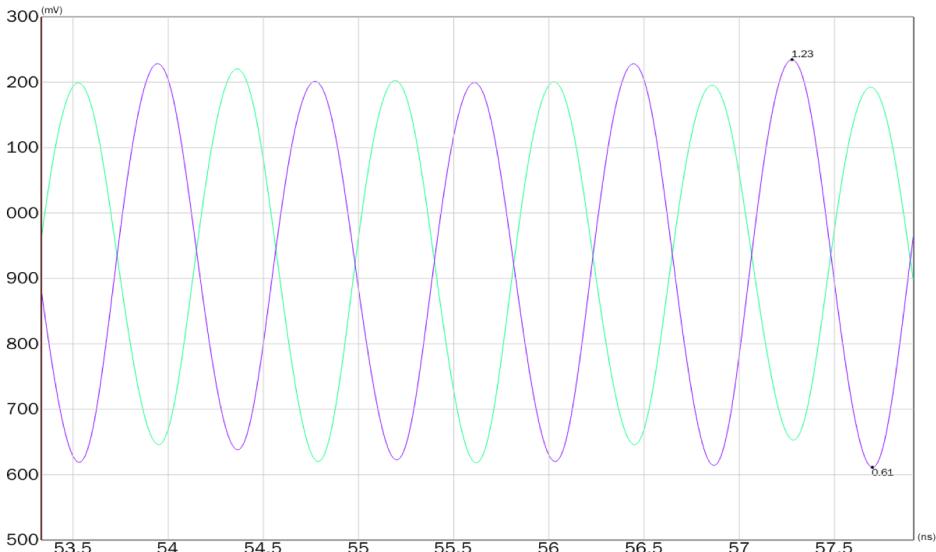
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Clock Waveform [U2]

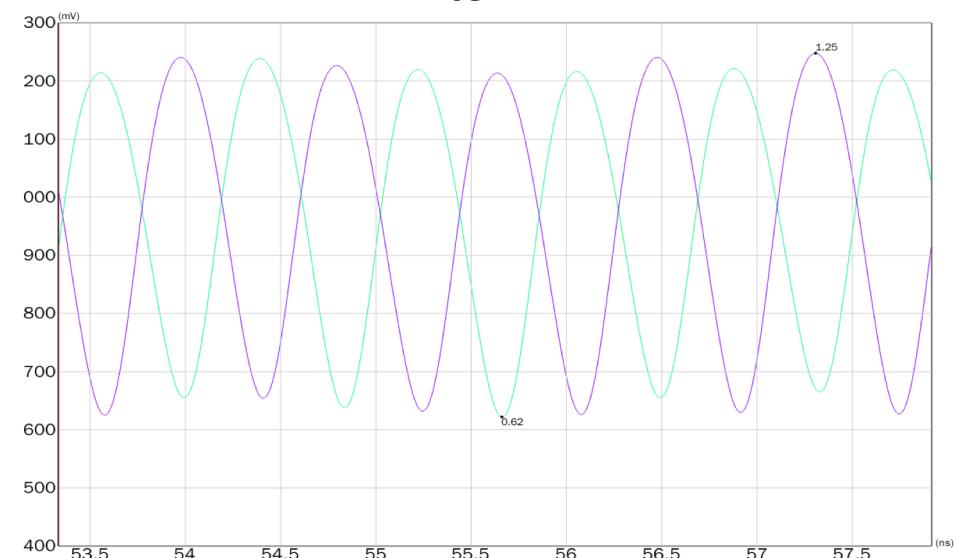


DQS信号波形图 -- Byte0

Read

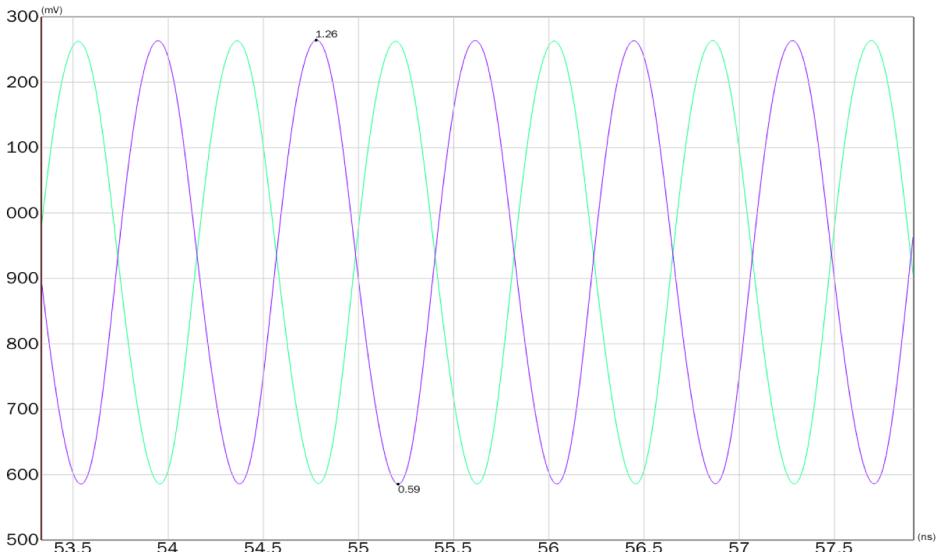


Write

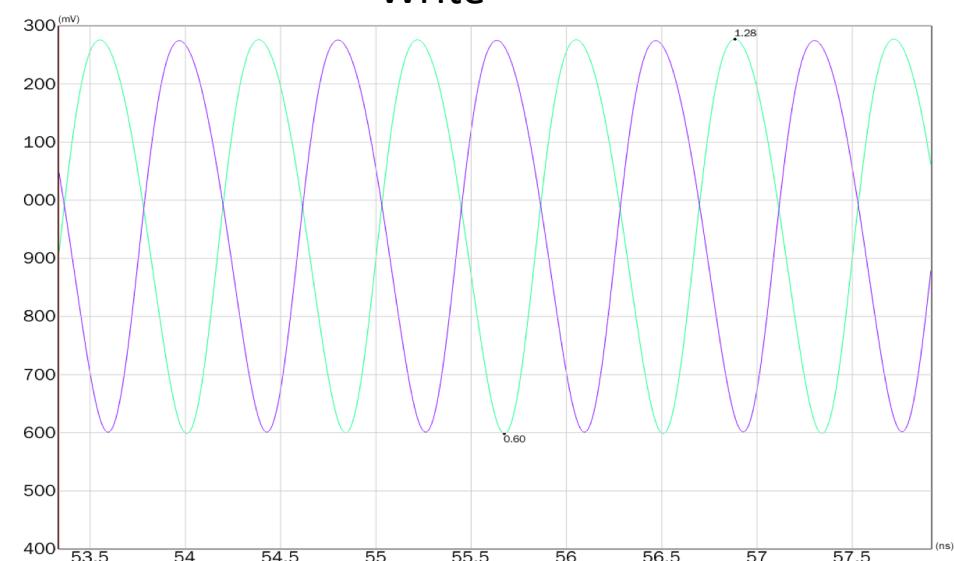


DQS信号波形图 -- Byte1

Read



Write



数据信号时序

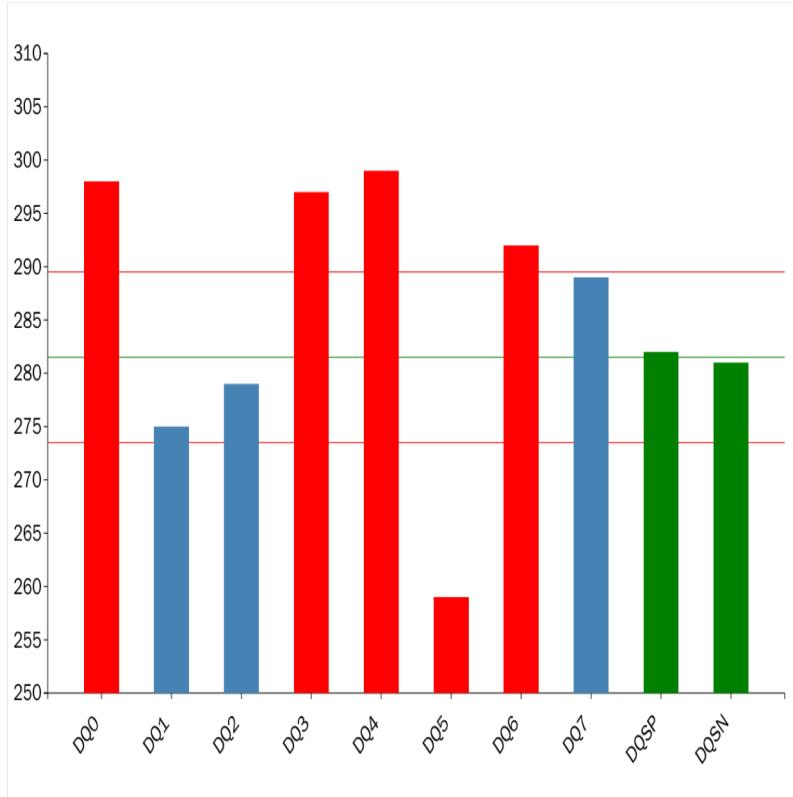
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Setup/Hold Timing Margin表 - Byte[0,1]

| Byte | Net Name | 读建立时间裕度(ps) | 读保持时间裕度(ps) | 写建立时间裕度(ps) | 写保持时间裕度(ps) |
|------|----------|-------------|-------------|-------------|-------------|
| 0 | NET276 | 64 | 140 | 16 | 123 |
| | NET289 | 93 | 118 | 46 | 96 |
| | NET311 | 83 | 123 | 35 | 103 |
| | NET297 | 67 | 142 | 19 | 124 |
| | NET294 | 65 | 138 | 16 | 123 |
| | NET313 | 114 | 103 | 67 | 77 |
| | NET314 | 64 | 138 | 18 | 121 |
| | NET296 | 88 | 124 | 36 | 99 |
| 1 | NET279 | 92 | 120 | 51 | 95 |
| | NET310 | 89 | 119 | 48 | 94 |
| | NET280 | 114 | 99 | 72 | 70 |
| | NET288 | 62 | 142 | 19 | 120 |
| | NET278 | 87 | 109 | 45 | 89 |
| | NET292 | 96 | 114 | 56 | 87 |
| | NET302 | 103 | 109 | 60 | 81 |
| | NET312 | 95 | 117 | 52 | 93 |

DQ/DQS信号Delay和Skew - Byte 0

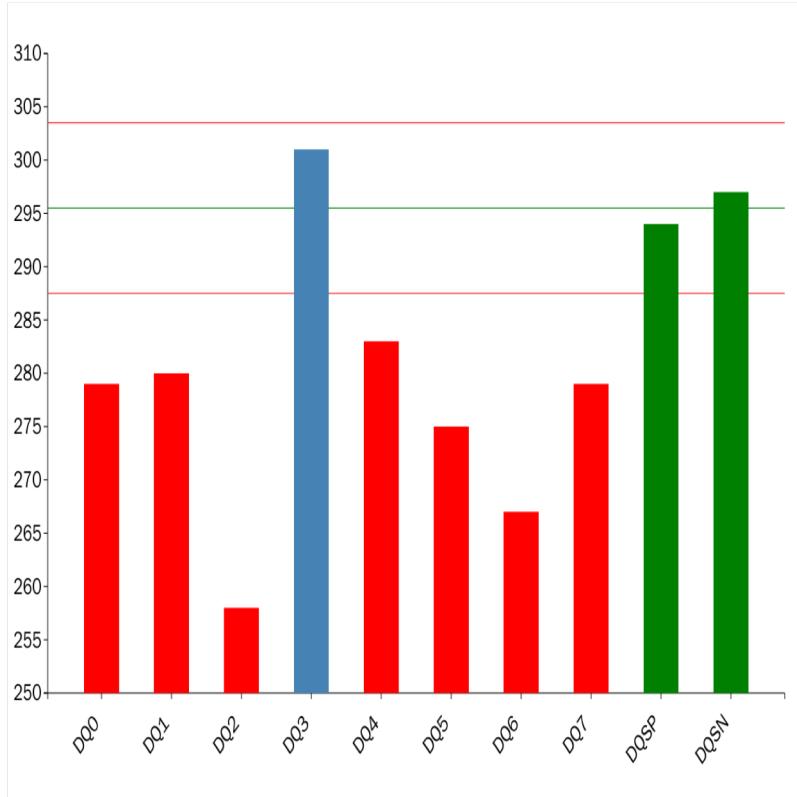
(单位:ps)



| 信号名 | Net Names | Delay | Skew | 标称值 | Net Vias |
|------|-----------|-------|------|-----|----------|
| DQ0 | NET276 | 298 | 16.5 | 8 | 3 |
| DQ1 | NET289 | 275 | 6.5 | 8 | 2 |
| DQ2 | NET311 | 279 | 2.5 | 8 | 2 |
| DQ3 | NET297 | 297 | 15.5 | 8 | 3 |
| DQ4 | NET294 | 299 | 17.5 | 8 | 3 |
| DQ5 | NET313 | 259 | 22.5 | 8 | 0 |
| DQ6 | NET314 | 292 | 10.5 | 8 | 2 |
| DQ7 | NET296 | 289 | 7.5 | 8 | 2 |
| DQSP | NET308 | 282 | | | |
| DQSN | NET303 | 280 | | | |

DQ/DQS信号Delay和Skew - Byte 1

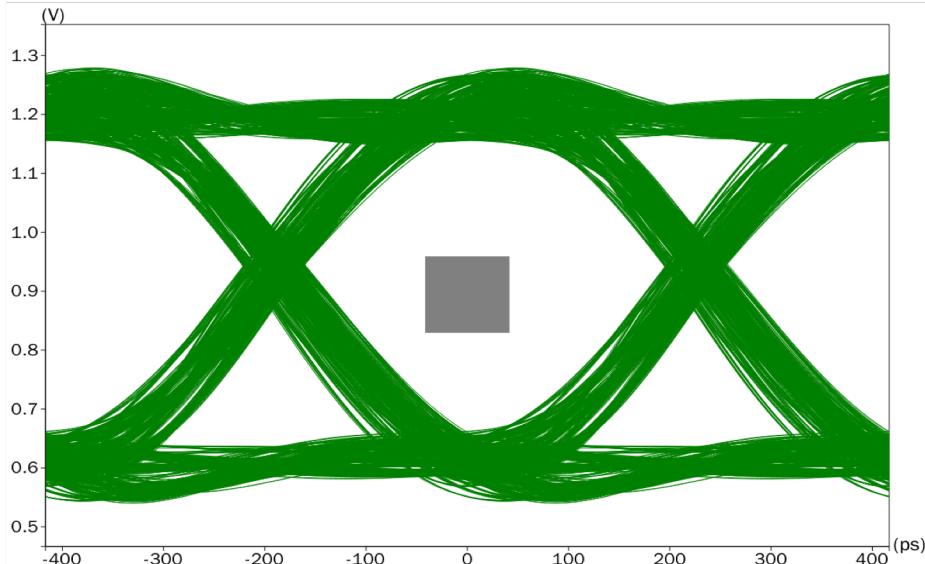
(单位:ps)



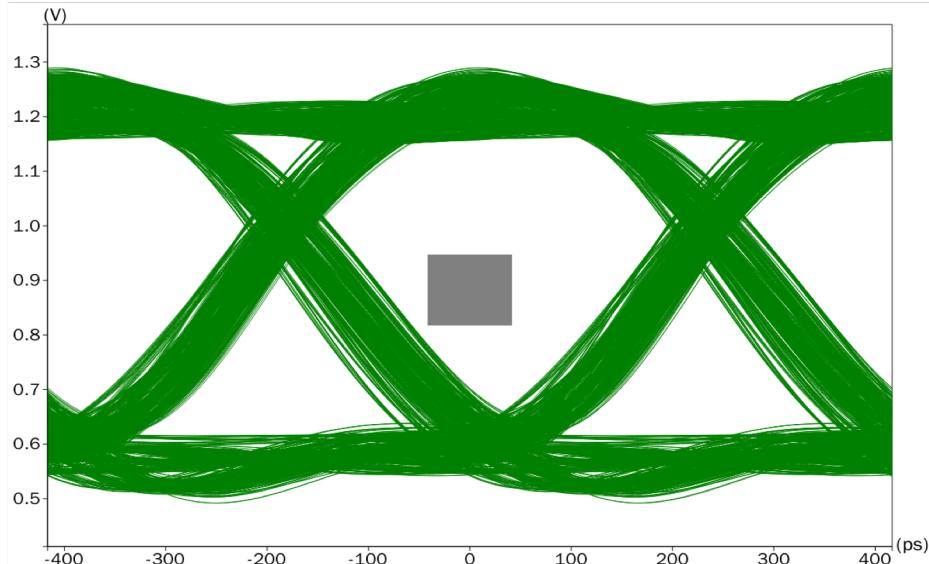
| 信号名 | Net Names | Delay | Skew | 标称值 | Net Vias |
|------|-----------|-------|------|-----|----------|
| DQ0 | NET279 | 279 | 16.5 | 8 | 2 |
| DQ1 | NET310 | 280 | 15.5 | 8 | 2 |
| DQ2 | NET280 | 258 | 37.5 | 8 | 0 |
| DQ3 | NET288 | 301 | 5.5 | 8 | 3 |
| DQ4 | NET278 | 283 | 12.5 | 8 | 2 |
| DQ5 | NET292 | 275 | 20.5 | 8 | 2 |
| DQ6 | NET302 | 267 | 28.5 | 8 | 0 |
| DQ7 | NET312 | 279 | 16.5 | 8 | 2 |
| DQSP | NET271 | 294 | | | |
| DQSN | NET270 | 296 | | | |

眼图 - Byte 0

Read



Write

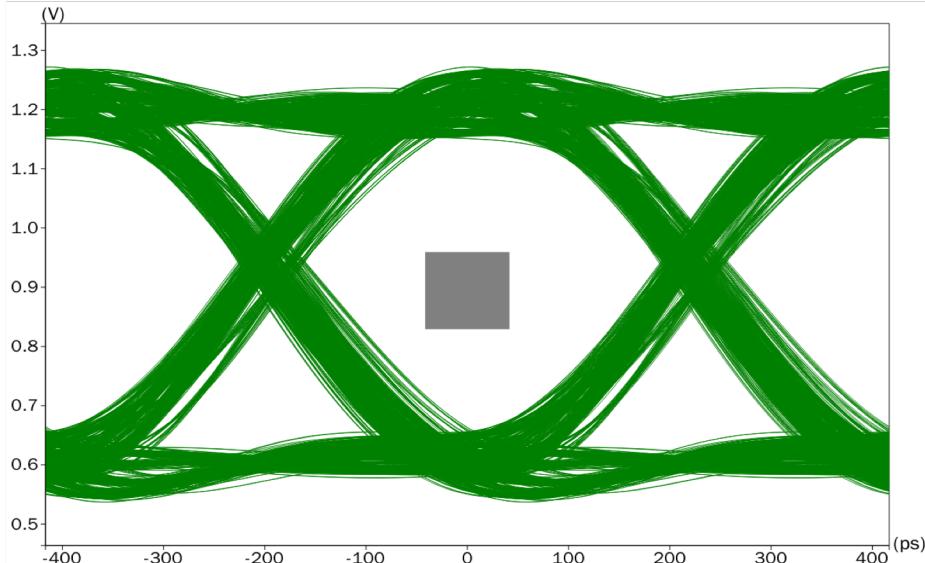


| | |
|------------|-----|
| 眼宽(ps) | 309 |
| 眼高(mv) | 427 |
| 抖动(ps) | 71 |
| 顶部裕度(mv) | 181 |
| 底部裕度(mv) | 115 |
| 建立时间裕度(ps) | 64 |
| 保持时间裕度(ps) | 103 |

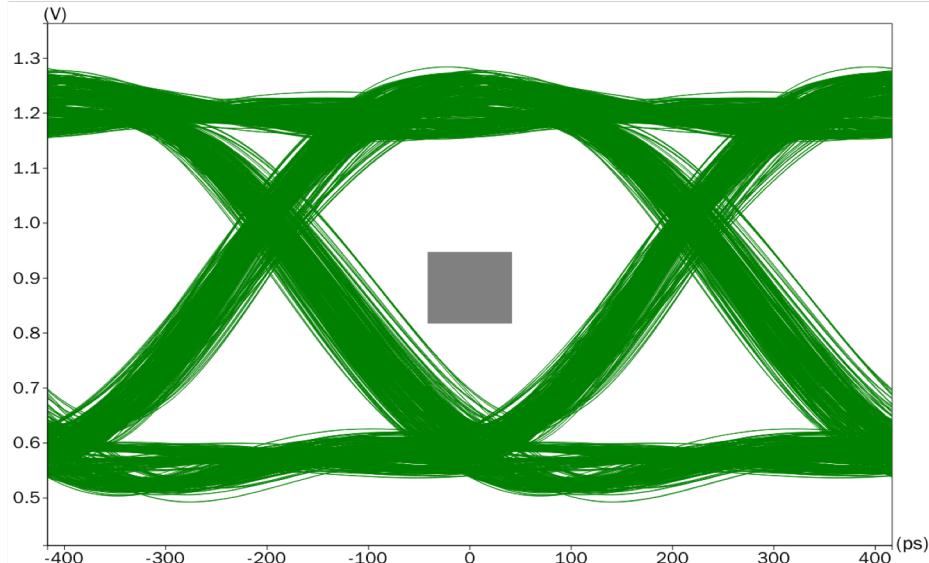
| | |
|------------|-----|
| 眼宽(ps) | 233 |
| 眼高(mv) | 371 |
| 抖动(ps) | 143 |
| 顶部裕度(mv) | 205 |
| 底部裕度(mv) | 36 |
| 建立时间裕度(ps) | 16 |
| 保持时间裕度(ps) | 77 |

眼图 - Byte 1

Read



Write



| | |
|------------|-----|
| 眼宽(ps) | 304 |
| 眼高(mv) | 424 |
| 抖动(ps) | 76 |
| 顶部裕度(mv) | 181 |
| 底部裕度(mv) | 112 |
| 建立时间裕度(ps) | 62 |
| 保持时间裕度(ps) | 99 |

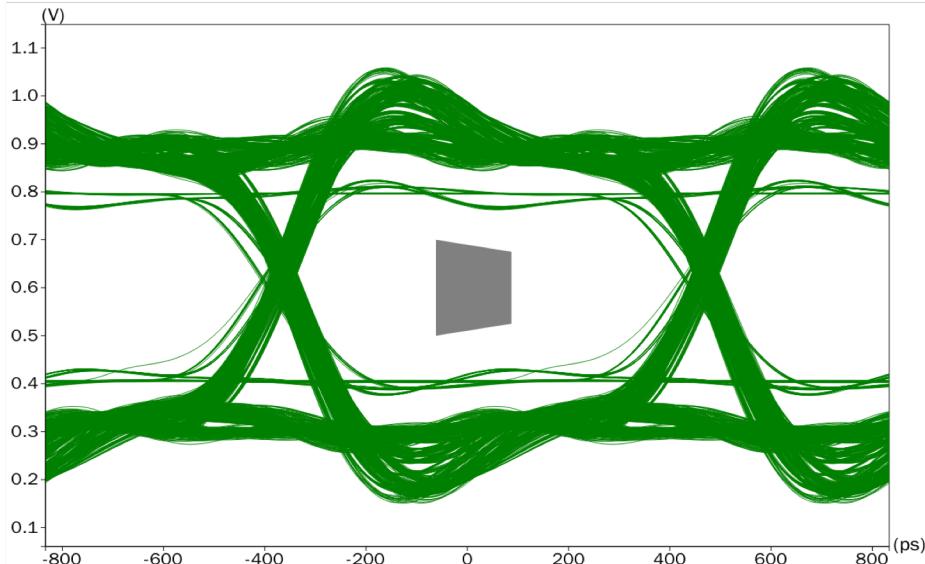
| | |
|------------|-----|
| 眼宽(ps) | 227 |
| 眼高(mv) | 376 |
| 抖动(ps) | 144 |
| 顶部裕度(mv) | 205 |
| 底部裕度(mv) | 41 |
| 建立时间裕度(ps) | 19 |
| 保持时间裕度(ps) | 70 |

Address/Command 信号时序

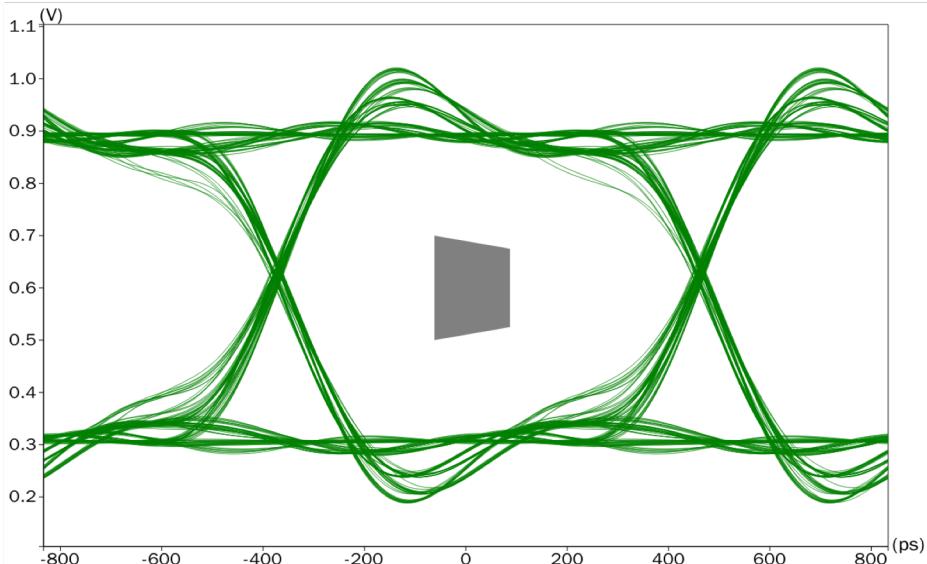
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眼图 - [U2]

Address



Commands



| | |
|------------|-----|
| 眼宽(ps) | 786 |
| 眼高(mv) | 527 |
| 抖动(ps) | 47 |
| 顶部裕度(mv) | 161 |
| 底部裕度(mv) | 166 |
| 建立时间裕度(ps) | 247 |
| 保持时间裕度(ps) | 313 |

| | |
|------------|-----|
| 眼宽(ps) | 785 |
| 眼高(mv) | 534 |
| 抖动(ps) | 48 |
| 顶部裕度(mv) | 163 |
| 底部裕度(mv) | 171 |
| 建立时间裕度(ps) | 244 |
| 保持时间裕度(ps) | 304 |