MIPI Timing计算说明

概述

MIPI的Time参数和协议波形的对应关系
MIPI 分辨率动态切换时间参数说明
MIPI HS 与 LP状态切换
MIPI Data Line 和 Clock Line开销计算
MIPI 数据净荷传输时间计算
MIPI Tvsp Tvfp Tvbp参数说明
MIPI Thsp Thfp Thbp参数计算说明及实例

参考文档

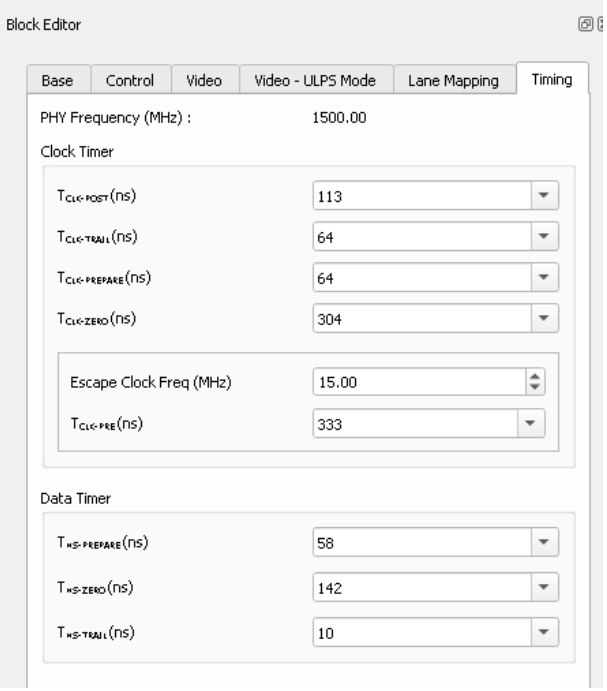
- MIPI Utility.xls
- AN 015: Designing with the Trion®MIPI Interface.pdf
- MIPI-CSI-2协议介绍.ppt

MIPI的Time参数

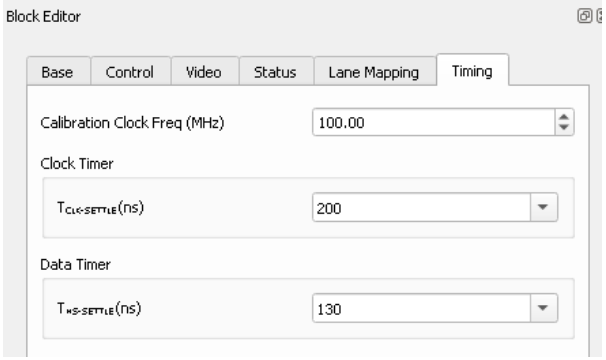
- MIPITx
  - Clk-Lane/Data-Lane — F_{EscClk} (T_{LPX})
  - Clk-Lane — $T_{CLK\text{-}Trail}$ $T_{CLK\text{-}Prepare}$ $T_{CLK\text{-}Zero}$
  - Data-Lane — $T_{HS\text{-}Trail}$ $T_{HS\text{-}Prepare}$ $T_{HS\text{-}Zero}$
  - Clk-Lane — $T_{CLK\text{-}Pre}$
  - Clk-Lane — $T_{CLK\text{-}Post}$
- MIPIRX
  - Clk-Lane — $T_{CLK\text{-}Settle}$
  - Data-Lane — $T_{HS\text{-}Settle}$

MIPI Timing参数

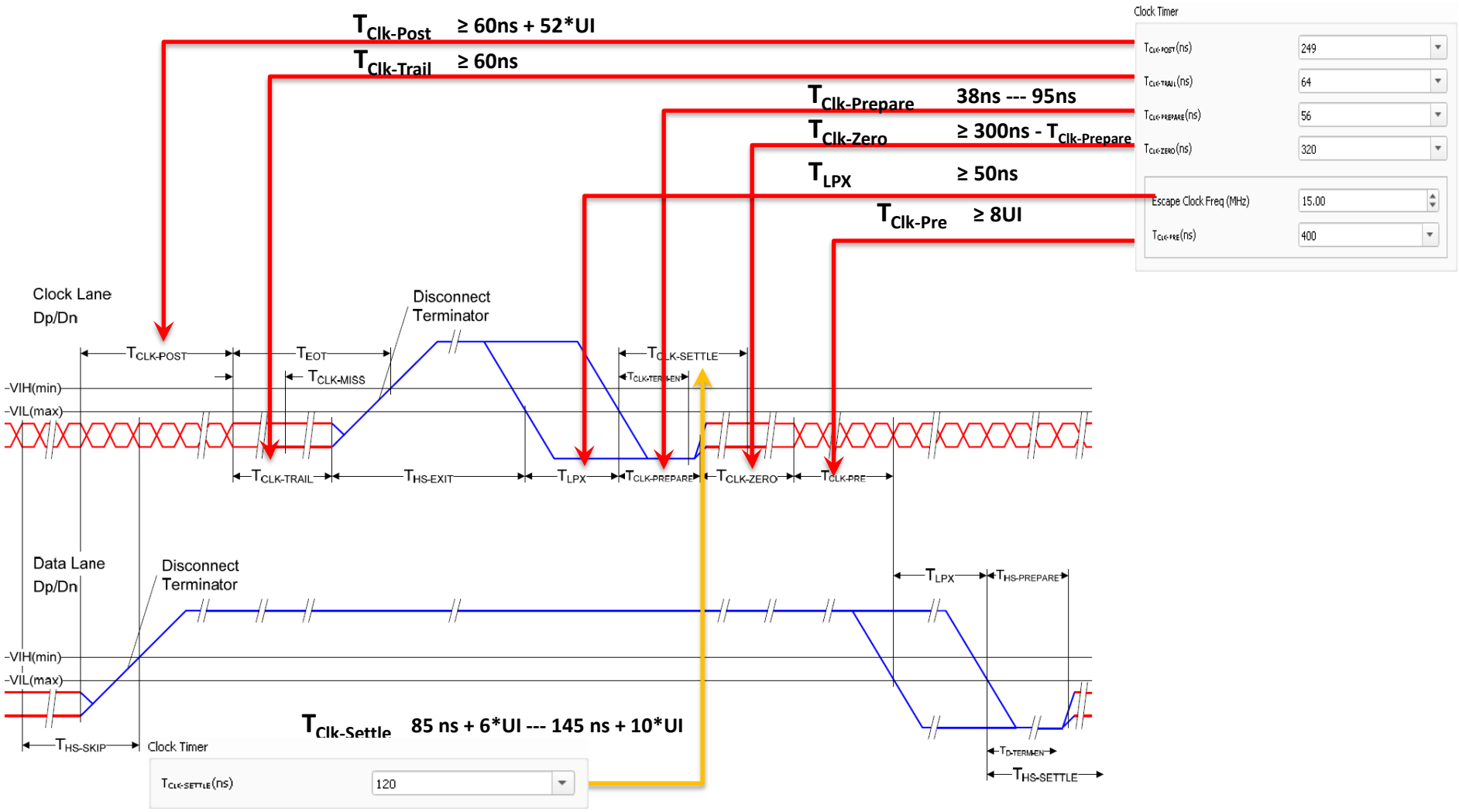
- MIPI发送有9个参数需要设定



- MIPI接收有2个参数需要设定



MIPI时钟定时参数和MIPI波形对应关系

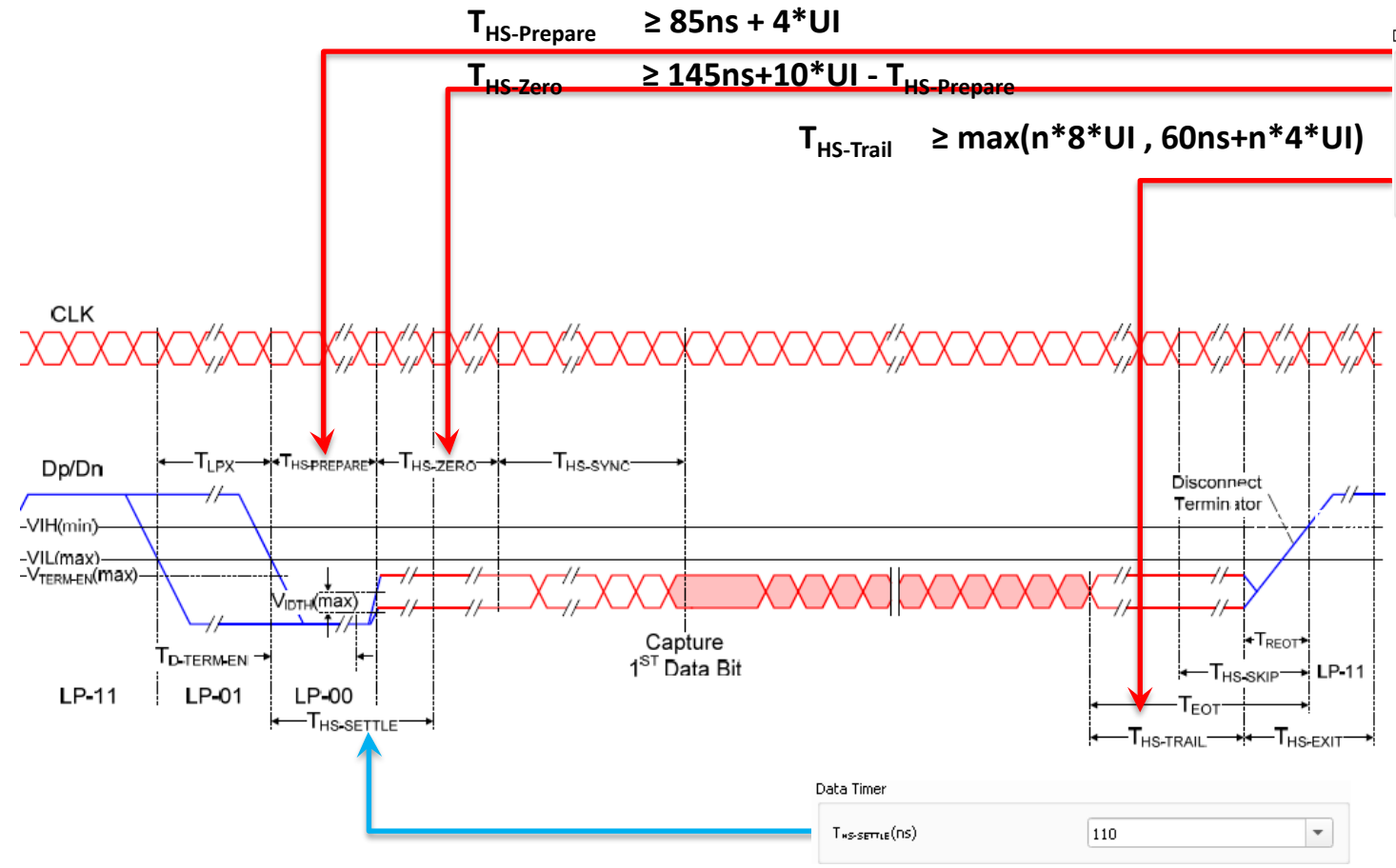


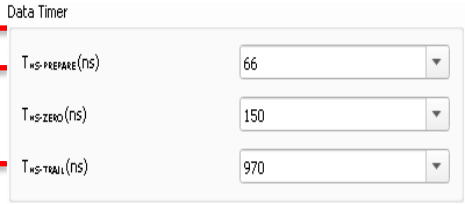
MIPI数据定时参数与MIPI波形对应关系

$T_{HS\text{-}Prepare}$ ≥ 85ns + 4*UI

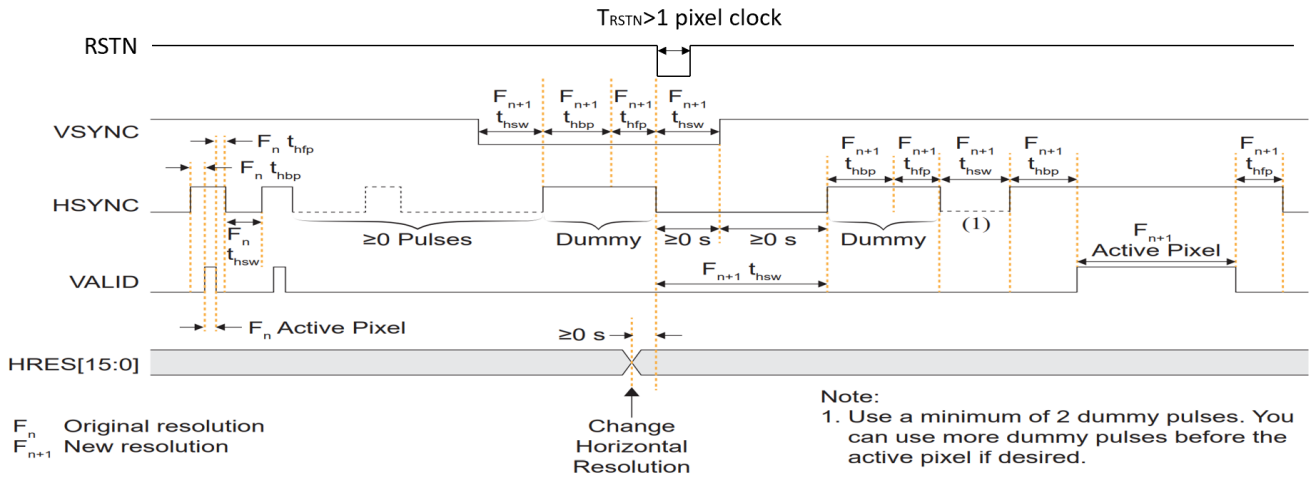
$T_{HS\text{-}Zero}$ ≥ 145ns+10*UI - $T_{HS\text{-}Prepare}$

$T_{HS\text{-}Trail}$ ≥ max(n*8*UI , 60ns+n*4*UI)



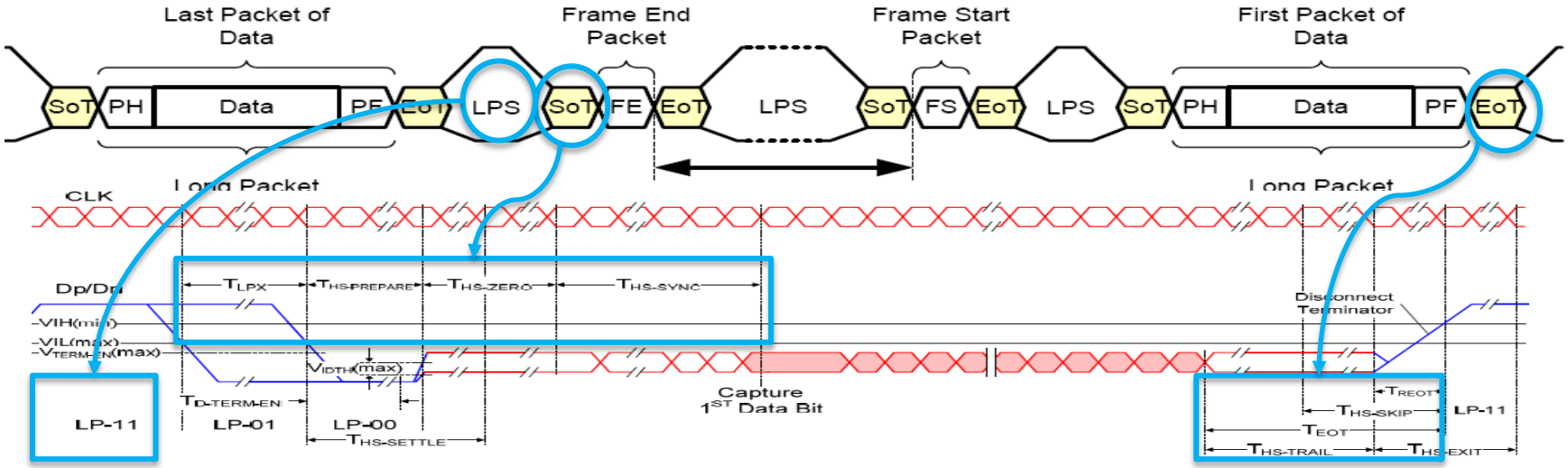


MIPI 分辨率动态切换时间参数说明



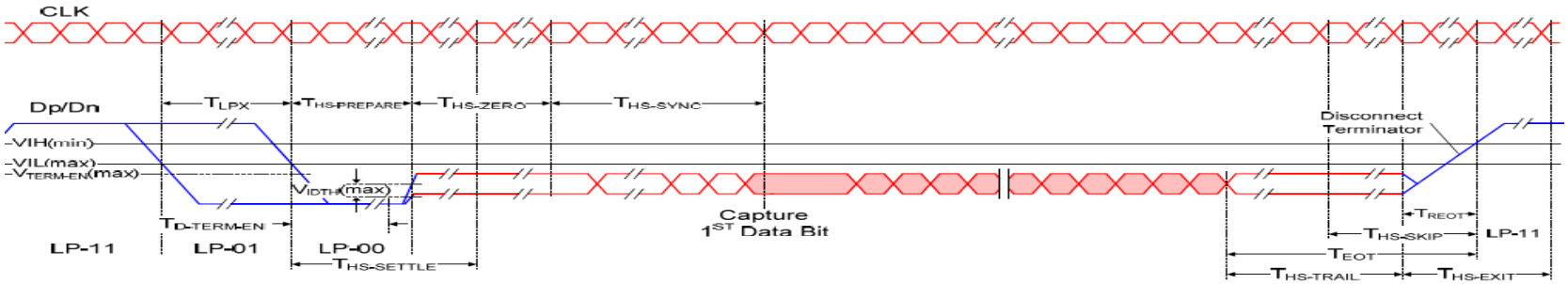
- MIPI TX分辨率进行动态切换需满足上图时序
  - 要进行分辨率动态切换Tvsp需大于2个banking line
  - 在VSYNC low 状态持续时间大于Thsp后改变行像素参数HRES[15:0]
  - 在HRES[15:0]改变大于1个pixel clock 时间后 RSTN low，仅复位MIPI CSI
  - RSTN low 时间大于1个Pixel clock

MIPI底层协议说明



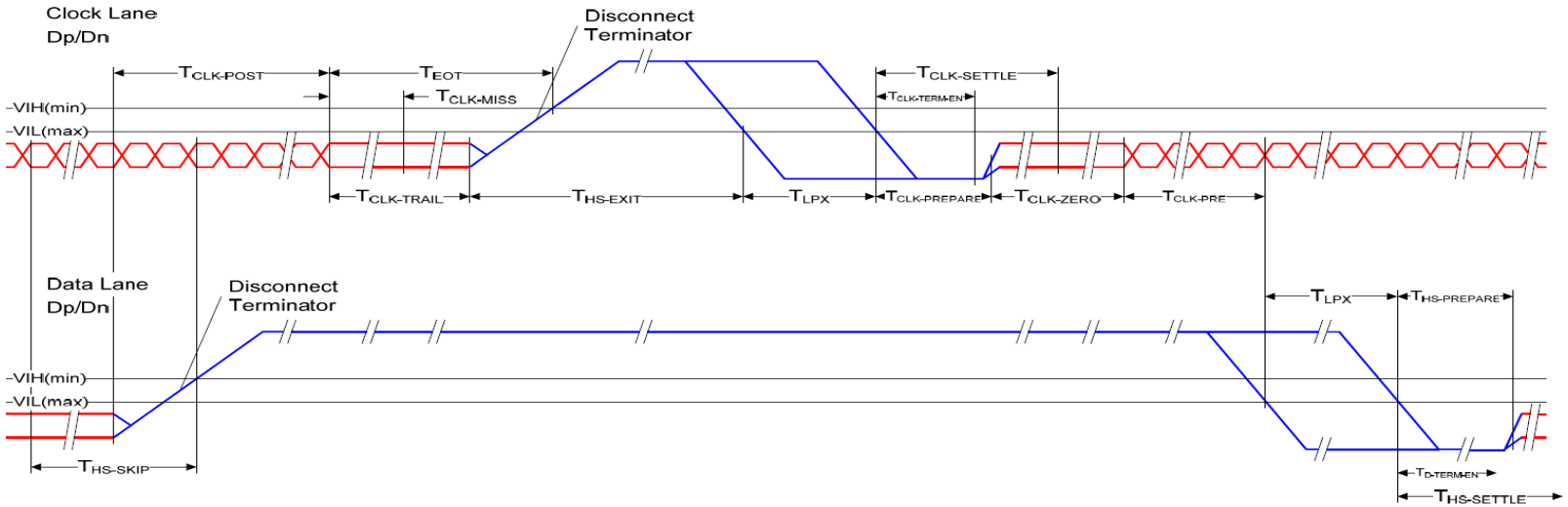
- MIPI的底层协议（LLP）是一个面向字节的，基于包的协议；它支持任意大小的数据通过短包和长包格式传输。各个包之间由EOT-LPS-SOT序列隔开；
  - EoT是由HS-Trail + LP上升时间组成；
  - SoT是由LP-01 + HS-Prepare + HS-Zero + HS-Sync 组成
  - LPS就是LP-11——LP模式且两个信号都为高；
- 在两个SoT和EoT之间采用HS模式传输数据；数据包括：
  - Short Framer （短帧）用于FS（Framer Start）、FE（Framer End）、LS（Line Start）、LE（Line End）；
  - 长帧用于传输数据；数据包含
    - PH（Packet Head，32Bit）；
    - 净负荷；
    - PF（Packet Footer，16Bit）

MIPI data lane工作状态切换



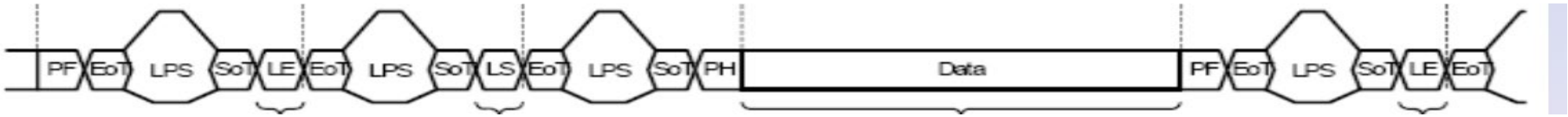
- 从LP -> HS状态
  - 从LP-11---LP-01,HS-Rqst持续TLPX时间
  - 进入LP-00状态持续THS-PREPARE时间
  - 使能HS 关闭LP，进入HS-0持续THS-ZERO时间
  - 发送HS SYNC-Seq ‘00011101’
  - 持续发送HS数据
- 从HS -> LP状态
  - 传输完最后的数据后保持THS-TRAIL时间
  - 关闭 HS-TX 使能LP-TX，进入LP-11状态保持THS-EXIT时间

MIPI clock lane工作状态切换



- Clk lane – HS -----> LP
  - 在所有data lane进入LP模式后，时钟运行$T_{clk\text{-}post}$时间后，以HS-0状态结束
  - 在HS-0状态保持$T_{clk\text{-}trail}$时间
  - CLK Lane 从HS-TX状态到LP-TX状态，直到进入LP-11状态，需要$T_{HS\text{-}EXIT}$
- Clk lane – LP -----> HS
  - 从LP-11 → LP-01,在LP-01状态持续T_{LPX}时间
  - 从LP-01 → LP-00,需要Tclk-prepare时间
  - HS使能，LP不使能，在HS-0状态持续Tclk-zero时间
  - 在任何一个data lane转到HS之前，CLK-HS保持 Tclk-pre时间

一行数据在Data lane各个开销计算



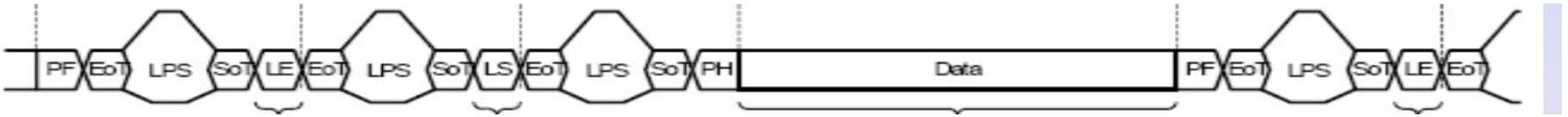
- SoT = $T_{LP} + T_{HS\text{-}prepare} + T_{HS\text{-}ZERO} + T_{HS\text{-}SYNC}$
- LPS = $T_{escape\text{-}clk}$
- EoT = $T_{HS\text{-}TRAIL} + T_{HS\text{-}EXIT}$
- LS = (1/ (DHY-Freq * LaneNum)) * ShortFrameLen
- LE = (1/ (DHY-Freq * LaneNum)) * ShortFrameLen

Frame mode =1
才有的开销

$T_{HS\text{-}SYNC}$ = (1/ (DHY-Freq) * 8
8bit HS-SYNC-Sequence ‘00011101’

$T_{HS\text{-}EXIT}$ = 250ns

一行数据在Data lane行开销计算



Frame mode = 0

DataOverhead-0 = SoT + LPS + EoT

Frame mode = 1

DataOverhead-1 = DataOverhead-0 + (SoT + LPS + EoT) * 2 + LS + LE

一行数据在Clock Lane上的开销

在非连续模式下才有以下开销

ClkLaneOverhead

$= T_{LPX} + T_{CLK\text{-}POST} + T_{CLK\text{-}TRAIL} + T_{HS\text{-}EXIT\text{-}CLOCK}$

$+ T_{CLK\text{-}PREPARE} + T_{CLK\text{-}ZERO} + T_{CLK\text{-}PRE} - T_{HS\text{-}EXIT}$

$T_{HS\text{-}EXIT\text{-}CLOCK} = 800ns$

$T_{HS\text{-}EXIT} = 250ns$

一行净荷数据在Data Line传输的时间

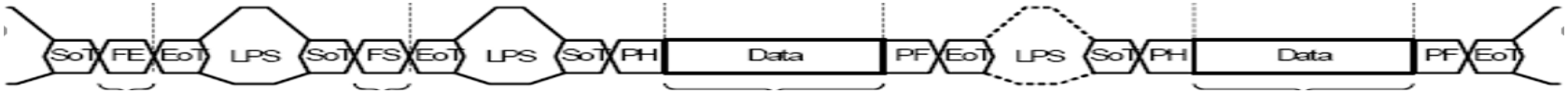
- $T_{DHY\text{-}Hori}$ = (HoriPixelNum* Bit_of_PerPixel)/DHY-Freq/LaneNum

一行净荷数据在Pixel Clock传输的时间

- T_{dvalid} = (HoriPixelNum /PixelNum_of_PerPixelClock) * $T_{pixel\text{-}clk}$

Bit_of_PerPixel: 每个像素的bit数
PixelNum_of_PerPixelClock: 每个pixel clock传多少个像素，详见AN015文档
DHY-Freq: Interface Design中MIPI的DHY Frequency
HoriPixelNum: 行像素

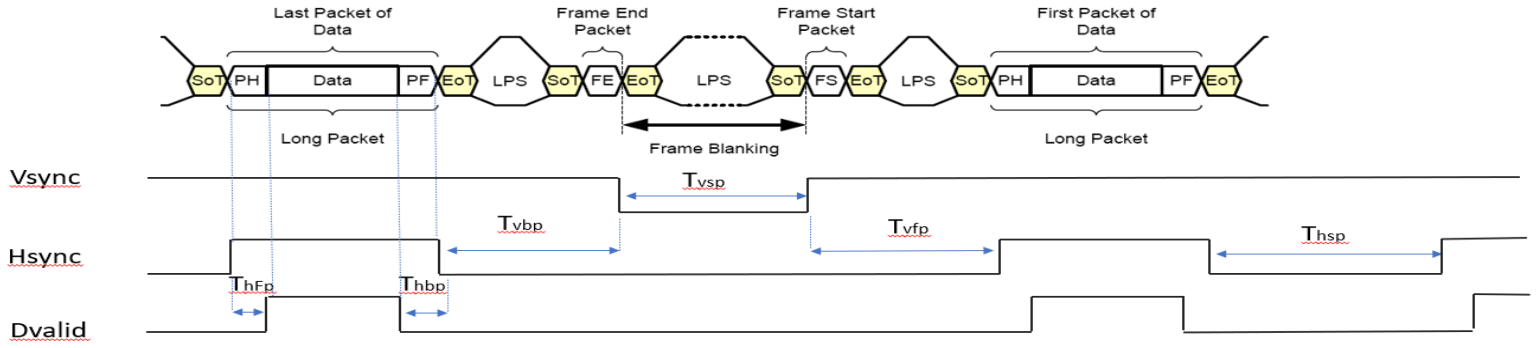
一帧数据在Data lane帧开销计算



- SoT = $T_{LP} + T_{HS\text{-}prepare} + T_{HS\text{-}ZERO} + T_{HS\text{-}SYNC}$
- LPS = $T_{escape\text{-}clk}$
- EoT = $T_{HS\text{-}TRAIL} + T_{HS\text{-}EXIT}$
- FS = (1/ (DHY-Freq * LaneNum)) * ShortFrameLen
- FE = (1/ (DHY-Freq * LaneNum)) * ShortFrameLen

ShortFrameLen: 32bit
DHY-Freq: Interface Design中MIPI的DHY Frequency

Tvsp Tvfp Tvbp计算

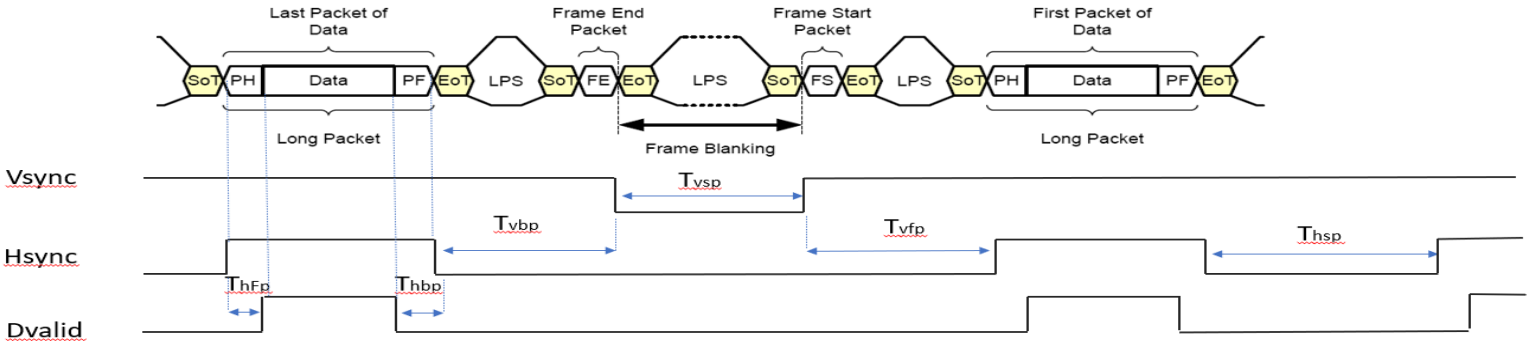


- 根据实测Tvsp,Tvfp,Tvbp的值至少是1个blanking line,以blanking line 为单位增加；
- T-blanking line = $T_{hfp} + T_{hbp} + T_{hsp}$

Enter the video information	
Data type	RAW8
# of data pixels per line	1920
# of data lines per frame	1080
# of blanking lines per frame	3
# of frames per second (Hz)	30
Horizontal blanking per line (us)	10
Pixel clock frequency (MHz)	100

在MIPI Utility 文档中
#of banking lines per frame的最小值为3

Thsp Thfp Thbp计算



- T_{hfp} = PH = 1/(DHY-Preq) *32， 最少2个pixel clock
- T_{hbp} = PF = 1/(DHY-Preq) *16， 最少2个pixel clock

Frame mode = 0

- 连续模式

- T_{hsp} - max = ((1/$T_{pixel-clk}$/(VertPixelNum+ BlankingLineNum)/FrameRate) – (HoriPixelNum/PixelsNum_of_per_PixelClk)) * $T_{pixel-clk}$ ----------单位:ns

- T_{hbp} - min = $T_{DHY-Hori}$ – $T_{pixel-dvalid}$ + DataOverhead-0 ----------单位:ns

- 非连续模式

- T_{hsp} - max = ((1/$T_{pixel-clk}$/(VertPixelNum+ BlankingLineNum)/FrameRate) – (HoriPixelNum/PixelsNum_of_per_PixelClk)) * $T_{pixel-clk}$ ------单位：ns

- T_{hbp} - min = $T_{DHY-Hori}$ – $T_{pixel-dvalid}$ + DataOverhead-0 + ClkLaneOverhead -------单位: ns

Bit_of_PerPixel: 每个像素的bit数
PixelNum_of_PerPixelClock: 每个pixel clock传多少个像素，详见AN015文档
DHY-Freq: Interface Design中MIPI的DHY Frequency
HoriPixelNum: 行像素
VertPixelNum: 行像素
$T_{pixel-clk}$: 1/Pixel_clk
FrameRate: DHY-Freq * Lane_num

Frame mode = 1

- 连续模式

- T_{hsp} - max = ((1/$T_{pixel-clk}$/(VertPixelNum+ BlankingLineNum)/FrameRate) – (HoriPixelNum/PixelsNum_of_per_PixelClk)) * $T_{pixel-clk}$ ----------单位:ns
- T_{hbp} - min = $T_{DHY-Hori}$ – Tpixel-dvalid + DataOverhead-1 ----------单位:ns

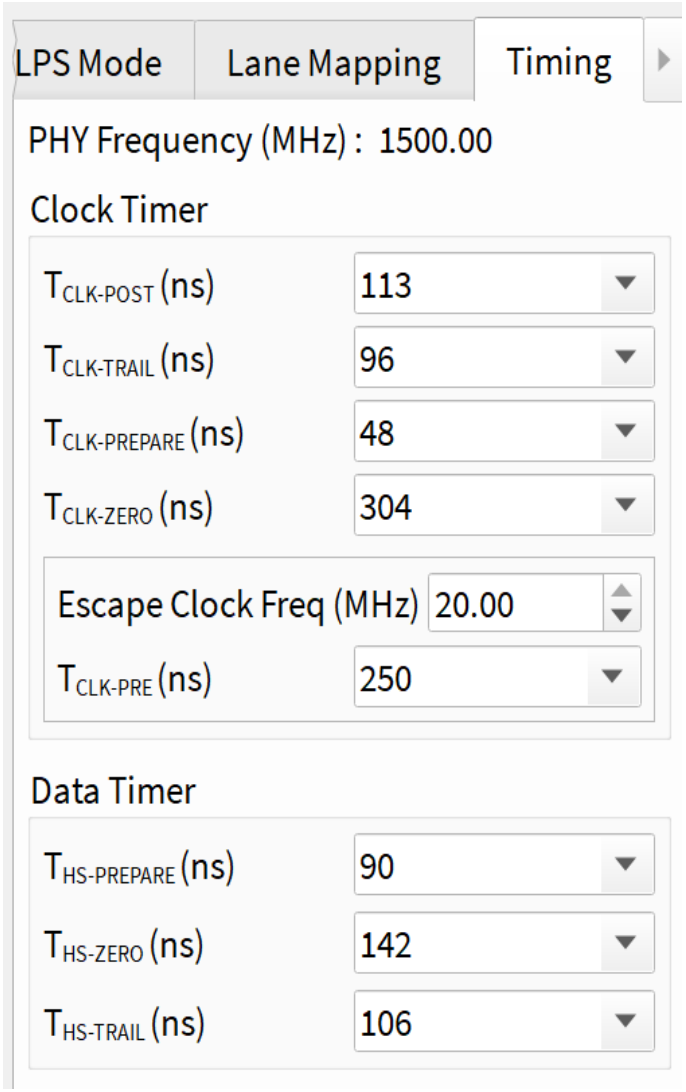
- 非连续模式

- T_{hsp} - max = ((1/$T_{pixel-clk}$/(VertPixelNum+ BlankingLineNum)/FrameRate) – (HoriPixelNum/PixelsNum_of_per_PixelClk)) * $T_{pixel-clk}$ ------单位：ns
- T_{hbp} - min = $T_{DHY-Hori}$ – Tpixel-dvalid + DataOverhead-1 + ClkLaneOverhead -------单位: ns

Bit_of_PerPixel: 每个像素的bit数
PixelNum_of_PerPixelClock: 每个pixel clock传多少个像素，详见AN015文档
DHY-Freq: Interface Design中MIPI的DHY Frequency
HoriPixelNum: 行像素
VertPixelNum: 行像素
$T_{pixel-clk}$: 1/Pixel_clk
FrameRate: DHY-Freq * Lane_num

以下面一组参数为例

- 1920x1080@30 RAW 8
- Frame mode = 0
- Lane num = 1
- Blanking Lines of per frame = 3
- Pixel clock　100Mhz
- DHY-Freq　连续模式 1500Mhz
- Escape clock 20Mhz



- SoT = $T_{LP} + T_{HS\text{-}prepare} + T_{HS\text{-}ZERO} + T_{HS\text{-}SYNC}$ = 287.3ns
  - T_{LP} = 50ns
  - $T_{HS\text{-}prepare}$ = 90ns
  - $T_{HS\text{-}ZERO}$ = 142ns
  - $T_{HS\text{-}SYNC}$ = (1/1500M) X 8 = 5.3ns
- LPS = 50ns
- EoT = $T_{HS\text{-}TRAIL} + T_{HS\text{-}EXIT}$ = 106+250 = 356ns
- DataOverhead-0 = 693.3ns
- $T_{DHY\text{-}Hori}$ = (1920x8)/1500Mhz/1 = 10.24us
- T_{dvalid} = (1920/8) *10ns = 2400ns

T_{hsp} --min = $T_{DHY-Hori}$ – T_{dvalid} + DataOverhead-0

- Thsp--min = 10.24us – 2400ns + 693.3

  约等于 8533.3ns -----> 853个pixel clock

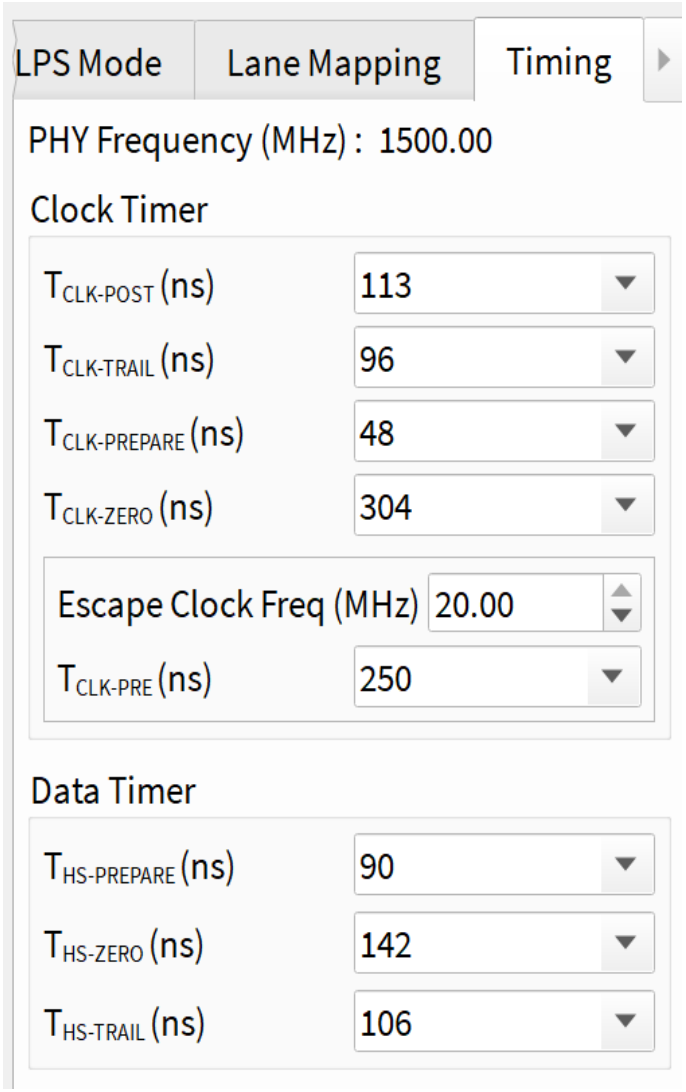
Thsp - max =((1/Tpixel-clk/(VertPixelNum+ BlankingLineNum)/FrameRate) – (HoriPixelNum/PixelsNum_of_per_PixelClk)) * Tpixel-clk

- Thsp -- max = (100000000/(1080+3)/30) –(1920/8)= 2837.87 * 10ns = 28378.7ns
  - 约等于28378.7ns ----> 2837.8个 pixel clock

- 853 pixel clock ≤ Thsp ≤ 2837.8 pixel clock

以下面一组参数为例

- 1920x1080@30 RAW 8
- Frame mode = 1
- Lane num = 1
- Blanking Lines of per frame = 3
- Pixel clock　100Mhz
- DHY-Freq　连续模式 1500Mhz
- Escape clock 20Mhz



- SoT = $T_{LP} + T_{HS\text{-}prepare} + T_{HS\text{-}ZERO} + T_{HS\text{-}SYNC}$ = 287.3ns
  - T_{LP} = 50ns
  - $T_{HS\text{-}prepare}$ = 90ns
  - $T_{HS\text{-}ZERO}$ = 142ns
  - $T_{HS\text{-}SYNC}$ = (1/1500M) X 8 = 5.3ns
- LPS = 50ns
- EoT = $T_{HS\text{-}TRAIL} + T_{HS\text{-}EXIT}$ = 106+250 = 356ns
- DataOverhead-1 = 2122.5ns
- $T_{DHY\text{-}Hori}$ = (1920x8)/1500Mhz/1 = 10.24us
- T_{dvalid} = (1920/8) *10ns = 2400ns

T_{hsp} --min = $T_{DHY-Hori}$ – T_{dvalid} + DataOverhead-1

- Thsp--min = 10.24us – 2400ns + 2122.5ns

  约等于 9962.5ns -----> 997个pixel clock

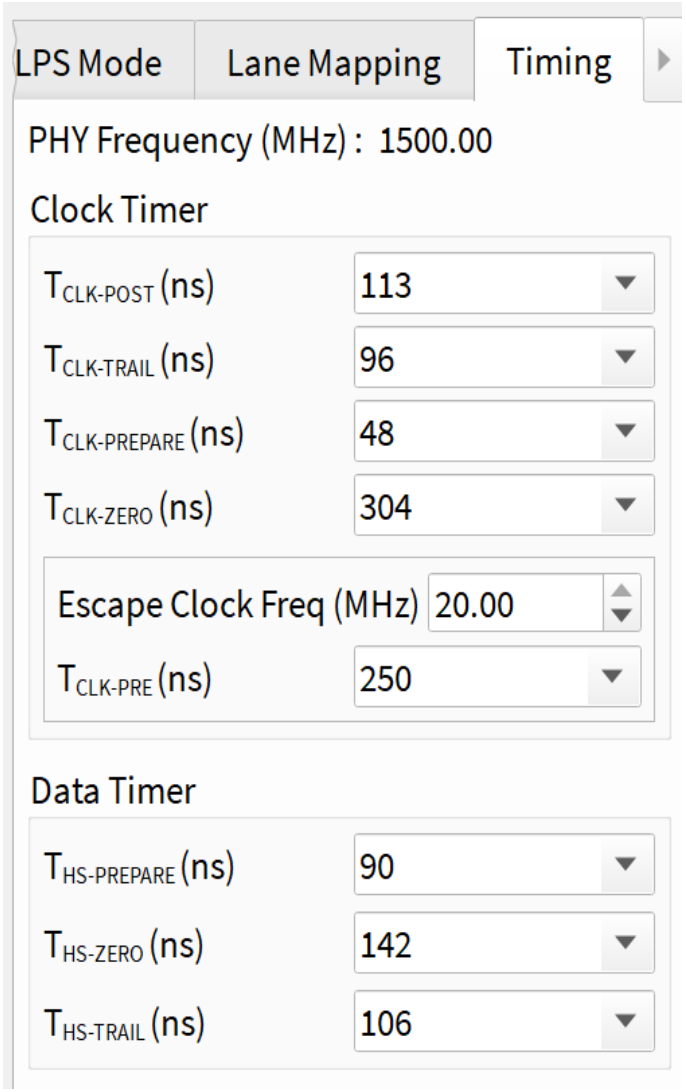
Thsp - max =((1/Tpixel-clk/(VertPixelNum+ BlankingLineNum)/FrameRate) – (HoriPixelNum/PixelsNum_of_per_PixelClk)) * Tpixel-clk

- Thsp -- max = (100000000/(1080+3)/30) –(1920/8)= 2837.87 * 10ns = 28378.7ns
  - 约等于28378.7ns ----> 2837.8个 pixel clock

- 997 pixel clock ≤ Thsp ≤ 2837.8 pixel clock

以下面一组参数为例

- 1920x1080@30 RAW 8
- Frame mode = 0
- Lane num = 1
- Blanking Lines of per frame = 3
- Pixel clock　　100Mhz
- DHY-Freq 非连续模式 1500Mhz
- Escape clock 20Mhz



- SoT = $T_{LP} + T_{HS\text{-}prepare} + T_{HS\text{-}ZERO} + T_{HS\text{-}SYNC}$ = 287.3ns
  - T_{LP} = 50ns
  - $T_{HS\text{-}prepare}$ = 90ns
  - $T_{HS\text{-}ZERO}$ = 142ns
  - $T_{HS\text{-}SYNC}$ = (1/1500M) X 8 = 5.3ns
- LPS = 50ns
- EoT = $T_{HS\text{-}TRAIL} + T_{HS\text{-}EXIT}$ = 106+250 = 356ns
- DataOverhead-0 = 693.3ns
- ClkLaneOverhead = 1411ns
- $T_{DHY\text{-}Hori}$ = (1920x8)/1500Mhz/1 = 10.24us
- T_{dvalid} = (1920/8) *10ns = 2400ns

T_{hsp} --min = $T_{DHY\text{-}Hori}$ – T_{dvalid} + DataOverhead-0 + ClkLaneOverhead

- Thsp--min = 10.24us – 2400ns + 693.3ns + 1411ns

  约等于 9944.3ns -----> 995个pixel clock

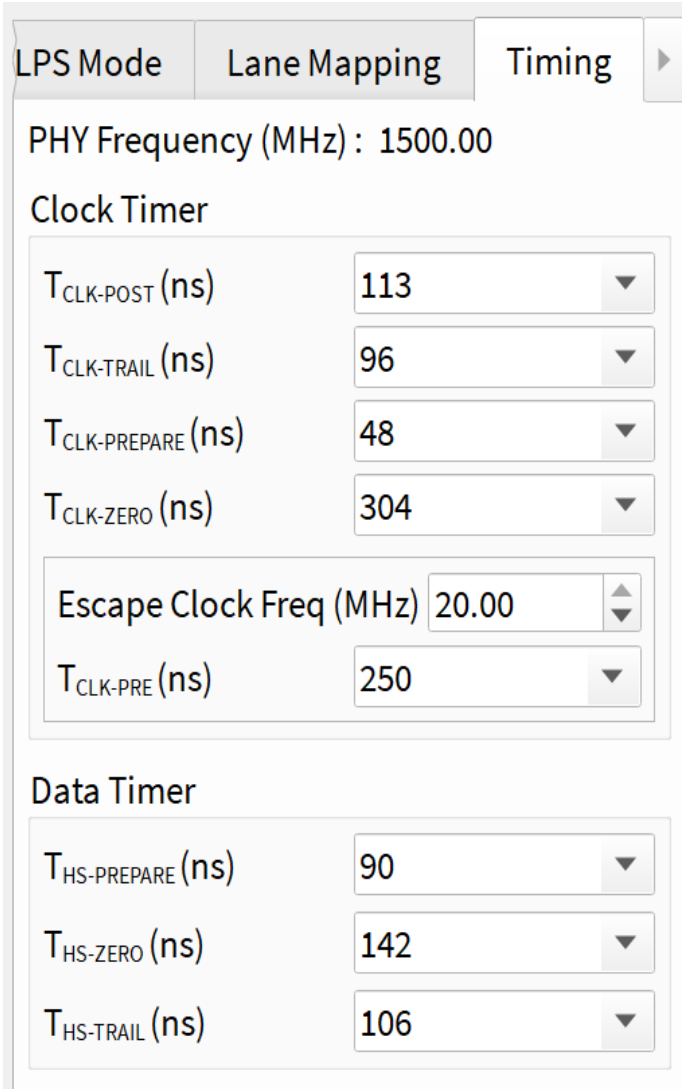
Thsp - max =((1/Tpixel-clk/(VertPixelNum+ BlankingLineNum)/FrameRate) – (HoriPixelNum/PixelsNum_of_per_PixelClk)) * Tpixel-clk

- Thsp -- max = (100000000/(1080+3)/30) –(1920/8)= 2837.87 * 10ns = 28378.7ns
  - 约等于28378.7ns ----> 2837.8个 pixel clock

- 995 pixel clock ≤ Thsp ≤ 2837.8 pixel clock

以下面一组参数为例

- 1920x1080@30 RAW 8
- Frame mode = 1
- Lane num = 1
- Blanking Lines of per frame = 3
- Pixel clock　100Mhz
- DHY-Freq 非连续模式 1500Mhz
- Escape clock 20Mhz



- SoT = $T_{LP} + T_{HS\text{-}prepare} + T_{HS\text{-}ZERO} + T_{HS\text{-}SYNC}$ = 287.3ns
  - T_{LP} = 50ns
  - $T_{HS\text{-}prepare}$ = 90ns
  - $T_{HS\text{-}ZERO}$ = 142ns
  - $T_{HS\text{-}SYNC}$ = (1/1500M) X 8 = 5.3ns
- LPS = 50ns
- EoT = $T_{HS\text{-}TRAIL} + T_{HS\text{-}EXIT}$ = 106+250 = 356ns
- DataOverhead-1 = 2122.5ns
- ClkLaneOverhead = 1411ns
- $T_{DHY\text{-}Hori}$ = (1920x8)/1500Mhz/1 = 10.24us
- T_{dvalid} = (1920/8) *10ns = 2400ns

T_{hsp} --min = $T_{DHY\text{-}Hori}$ – T_{dvalid} + DataOverhead-1 + ClkLaneOverhead

- Thsp--min = 10.24us – 2400ns + 2122.5ns + 1411ns
  约等于 11373.5ns -----> 1138个pixel clock

Thsp - max =((1/Tpixel-clk/(VertPixelNum+ BlankingLineNum)/FrameRate) – (HoriPixelNum/PixelsNum_of_per_PixelClk)) * Tpixel-clk

- Thsp -- max = (100000000/(1080+3)/30) –(1920/8)= 2837.87 * 10ns = 28378.7ns
  - 约等于28378.7ns ----> 2837.8个 pixel clock

- 1138 pixel clock ≤ Thsp ≤ 2837.8 pixel clock

谢　谢