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06-267r0 SAS-2 Spread Spectrum Clocking Options

Serial Attached SCSI

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SAS-2 Phy Working Group

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Spread Spectrum Clocking (SSC) Options

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- Four SSC Options Considered
  1) No SSC
  2) Down Spread 5000 ppm
  3) Center spread +/- 2500 ppm
  4) Up spread 5000 ppm
- Need to consider the Advantages and Disadvantages of Each Option
- Assumptions / Background
  - SSC is Highly Desirable and Beneficial in solving EMI issues (HP 06-064r2)
  - 6G SATA will most likely remain Down Spread 0 → -5000ppm (Infineon 06-192r0)
  - Center Spread has implementation advantages (PMC 06-193r0)
  - Multiplexing Legacy drives and Down Spread SSC of the uplink will not work (May Phy. Meeting Discussion)
    - 6G Links with 5000ppm Down Spread SSC do not have the throughput to support two legacy 3G SAS Devices
  - Expanders will remove and or insert aligns as necessary
- Reference Numbers
  - SATA SSC Down Spread Fc →Fc – 5000ppm
  - SATA Align Density 2/256 → Fc – 7812ppm (Sufficient to support 5000ppm down spread SSC and Rate matching)
  - SAS Align Density 2/4096 → Fc – 488ppm (Insufficient to support 5000ppm down spread)
  - SAS Reference Clock Fc +/- 100ppm
  - SATA Reference Clock Fc +/- 350ppm

Buffer Size Calculations

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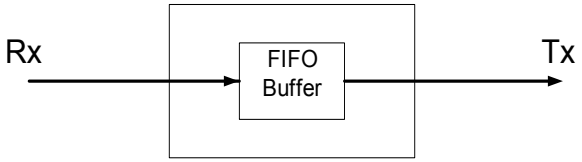
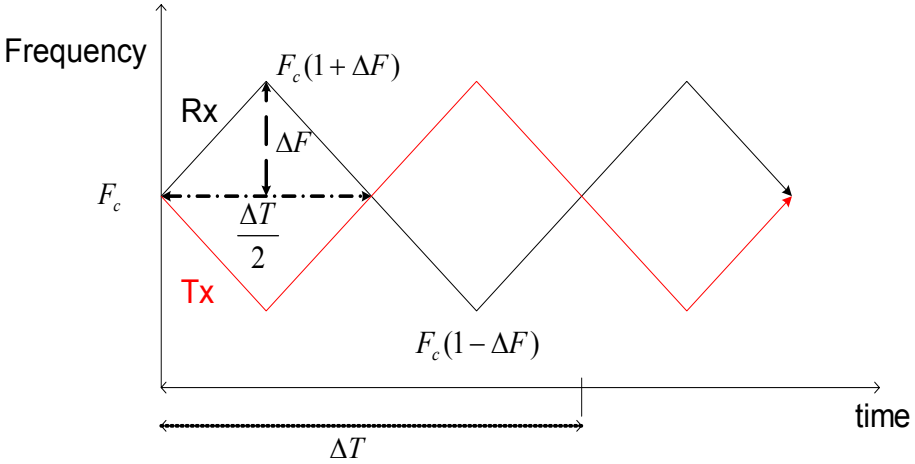
Worst Case Buffer Sizing w/ Sawtooth SSC

- Largest Buffer required when Rx and Tx are 180 out of phase
- Rx at Highest Data Rate and Tx at Slowest Data Rate
- Integrate the frequency Difference to see the Buffer size





Integrated Frequency Difference
over ½ Period at the worst Alignment

$$\Delta bits = \Delta F \cdot \Delta T$$

$$\Delta Words = \frac{\Delta F \cdot \Delta T}{40}$$

Maximum full rate Clock Interval

$$T_{\min} = \frac{1}{F_c(1+\Delta F)}$$

Example: 6G 5000ppm Down Spreading @ 30KHz

$$F_c = 6G - 2500ppm$$

$$\Delta F = 2500ppm \cdot (6G - 2500ppm) = 14.96MHz$$

$$\Delta T = 1/30K = 33.3us$$

$$\Delta bits = \Delta F \cdot \Delta T = 249.3bits$$

$$\Delta Words = \frac{\Delta F \cdot \Delta T}{40} = 6.23DWords$$

Not an Unreasonable Amount

Buffer Size Calculations

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- Compare the Up, Down, Center Spread Buffers

$$T_{\min} = \frac{1}{F_c(1+\Delta F)} \qquad \Delta bits = \Delta F \cdot \Delta T \qquad \Delta Words = \frac{\Delta F \cdot \Delta T}{40}$$

Spread	Fc (GHz)	Tc min (ps)	Delta Tc (ps)	F SSC (Hz)	# bits =dF*dT	#words
No	6.000	166.67	0.00	0	?	>0
Up	6.015	167.50	0.83	30000	250.63	6.27
Center	6.000	167.08	0.42	30000	250.00	6.25
Down	5.985	166.67	0.00	30000	249.38	6.23

- Observations
  - Bit interval spread is very small (0.83ps)
  - Buffer Sized is Basically Independent of SSC Choice and Reasonable in Size

Configuration Management

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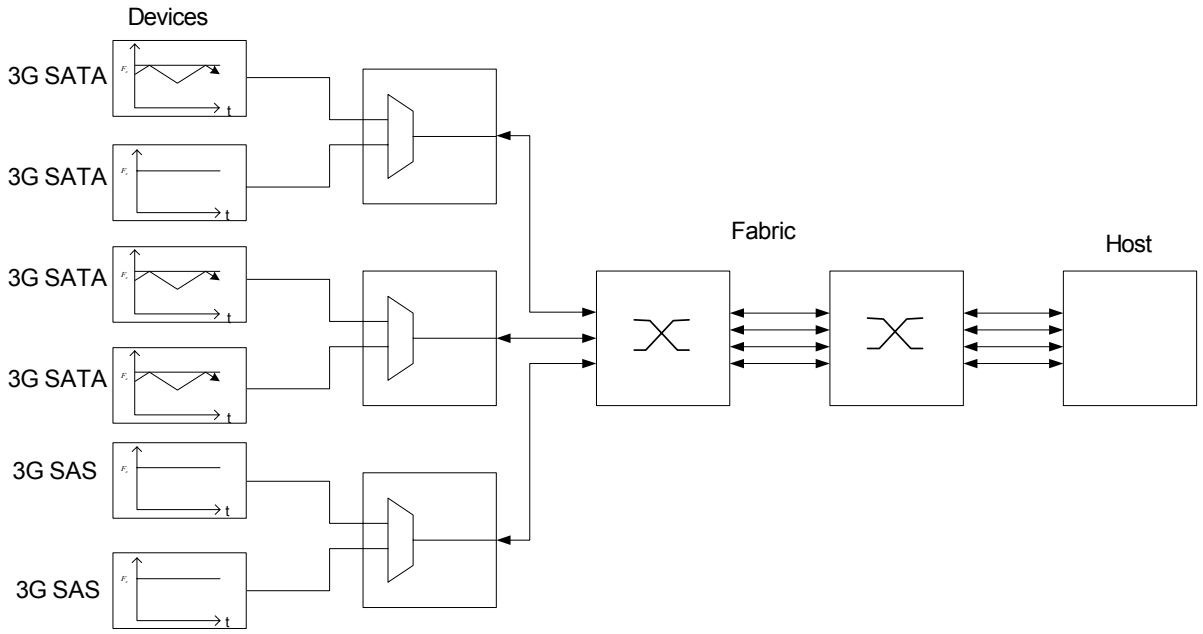
- SSC Support in the SAS-2 Fabric is a function of the SSC Option
  - No SSC – no issue
  - Center or Up spread SSC can be Supported in any Fabric Links
  - Down Spread SSC on the Fabric Links Causes a Management Nightmare



Phy Complexity

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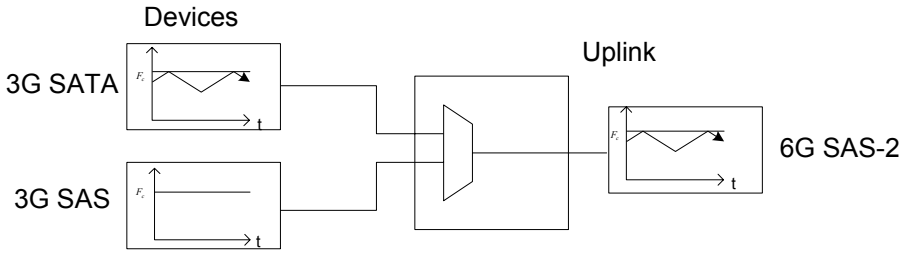
Legacy Devices and SSC

- Legacy SAS does Not Support SSC
- SATA may or may not have SSC Enabled
- If SSC is supported on the uplink it will need to be Provisionally on a port-by-port basis because legacy SAS ports cannot have SSC active
- This Precludes Modulating the Reference Clock in a Multiplexing Device



SSC Range Required to Support 6G SAS and 6G SATA in 20xx ?

- Up Spread 10,000 ppm Range
- Center Spread 7,500 ppm Range
- Down Spread 5,000 ppm Range
- No Spread 5,000 ppm Range (Rx Only)

Comparison

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SSC Option	EMI Reduction	Legacy Support	Support Multiplexing	Buffer Size (DWords	PHY SSC Range PPM
None	No	Yes	Yes	>0	5000
Up	Yes	Yes	Yes	7	10000
Center	Yes	Yes	Yes	7	7500
Down	Yes	No	No	7	5000

- Up and Center Spread SSC are the best solutions, Center Spread is Lower Risk

Summary

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- Recommend That We Support SSC
- Recommend Center Spread SSC of +/- 2500PPM
- Modify the Align Density Specification to Allow Higher Rates