10GEPON Burst Receiver Simulation

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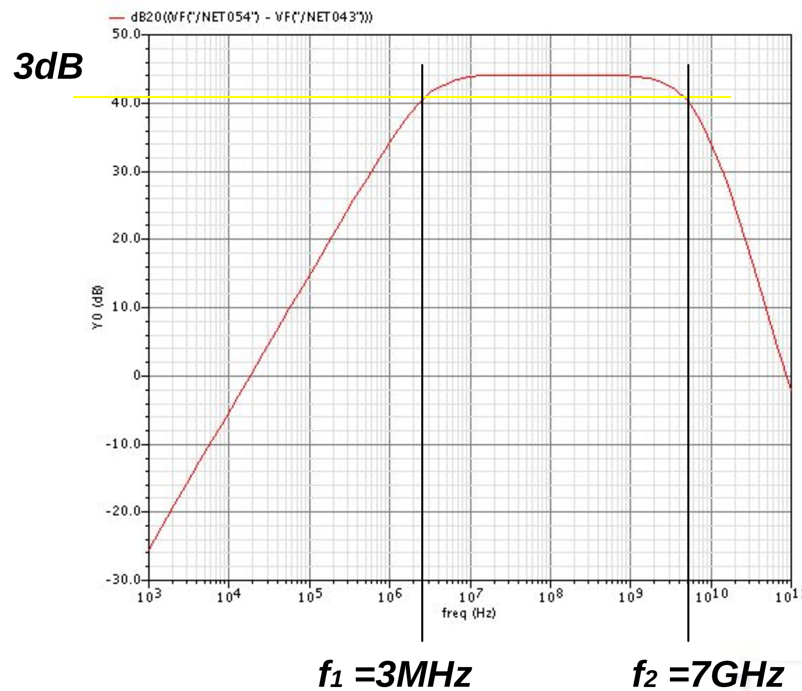
Outline

- The LIA Model
  - AC Coupled
  - DC Coupled
- Results
- Conclusions

10GEPON AC Coupled

10G LIA – Transfer Function

- A 10G AC coupled LIA has been simulated by the following Transfer Function
- The lower cut-off pole (f_1) determines the CID length, while the higher cut-off pole (f_2) determines the Bandwidth
- For the lower frequency pole set to be 3MHz
- For the higher frequency pole set to be 7GHz



$$H(s) = \frac{\frac{s}{2\pi f_1}}{1+\frac{s}{2\pi f_1}} \bullet \frac{1}{1+\frac{s}{2\pi f_2}}$$

Considerations in choosing the frequency poles

- The higher frequency determines the Bandwidth of the LIA
  - Therefore the higher frequency pole set to be 7GHz as it should be 0.7B, where B = 10Gbps
- The lower frequency determines the CID length and how much DC droop from the baseline is allowed
  - The lower frequency set to be 3MHz to support 64 bits of CID and maximum 6% DC droop
- If the lower frequency cut-off will be too low than the optimum level, it will cause Jitter due to Flicker Noise
- If it will be too high then it will cause too large DC droop

Considerations in choosing the Coupling Capacitor

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- In AC Coupled applications with long CID the coupling capacitor generates Pattern Dependent Jitter
- In order to minimize this Jitter, the low frequency cut-off should be optimal as possible
- In one hand, the low frequency cut-off must be as close to DC as possible to avoid baseline DC droop and ISI (which close the Eye Diagram Vertically).
- In other hand, if the low frequency cut-off will be too low than the optimum it cause to long preamble

Coupling Capacitor – Calculation

$$\Delta V = 6\% V_{P-P}$$

$$\Delta V = \frac{6}{100} V_{P-P}$$

$$\frac{6}{100} V_{P-P} = \frac{V_{P-P}}{2}(1 - e^{\frac{-t}{\tau}})$$

$$e^{\frac{-t}{\tau}} = 1 - \frac{\frac{6}{100} V_{P-P}}{\frac{V_{P-P}}{2}}$$

$$e^{\frac{-t}{\tau}} = 0.88$$

$$t = -\tau \ln 0.88$$

$$t = 0.12\tau$$

$$\tau = 7.8t$$

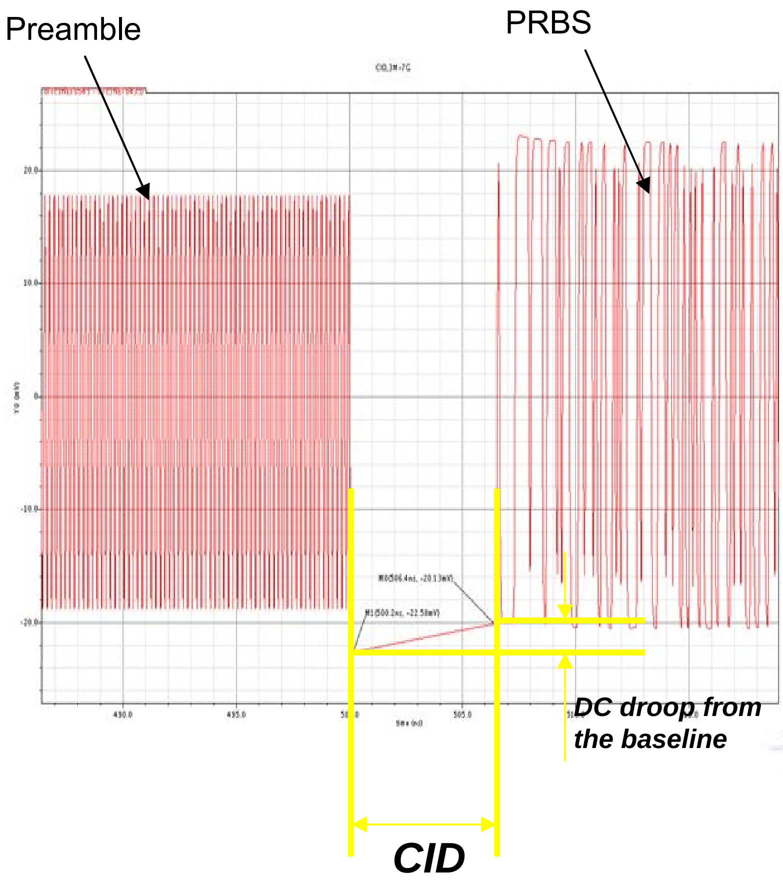
$$t = N_{CID} T$$

$$\tau = RC$$

$$\boxed{C = \frac{7.8 N_{CID} T}{R}}$$

LIA with CID

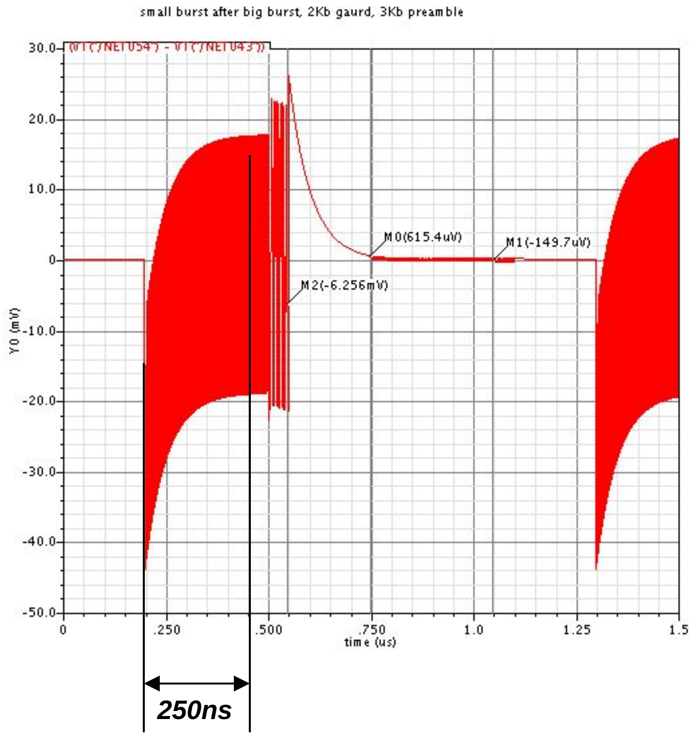
- 64 bits of CID have been generated through the Transfer Function



LIA – Conclusion

- We have found, by the simulation, that 3MHz as a low frequency cut-off is the optimum value to maintain CID of 64 bits
- This low frequency cut-off has about ***2500bits*** (250ns) preamble length

20dB Dynamic Range



10GEPON DC Coupled

10G LIA – DC Coupled

- In DC Coupled the $\tau_{(RC)}$ determined by internal 2 Capacitors
- One capacitor for "fast" acquisition, during preamble, and the second for CID support
- During Preamble, the threshold acquisition done by "Middle" frequency cut-off pole
- Once the threshold acquired then it switch to "low" frequency cut-off pole to support CID

Transfer Function

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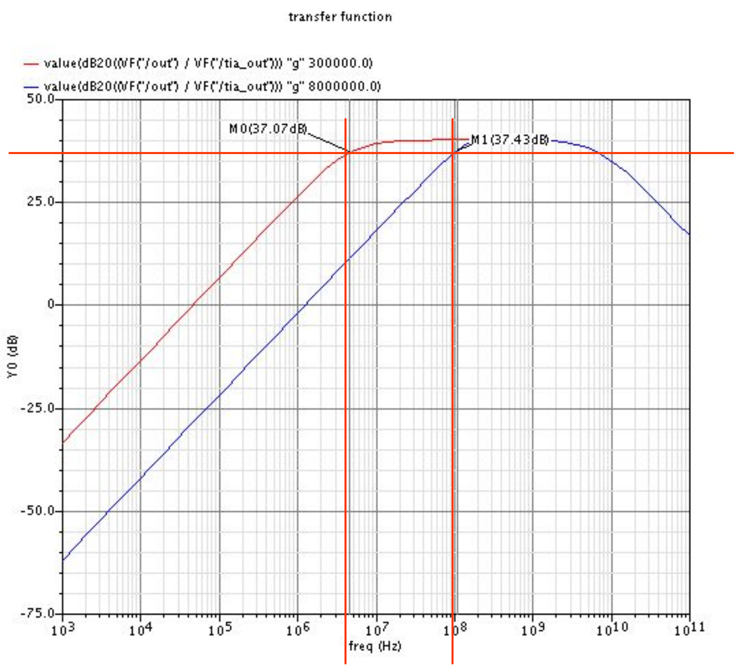


3dB

f_{1_low} = 3MHz ***f_{1_high} = 80MHz***

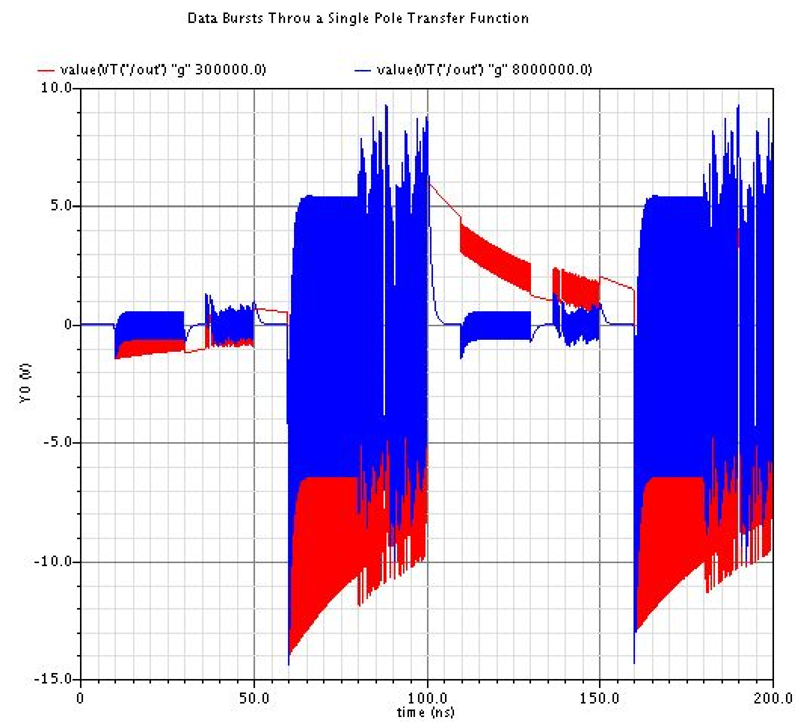
- f_1 and f_2 determine how much DC droop from the baseline is allowed and to maintain 64bits CID
- During preamble the f_{1_high} is active then after a "short" time f_{1_low} becomes an active to support CID

$$\frac{V_{out}}{V_{in}} = \frac{AS\left(1+\frac{S}{W_L}\right)}{S\left(1+\frac{S}{W_L}\right)\left(1+\frac{S}{W_H}\right)+AK}$$

A: forward gain.
K: feedback gain.
$W_{L:}$ low pass frequency pole (in feedback loop).
W_H: high pass frequency pole (in forward path).

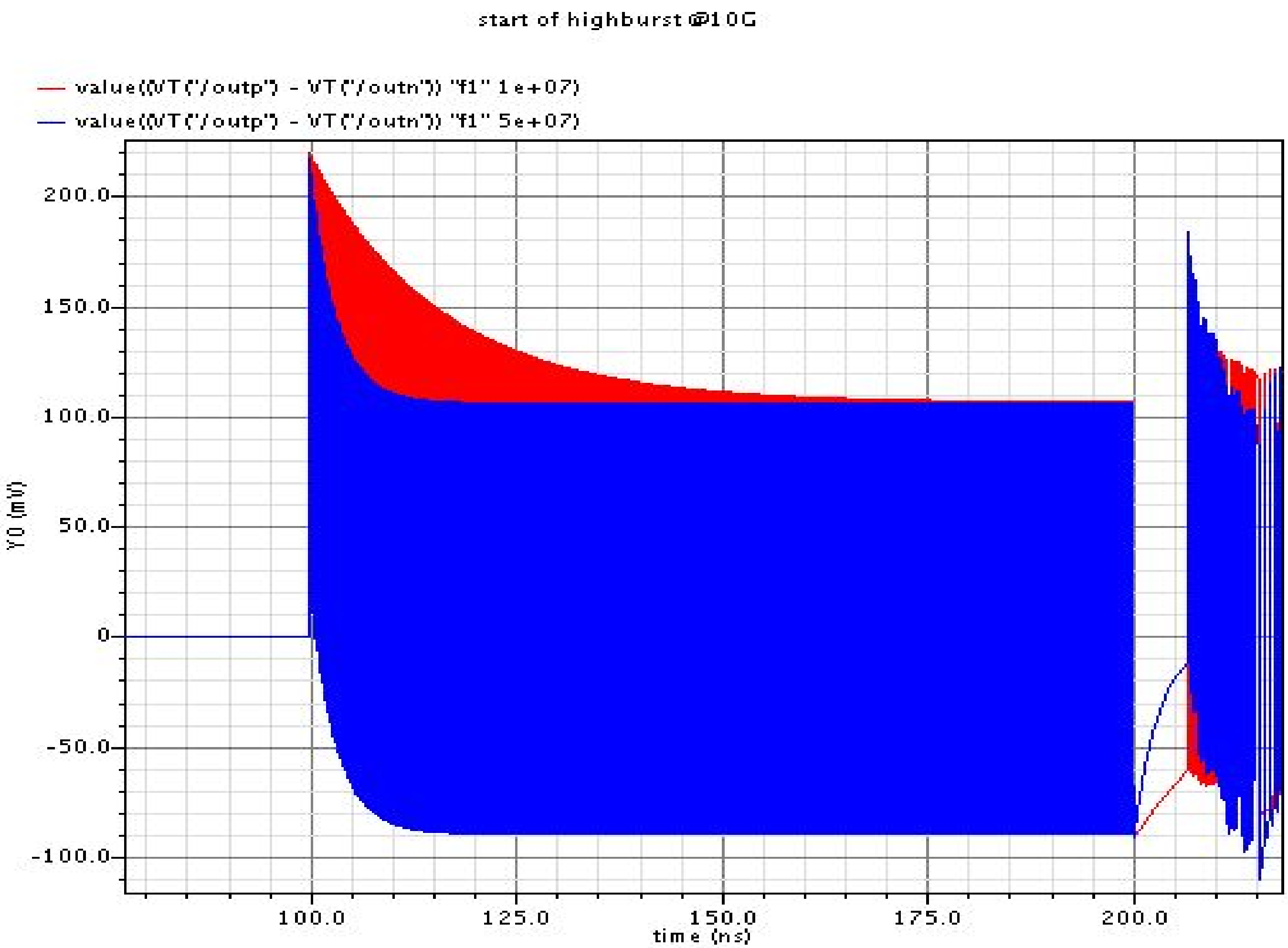
Transfer Function response

- 2 Burst packets (weak and high) have been transmitted though the 2 poles Transfer Function (Red and Blue)
- The Red model has a low frequency cut-off in 3MHz, which is very good for CID but has long preamble
- The Blue model has a low frequency cut-off in 80MHz, which is good for short preamble but bad for CID

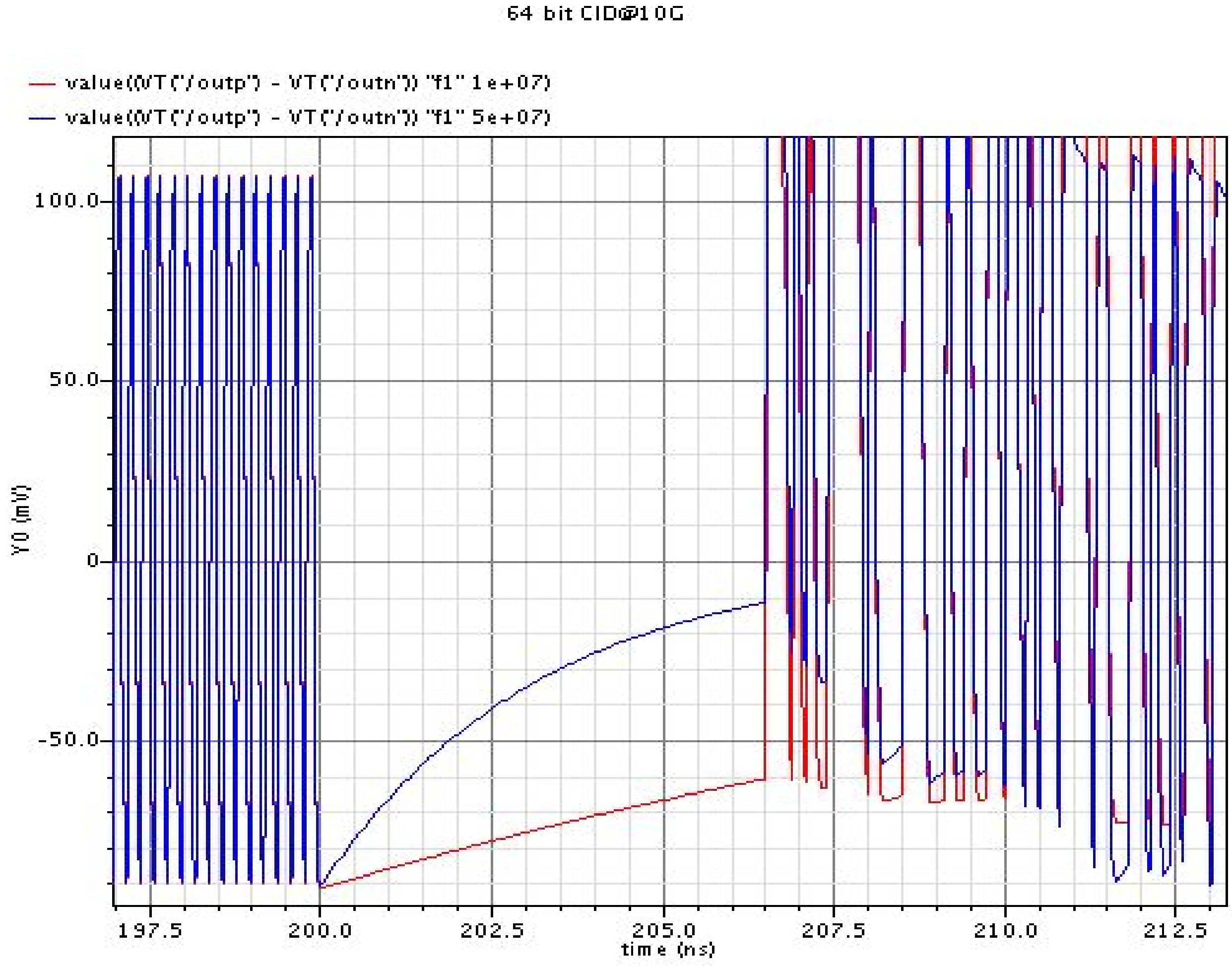


DC Coupled is mixed between the 2 Transfer Function models

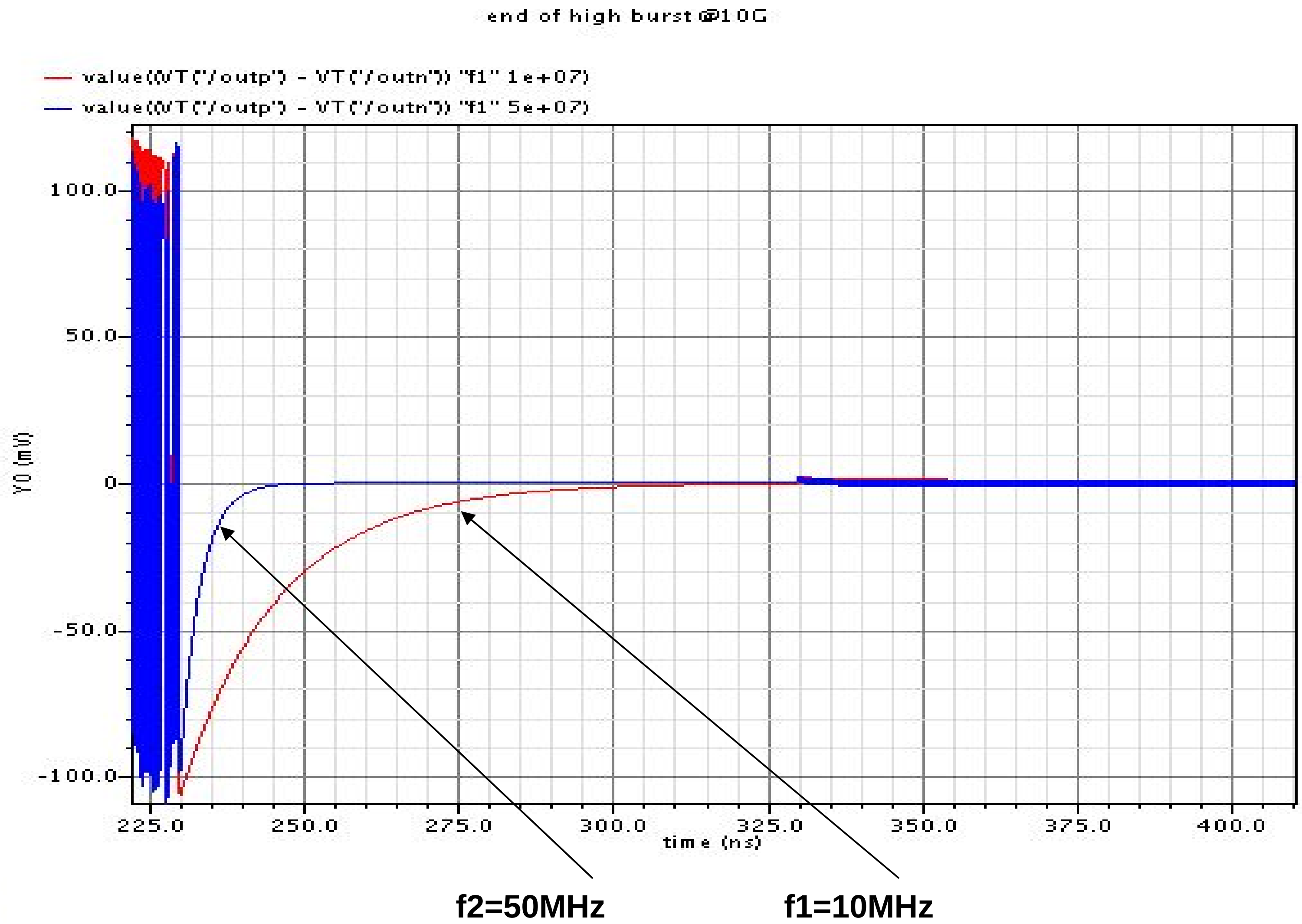
Simulation – Start of High Burst



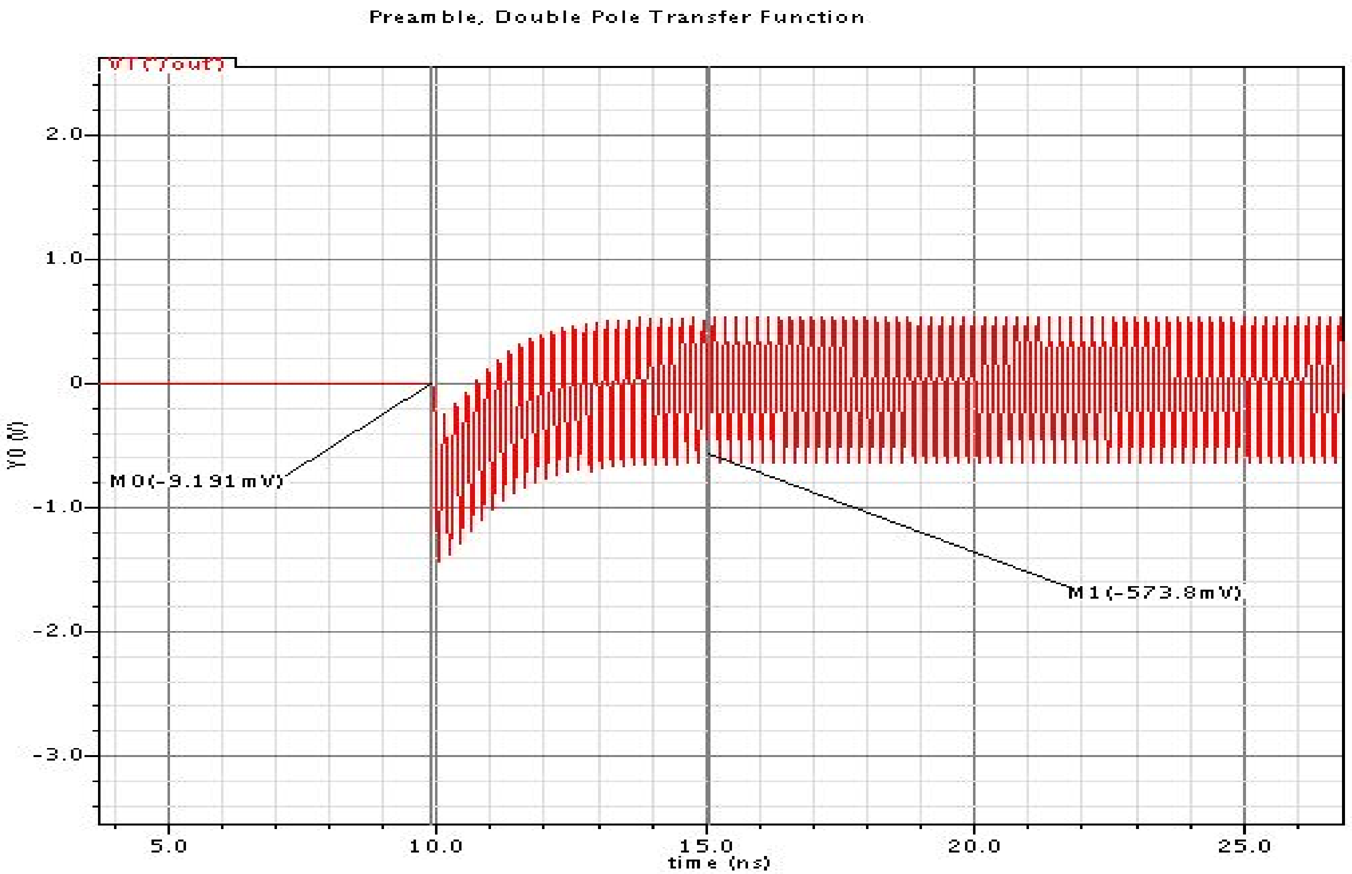
Simulation – CID



Simulation – End of High Burst

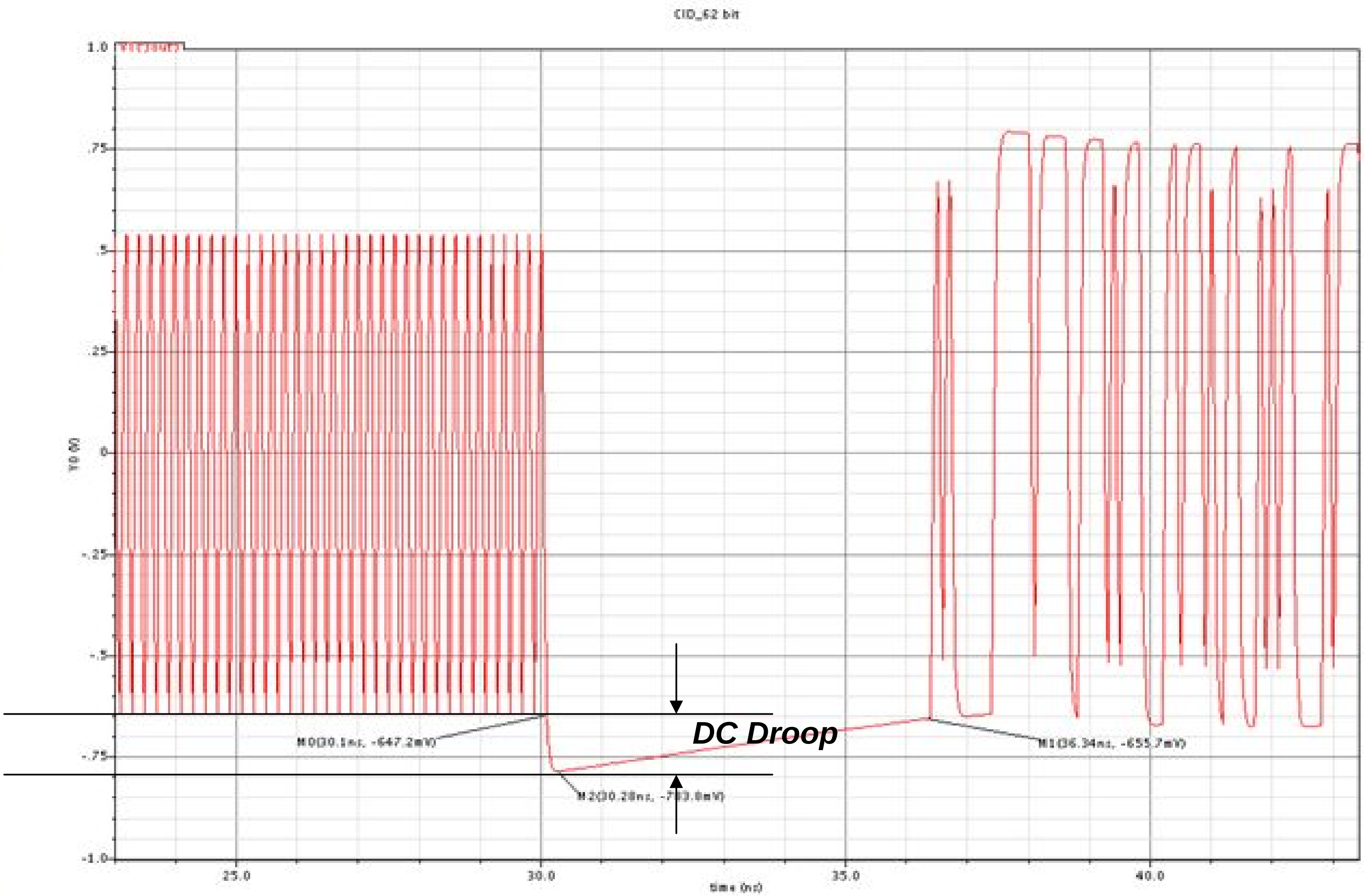


Preamble Length



Preamble is stable after ***5ns!***

CID


CID_62 bit
1.0
.75
.5
.25
0
-.25
-.5
-.75
-1.0
Y0 (V)
25.0
30.0
35.0
40.0
time (ns)
M0(30.1ns, -647.2mV)
M1(36.34ns, -655.7mV)
DC Droop

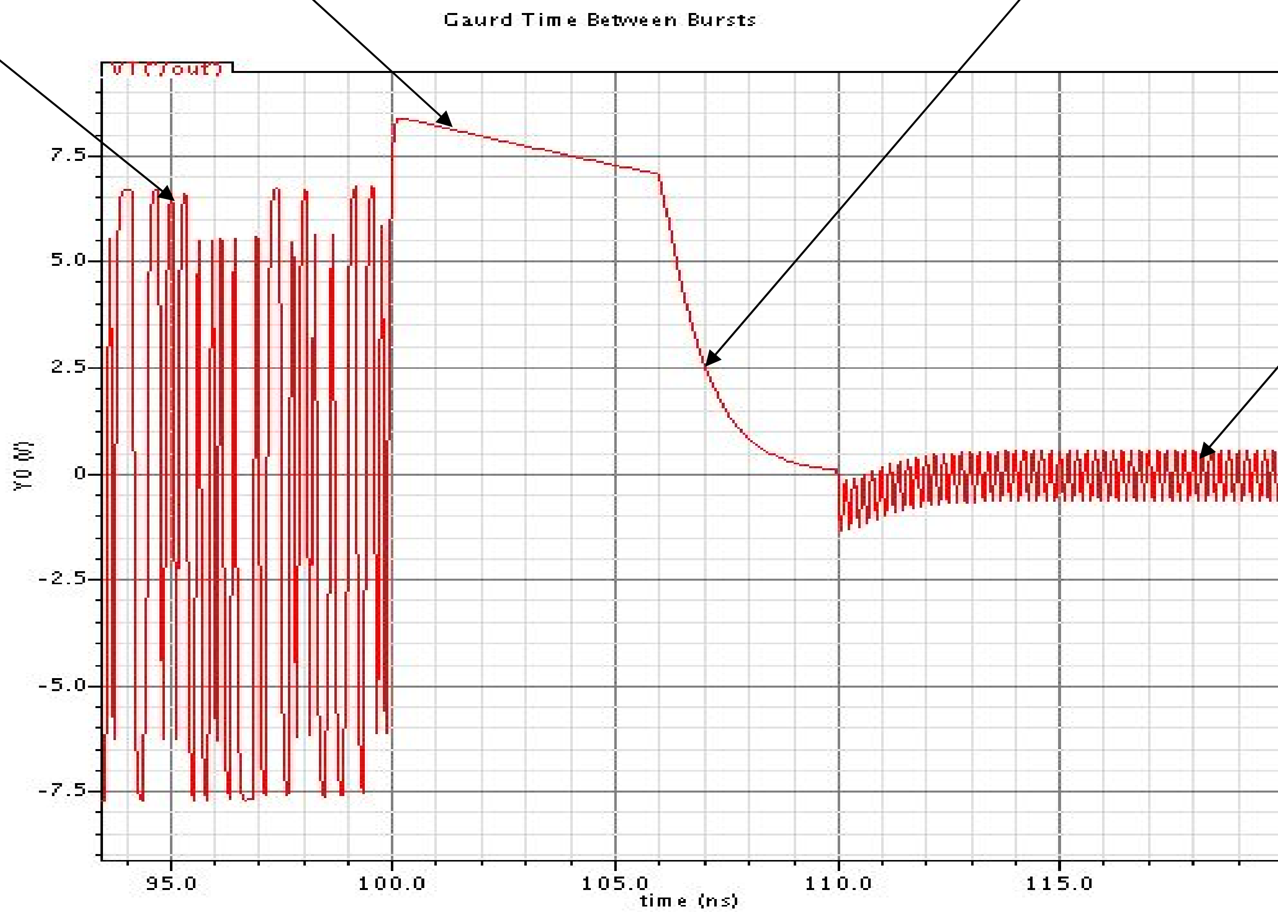
Guard Time

CID Pole – End of Burst

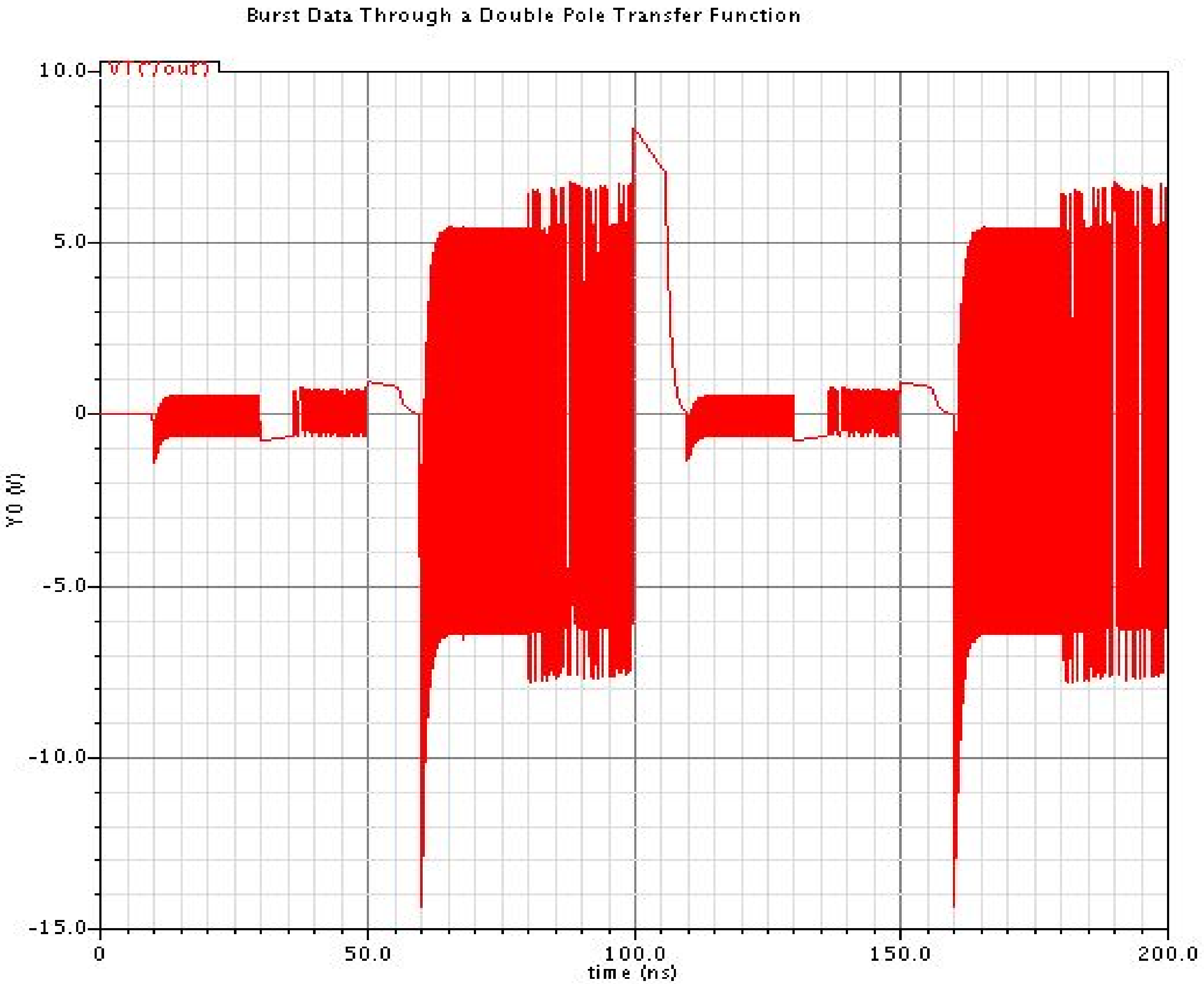
High Burst

Preamble Pole – End of Burst

Weak Burst



Dynamic Range – 20dB



Conclusion – Preamble Length

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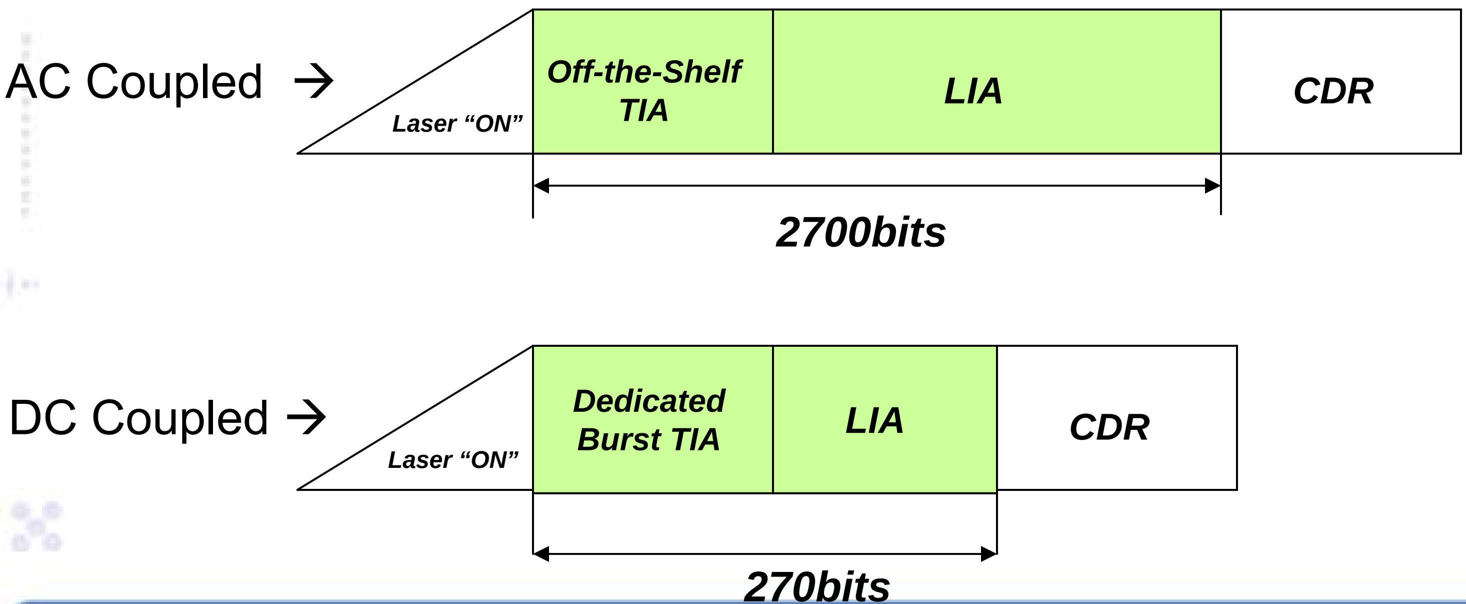
LIA

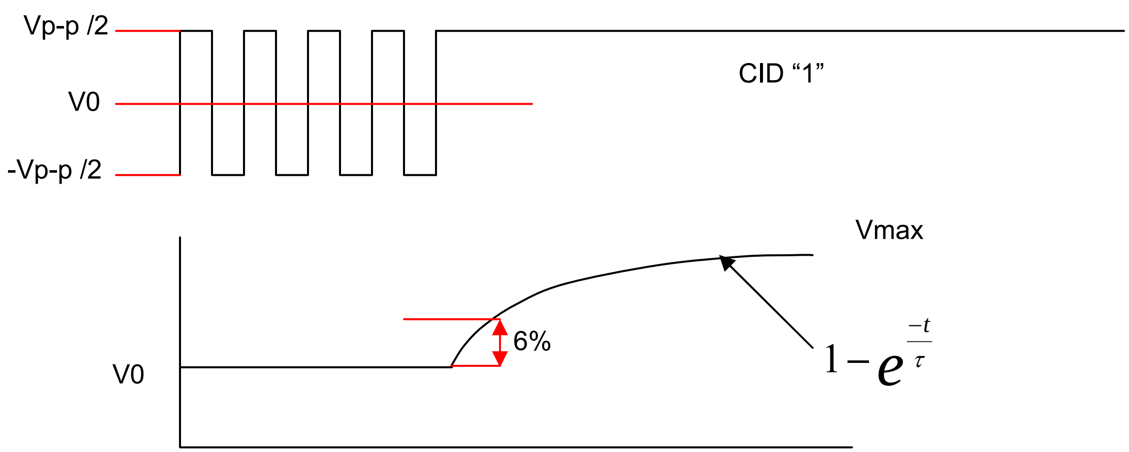
- We have assumed 6% DC droop from the baseline
- In AC coupled the preamble length is:
  - 2600bits
- In DC coupled the preamble length is:
  - 50bits

Conclusion

- DC coupled method is the preferable choice over AC Coupled
- A dedicated TIA for Dual Rate Burst Receiver is needed
- Too tight preamble length is not needed (don't like to be 2nd GPON)
- The recommended preamble length is following:



Back up



When consecutive "1" bits pass through AC coupled optical receiver, it behaves like

$$1-e^{\frac{-t}{\tau}}$$

Where:

t = CID length

$\tau = RC$

When

t → ∞ the function equals to 1

t → 0 the function equals to 0

An Example:

Assumptions:
$V_{p\text{-}p}$ = 400mV
ΔV [k] = 6%
t = 5.2τ

$$\Delta V = \frac{k}{100} V_{p-p} = \frac{V_{p-p}}{2}(1 - e^{\frac{-t}{\tau}})$$

$$\frac{k}{100} V_{p-p} = \frac{V_{p-p}}{2}(1 - e^{\frac{-t}{\tau}})$$

$$e^{\frac{-t}{\tau}} = 1 - \frac{\frac{k}{100} V_{p-p}}{\frac{V_{p-p}}{2}}$$

Eq 1 $$t = -\tau \ln(1 - \frac{k}{50})$$

Eq 2 $$t = N_{CID} T$$

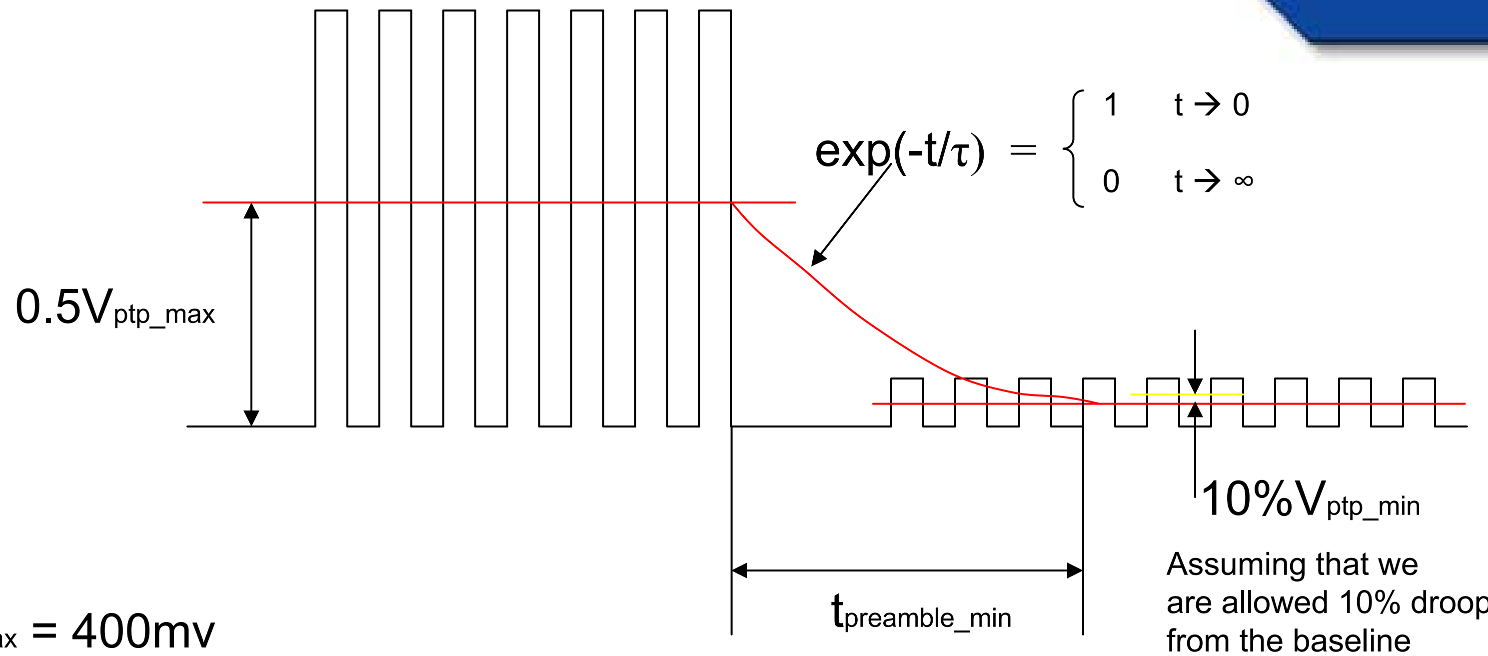
Eq 1 + Eq 2 $$N_{CID} T = -\tau \ln(1 - \frac{k}{50})$$

$$\tau = \frac{-N_{CID} T}{\ln(1 - \frac{k}{50})}$$

$$N_{PREAMBLE} = \frac{5.2\tau}{T}$$

$$N_{PREAMBLE} = \frac{-5.2 * N_{CID}}{\ln(1 - \frac{k}{50})}$$

For :
k=6%
$N_{Preamble}$ = 2600 bits



V_{ptp_max} = 400mv

V_{ptp_min} = 10mv

$\exp(-t/\tau) * 0.5V_{ptp\_max} < 0.1V_{ptp\_min}$

$\exp(-t/\tau) * 200 = 1$

$\exp(-t/\tau) = 1/200$

$t = -\tau * \ln(1/200)$

$t = 5.2\tau$

A Formula – Preamble(CID)

- Assuming that 5 time constants is needed

$$N_{preamble} = \frac{-5 \cdot N_{cid}}{\ln(1 - X)}$$

Where:

N_{CID} = Number of CID

$N_{preamble}$ = Required Preamble length [bits]

X = Deviation of baseline permitted during CID

An example:

CID = 64

X = 0.1 (10%)

N =

$$\frac{-5 * 64}{\ln(1 - 0.1)} = \mathbf{2430bits}$$

For 6% droop

$$N = \frac{-5 * 64}{\ln(1 - 0.06)} = \mathbf{5170bits}$$

Straw poll #2

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Do we maintain the sensitivity of the 1G OLT receiver (PX10 and PX20) ?

Yes: _29_

No: _0_

No opinion: _2_