802.3av Dual Rate Burst Receiver – TIA

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Outline

- Goals
- TIA
- Conclusion

Goals

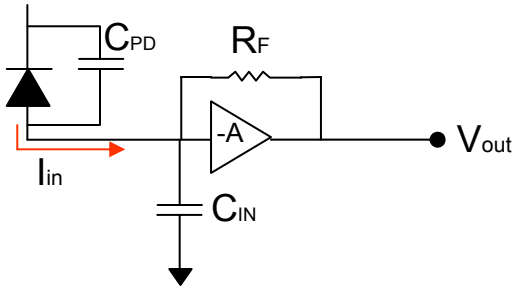
- To assess the theory and calculated simulation Fixed Gain vs. Variable Gain parameters of single TIA for 10G and 1G in Dual Rate Burst Receiver
- The simulation has been done by Excel sheet

10GEPON TIA

TIA Parameters

- The primary function of the TIA is to convert the small current, from the photodiode, into a voltage while adding as little noise as possible to the output signal

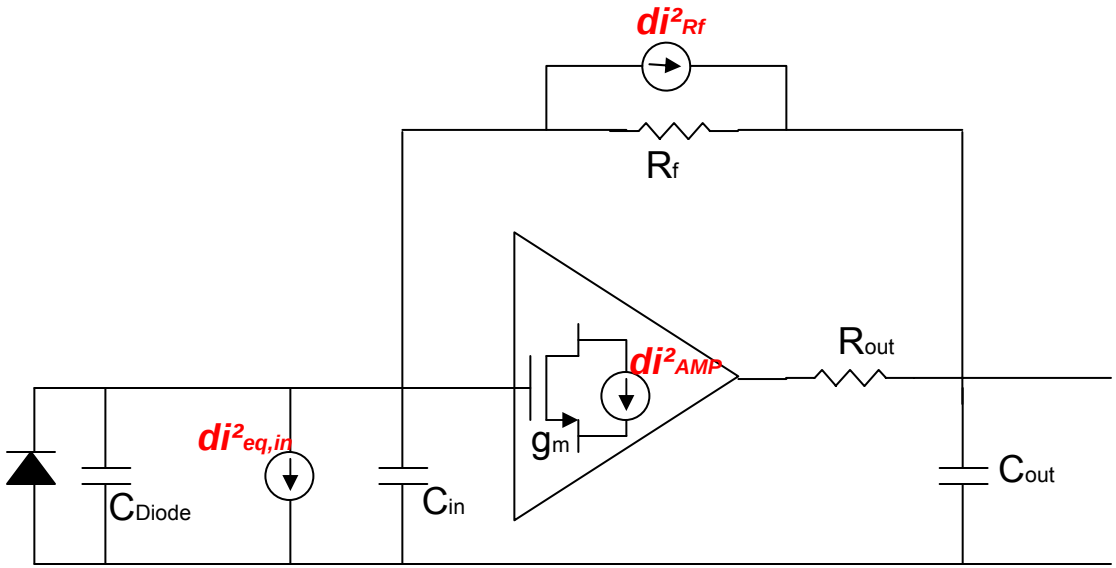
  - TIA is characterized by several parameters:
    - Transimpedance Gain
    - Input Referred Noise
    - Bandwidth



One of the main “problems” of the TIA is the trade-off between Gain, Noise and Bandwidth

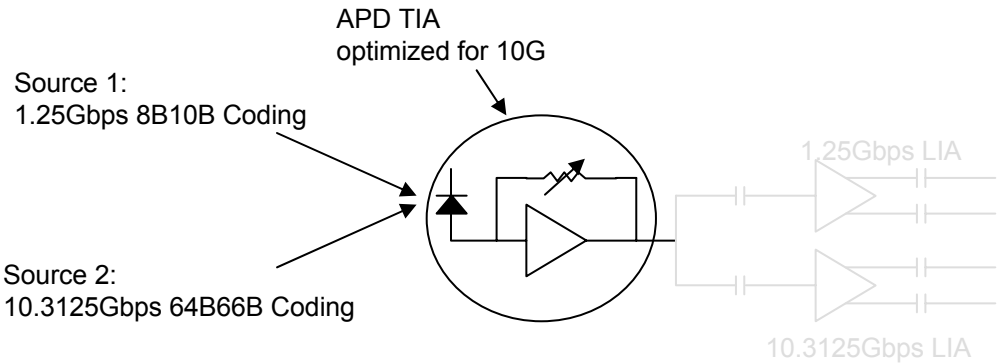
TIA – Input Referred Noise

- The ultimate limitation on the Optical Receiver sensitivity is the Noise
- The noise includes the Photodiode's Shot Noise and the noise added by the TIA
- The major noise sources are the Feedback Resistor and Voltage Amplifier



Burst TIA Gain Parameter - Different for 1G and 10G?

- In order to optimize the performance of the TIA in both 1G and 10G we need to support Variable TIA Gain
- Gain can be varied between 1G and 10G bursts by changing the feedback resistor
- In order to analyze the impact on TIA performance in 1G, we need to calculate the SNR of the TIA



Simulation Method

- Excel sheet is used containing optimal parameters for 10G
- The Excel sheet divided into 2 main categories
  - Photodiode – APD
  - TIA
- The important parameters in this model are:
  - Optical Input Power
  - Feedback Resistor Value
  - TIA Output Voltage Amplitude
  - Bit Error Rate

An Excel Sheet for optimized 10G TIA

Operating Conditions	
Input power Pdmb [dBm]	-25.00
Temperature T [K]	300.00
Photodiode technology	
Responsivity Rd [A/W]	0.80
APD gain M	8.00
APD process factor x	0.70
Photodiode Bandwidth BWd [Hz]	8.00E+09
Photodiode Capacitance Cd [F]	2.00E-13
Amplifier technology	
Ft [Hz]	1.50E+11
gm [mho]	2.00E-03
Voltage Amplifier Gain A	20
Voltage amplifier input capacitance Ca [F]	2.00E-13
Feedback Resistor Rf [Ohm]	1.00E+03
Constants	
Electron charge q [C]	1.60E-19
Boltzman constant k	1.38E-23

Input power P [W]	3.16E-06
APD exess noise factor F	6.16
APD current Id [A]	2.02E-05
APD noise current Ind [A rms]	1.60E-06
Voltage amplifier Bandwidth BWa [Hz]	1.50E+09
TIA Bandwidth BWtia [Hz]	8.36E+09
Amplifier input referred noise Vna [Vrms]	1.14E-04
Amplifier input equivalent noise current Ina [Arms]	2.28E-06
TIA Output Voltage [V]	2.02E-02
Total input referred noise current Int [A rms]	**2.79E-06**
SNR (at TIA input) [dB]	**17.23**
Signal to noise ratio (Q)	**7.27E+00**
Bit Error Rate	**1.84E-13**

- An optimized 10G parameters have been used
- The main parameters
  - Input Power: [-25dBm]
  - Feedback Resistor: 1KΩ
- The results of this scenario
  - TIA Output Voltage: 20mV
  - Bit Error Rate: 1.8E-13

Optimized 10G with 1G Signal

Operating Conditions	
Input power Pdmb [dBm]	*-30.00*
Temperature T [K]	300.00
Photodiode technology	
Responsivity Rd [A/W]	0.80
APD gain M	8.00
APD process factor x	0.70
Photodiode Bandwidth BWd [Hz]	8.00E+09
Photodiode Capacitance Cd [F]	2.00E-13
Amplifier technology	
Ft [Hz]	1.50E+11
gm [mho]	2.00E-03
Voltage Amplifier Gain A	20
Voltage amplifier input capacitance Ca [F]	2.00E-13
Feedback Resistor Rf [Ohm]	*1.00E+03*
Constants	
Electron charge q [C]	1.60E-19
Boltzman constant k	1.38E-23

Input power P [W]	1.00E-06
APD exess noise factor F	6.16
APD current Id [A]	6.40E-06
APD noise current Ind [A rms]	8.99E-07
Voltage amplifier Bandwidth BWa [Hz]	1.50E+09
TIA Bandwidth BWtia [Hz]	8.36E+09
Amplifier input referred noise Vna [Vrms]	1.14E-04
Amplifier input equivalent noise current Ina [Arms]	2.28E-06
TIA Output Voltage [V]	*6.40E-03*
Total input referred noise current Int [A rms]	**2.45E-06**
SNR (at TIA input) [dB]	**8.33**
Signal to noise ratio (Q)	*2.61E+00*
Bit Error Rate	*4.52E-03*

- In this case, we assume that 1G packet is coming with an optical input power of -30dBm
- The Feedback Resistor remains as was for 10G → 1KΩ
- The results
  - The TIA output voltage drooped to ***6.4mV!***
  - No LIA which can handle such a low amplitude level
  - BER goes down to ***4.5E-03!***

Optimized 10G with an adaptation to1G Signal

Operating Conditions	
Input power Pdmb [dBm]	*-30.00*
Temperature T [K]	300.00
Photodiode technology	
Responsivity Rd [A/W]	0.80
APD gain M	8.00
APD process factor x	0.70
Photodiode Bandwidth BWd [Hz]	8.00E+09
Photodiode Capacitance Cd [F]	2.00E-13
Amplifier technology	
Ft [Hz]	1.50E+11
gm [mho]	2.00E-03
Voltage Amplifier Gain A	20
Voltage amplifier input capacitance Ca [F]	2.00E-13
Feedback Resistor Rf [Ohm]	*1.00E+04*
Constants	
Electron charge q [C]	1.60E-19
Boltzman constant k	1.38E-23

Input power P [W]	1.00E-06
APD exess noise factor F	6.16
APD current Id [A]	6.40E-06
APD noise current Ind [A rms]	8.99E-07
Voltage amplifier Bandwidth BWa [Hz]	1.50E+09
TIA Bandwidth BWtia [Hz]	8.36E+08
Amplifier input referred noise Vna [Vrms]	1.14E-04
Amplifier input equivalent noise current Ina [Arms]	2.28E-07
TIA Output Voltage [V]	*6.40E-02*
Total input referred noise current Int [A rms]	**9.27E-07**
SNR (at TIA input) [dB]	**16.78**
Signal to noise ratio (Q)	*6.90E+00*
Bit Error Rate	*2.56E-12*

- In this case, the Optical Input Power remains [-30dBm]
- The Feedback Resistor changed to optimum value for 1G → 10KΩ
- The results are:
  - TIA Output Voltage level is 64mV
  - Bit Error Rate: 2.5E-12

Conclusion

- By the Excel sheet we showed that using optimized 10G Dual Rate Receiver with TIA fixed feedback resistor the performance decrease dramatically when receives 1G traffic
- In case of 1G the BER becomes 4.5E-03
- But when using a variable resistor instead of fixed resistor, the performance significantly improved from 4.5E-03 to 2.5E-12

Back up