S-Parameter to Single Bit Response (SBR) Transformation and Convergence Study

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Motivations and Methods

- Motivation
  - To study and understand the variation and range for different methods for S-parameter to SBR transformation
- Methods
  - Using a range 25 G S-parameters of BPs and CCs published on 8023.bj web site (http://www.ieee802.org/3/100GCU/public/channel.html)
  - Calculate the SBR with several known/common methods
  - Study and quantify the variations

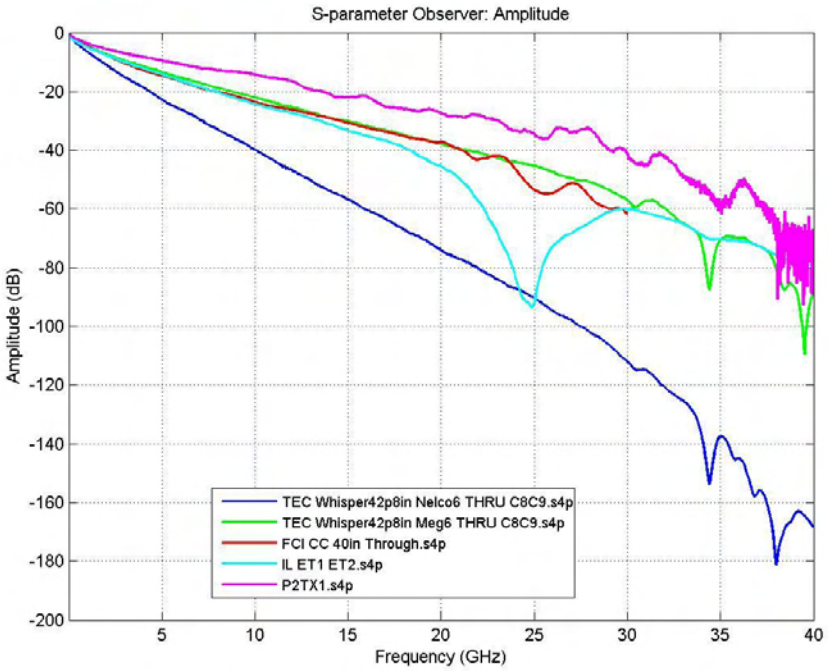
S-Parameter to SBR Post-Processing Methods

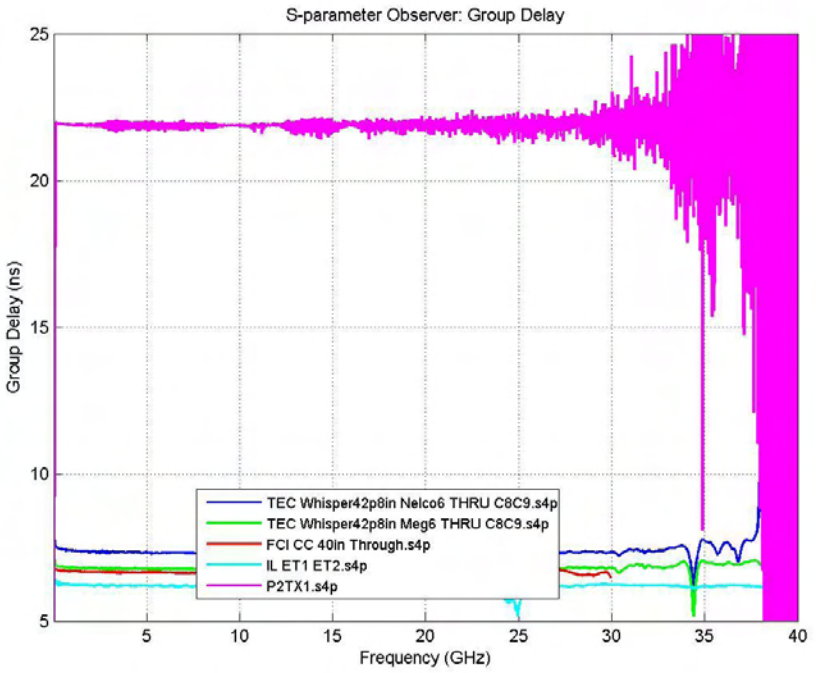
ID	Method Name	Description
1	Rational Fitting	•Approximate insertion loss using rational function [1]
2	Iterative Minimum Phase	•Extrapolate to find DC value if it is missing •Approximate and adjust phase using iterative techniques for minimum phase reconstruction from magnitude data [2]
3	DC Fix Only	•Extrapolate to find DC value if it is missing
4	Hilbert Minimum Phase	•Extrapolate to find DC value if it is missing •Approximate phase using Hilbert transformation from magnitude data [3]

S-Parameter Post-Processing Objectives and Techniques

- DC Value Missing Mitigation
  - Extrapolation (e.g. linear, spline, rational fitting, … etc.)
- Causality Violation Fixing
  - Minimum-Phase Methods (Iterative and Hilbert)
  - Rational Fitting
- Passivity Violation Fixing
  - Enforcing no-gain
    - Not covered in this study

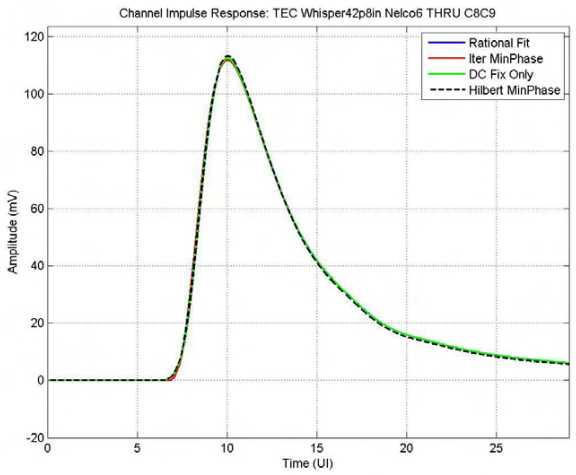
Five 25 G BP&CC S-Parameters Are Studied



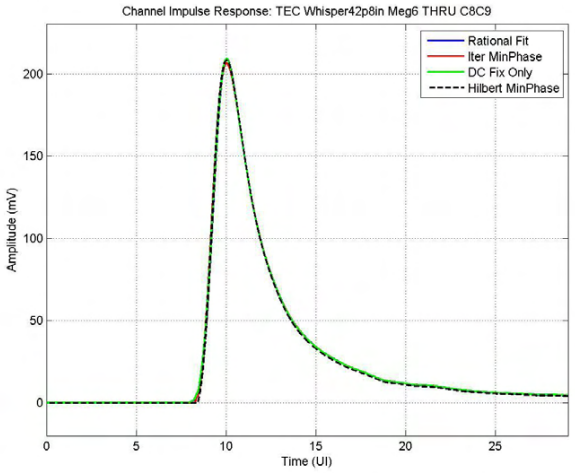


Channel	Fmin	Fmax	Fstep
TEC_Whisper42p8in_Nelco6_THRU_C8C9	0 MHz	40 GHz	10 MHz
TEC_Whisper42p8in_Meg6_THRU_C8C9	0 MHz	40 GHz	10 MHz
FCI_CC_40in_Through	50 MHz	30GHz	50 MHz
Qlogic IL_ET1_ET2.s4p	0 MHz	40 GHz	40 MHz
Molex 5M Cable P2TX1.s4p	50 MHz	40 GHz	10 MHz

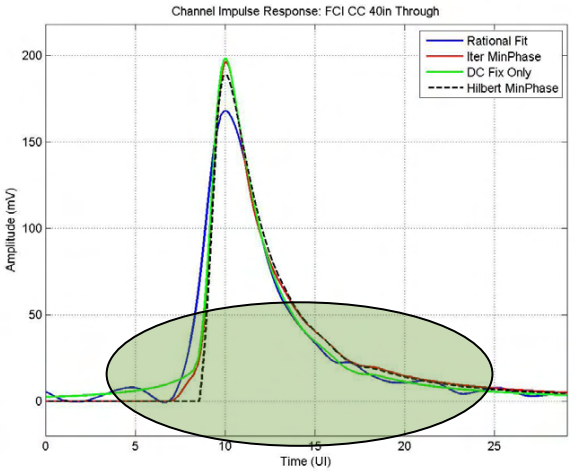
SBRs For 5 Channels with 4 Known/Common Methods



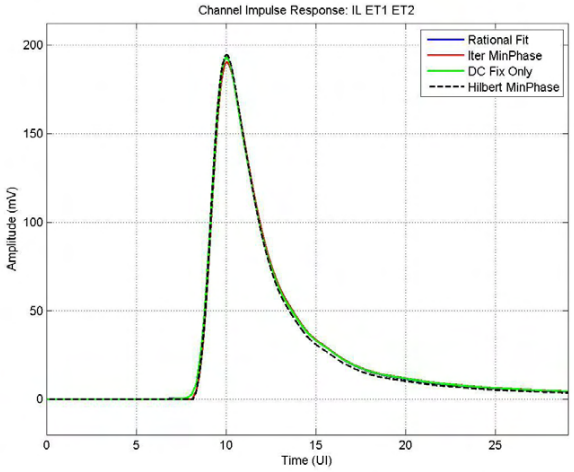
Ch1: TEC_Whisper42p8in_Nelco6_THRU_C8C9.s4p



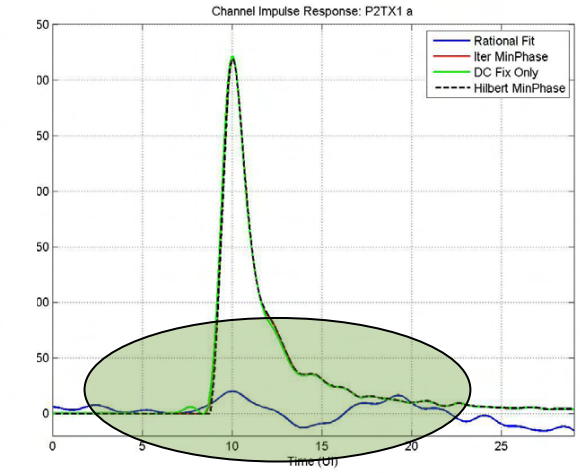
Ch2: TEC_Whisper42p8in_Meg6_THRU_C8C9.s4p



Ch3: FCI_CC_40in_Through.s4p

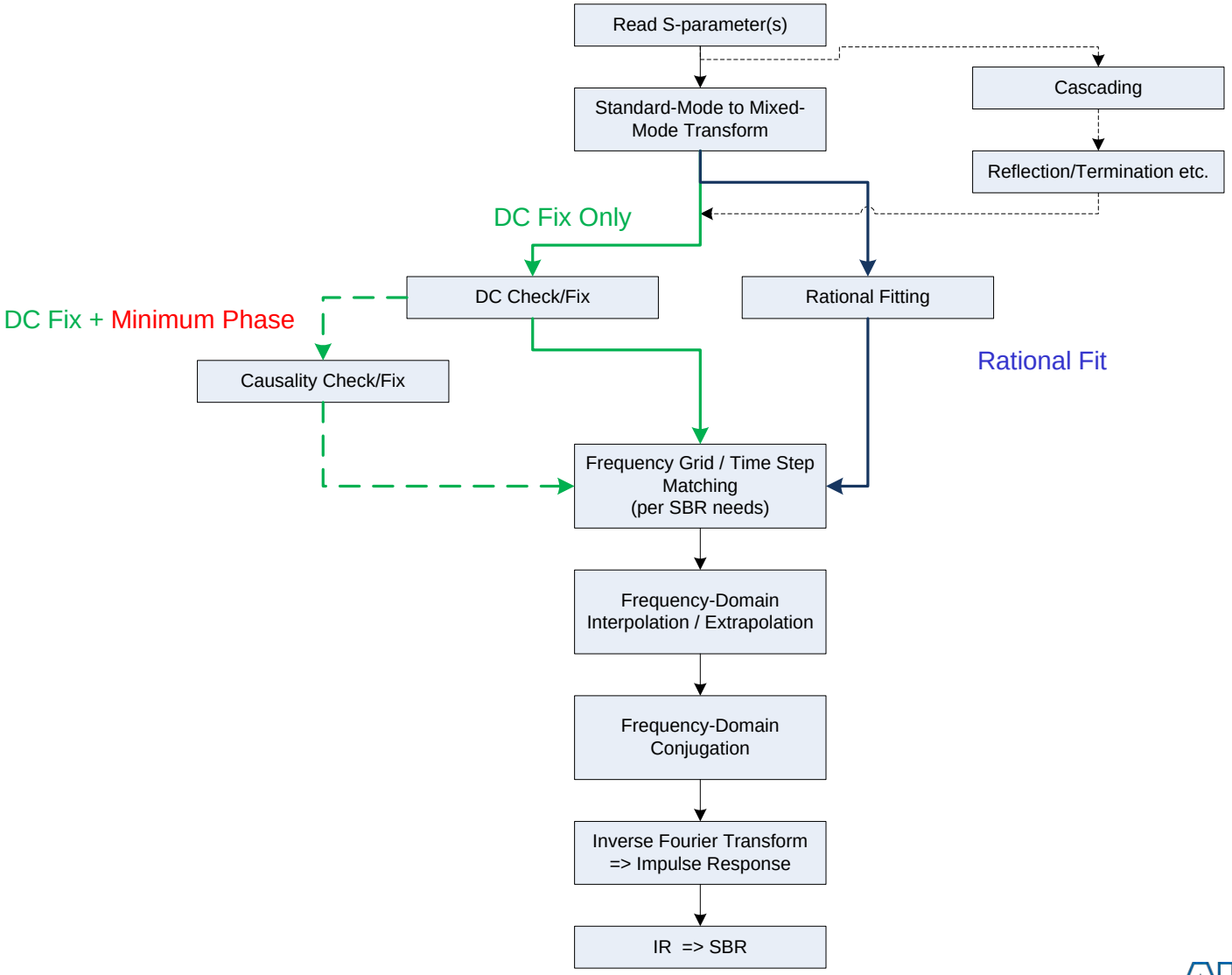


Ch4: Qlogic IL_ET1_ET2.s4p



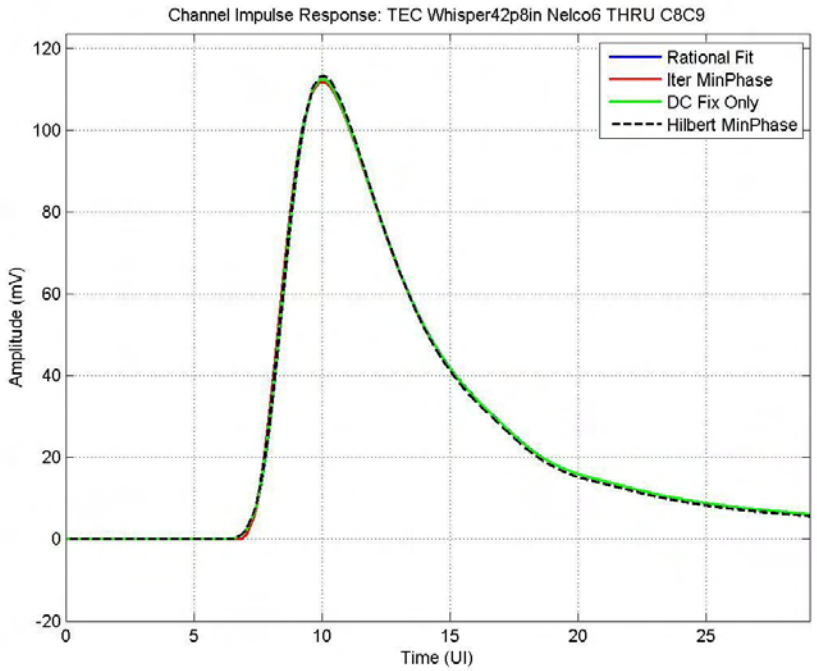
Ch5: Molex P2TX1.s4p

S-parameter to SBR Flow Example

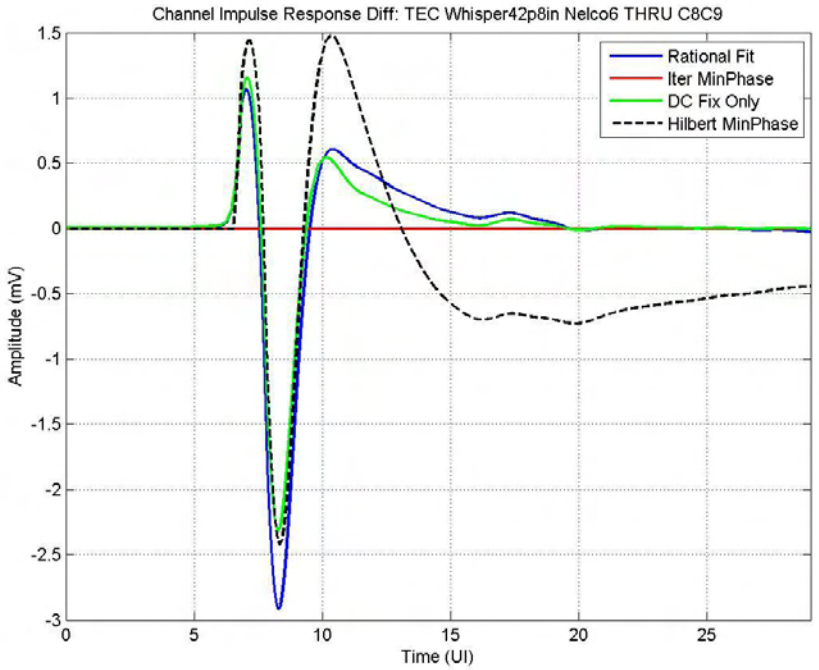


Ch1: TEC_Whisper42p8in_Nelco6_THRU_C8C9.s4p

Single Bit Response



SBR Comparison (Base=Iter. Min. Phase)

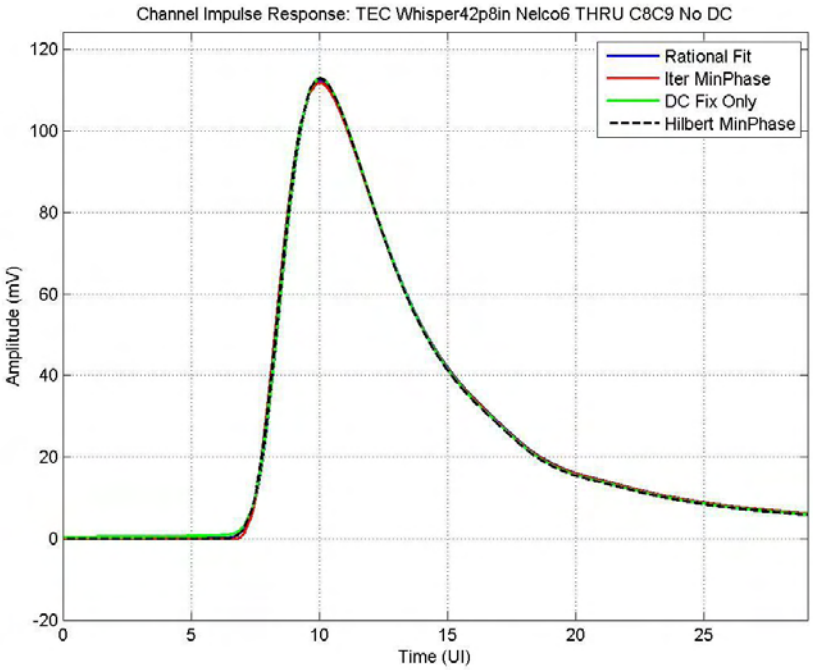


[-3 mv 1.5 mv]

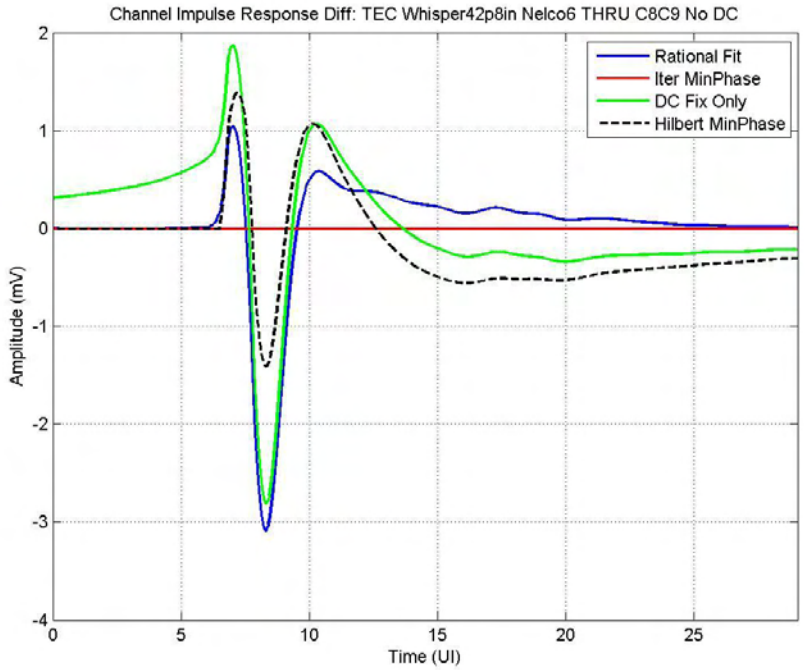
Channel	Fmin	Fmax	Fstep
TEC_Whisper42p8in_Nelco6_THRU_C8C9	0 MHz	40 GHz	10 MHz

Ch1a: TEC_Whisper42p8in_Nelco6_THRU_C8C9_No_DC.s4p

Single Bit Response



SBR Comparison (Base=Iter. Min. Phase)

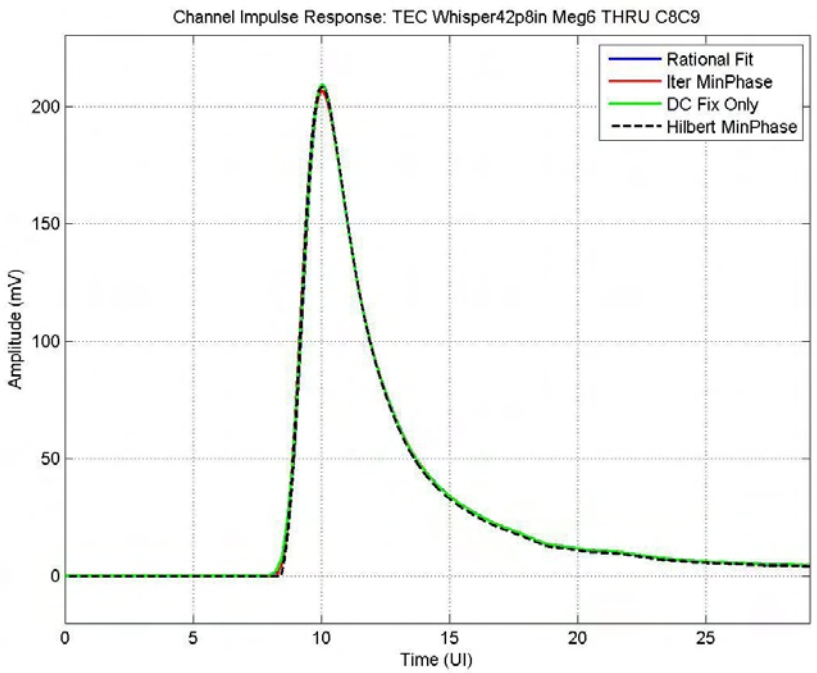


[-3.1 mv 1.8 mv]

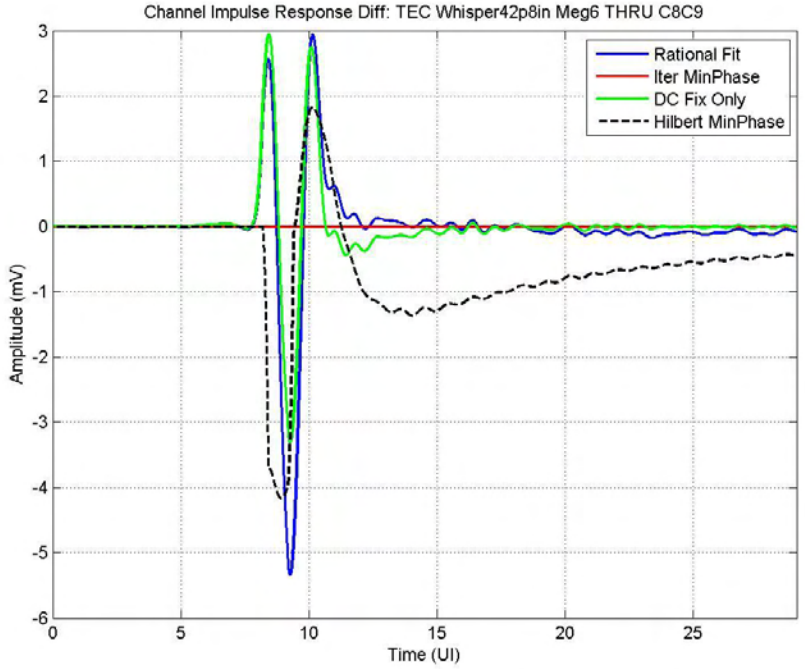
Channel	Fmin	Fmax	Fstep
TEC_Whisper42p8in_Nelco6_THRU_C8C9_No_DC	10 MHz	40 GHz	10 MHz

Ch2: TEC_Whisper42p8in_Meg6_THRU_C8C9.s4p

Single Bit Response



SBR Comparison (Base=Iter. Min. Phase)

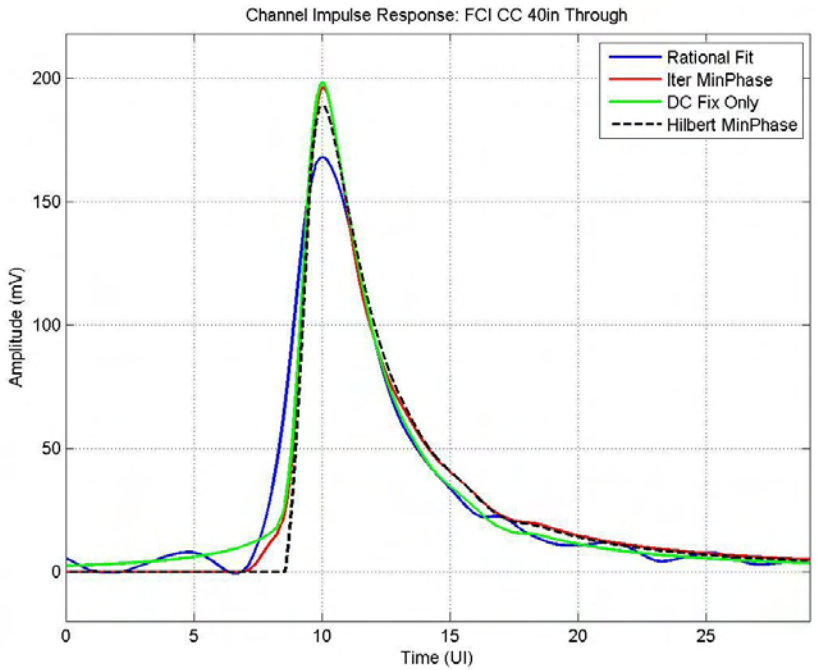


[-5.2 mv 3.0 mv]

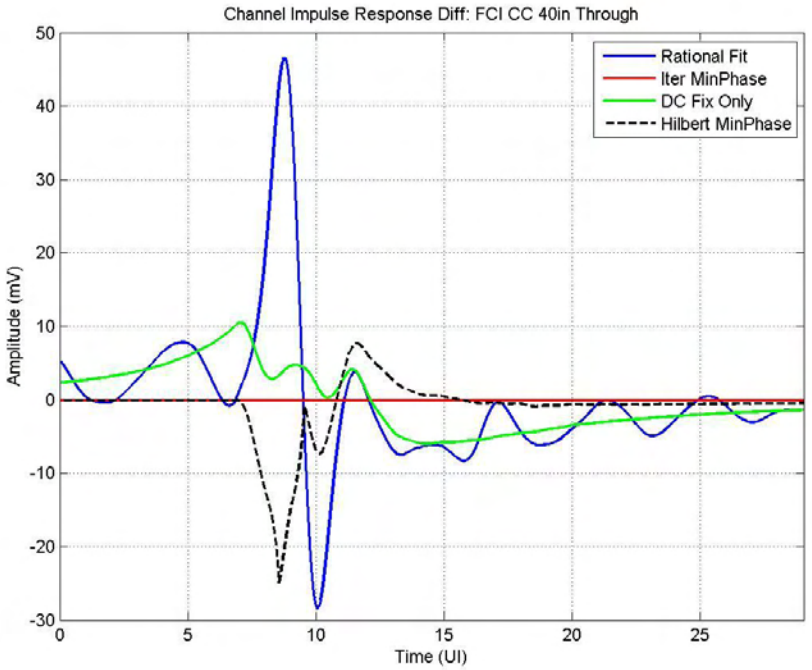
Channel	Fmin	Fmax	Fstep
TEC_Whisper42p8in_Meg6_THRU_C8C9	0 MHz	40 GHz	10 MHz

Ch3: FCI_CC_40in_Through.s4p

Single Bit Response



SBR Comparison (Base=Iter. Min. Phase)



[-28 mv 47 mv]

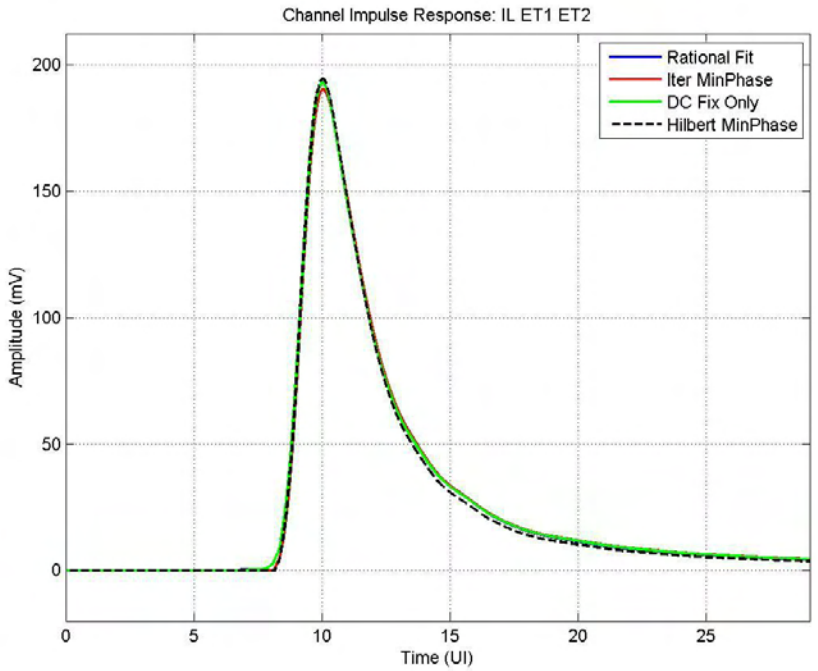
Observations

- *Rational Fitting failed to converge*
- *All but Hilbert minimum phase appears to have causality issue*
- *Hilbert Minimum-Phase method appears to have smaller peak amplitude than DC Fix Only and Iterative Minimum Phase methods.*

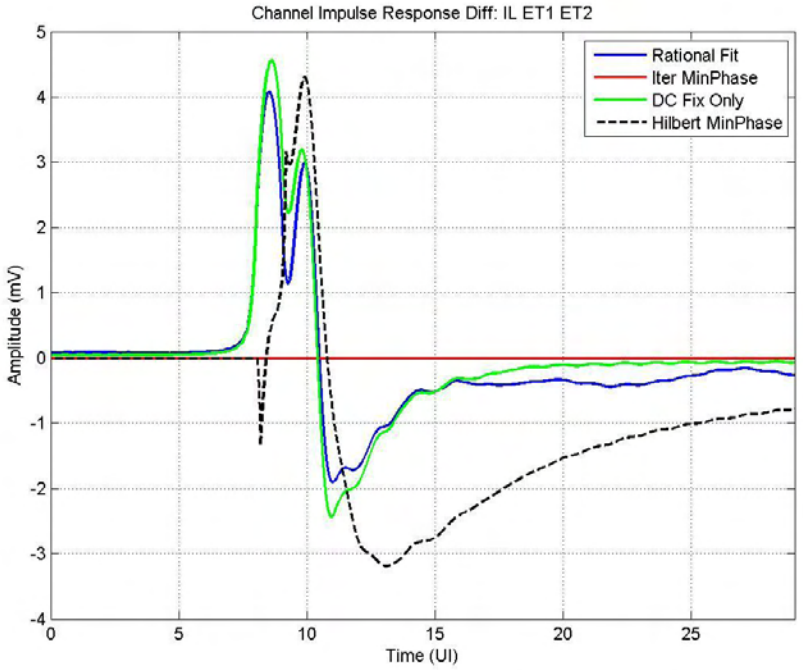
Channel	Fmin	Fmax	Fstep
FCI_CC_40in_Through	50 MHz	30GHz	50 MHz

Ch4: Qlogic IL_ET1_ET2.s4p

Single Bit Response



SBR Comparison (Base=Iter. Min. Phase)

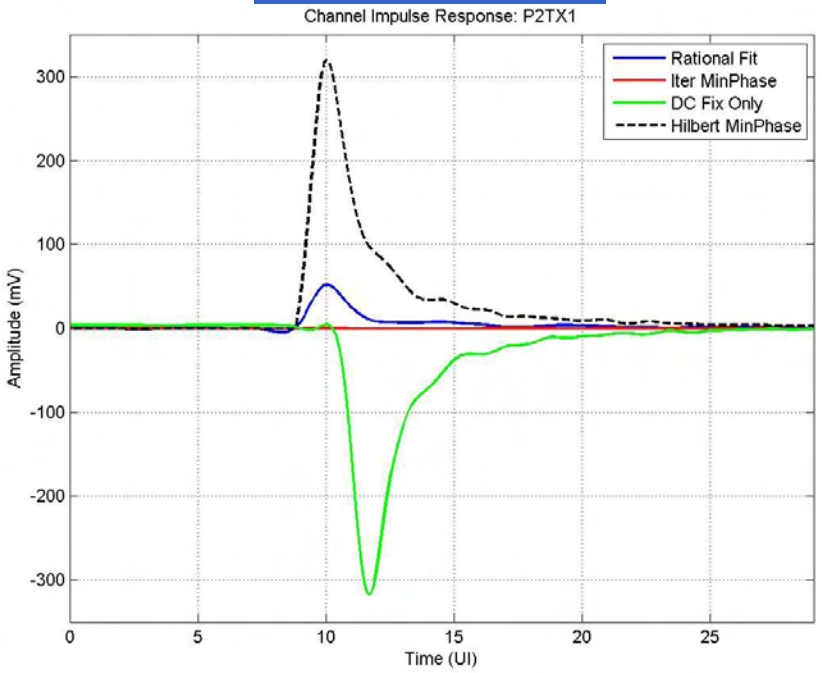


[-3.2 mv 4.5 mv]

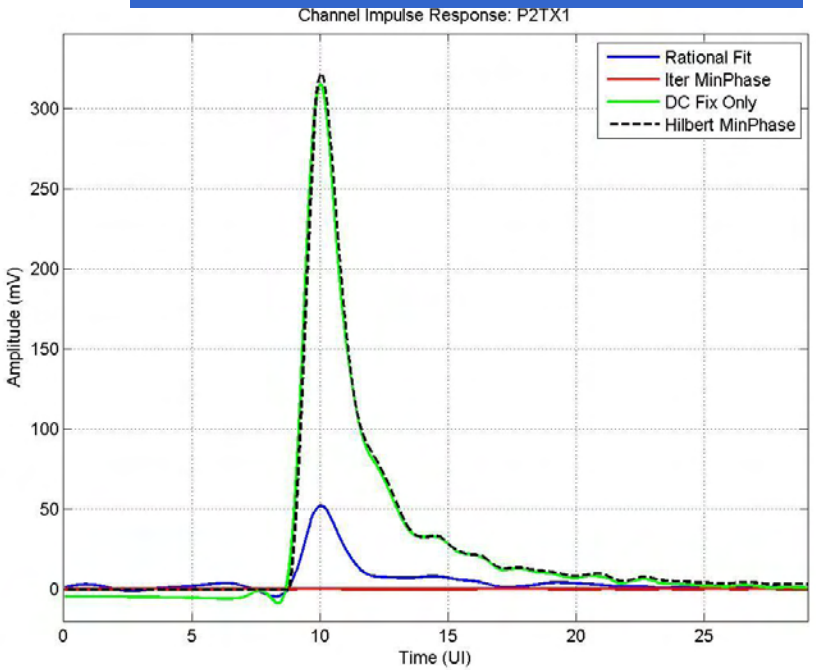
Channel	Fmin	Fmax	Fstep
Qlogic IL_ET1_ET2.s4p	0 MHz	40 GHz	40 MHz

Ch5: Molex 5M Cable P2TX1.s4p

Single Bit Response



Single Bit Response (After DC Phase Fix)



All methods but Hilbert method failed to generate proper SBR. Possible causes may be:

- DC extrapolation resulted in negative amplitude due to (incorrect?) DC phase offset.
- Long propagation delay (22ns, 5M cable)?
- Assumption for the port assignment? ((1,3)<->(2,4))

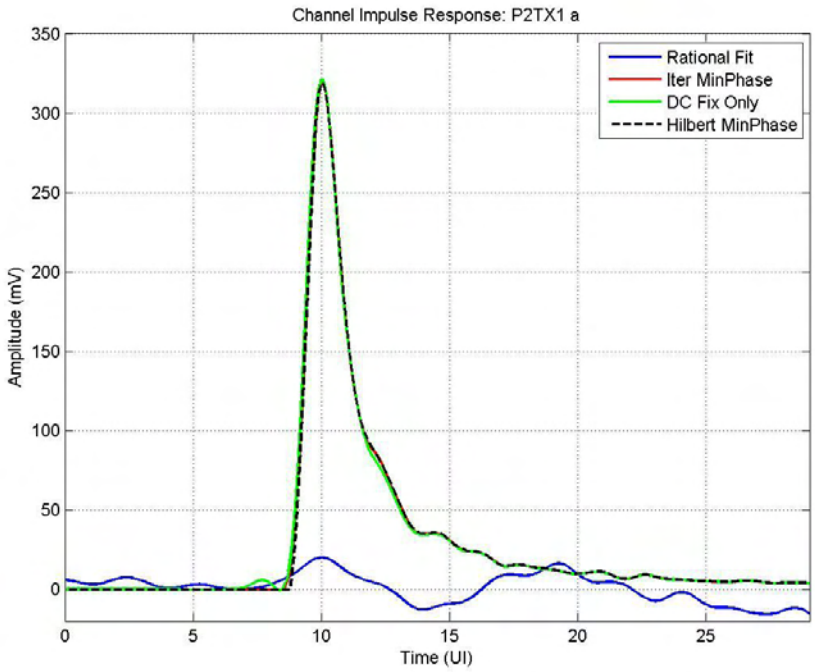
•By applying additional adjustment (e.g. remove DC phase offset), DC Fix only method works.

•Rational Fitting and Iterative Minimum Phase methods still failed to converge as they might need additional adjustments.

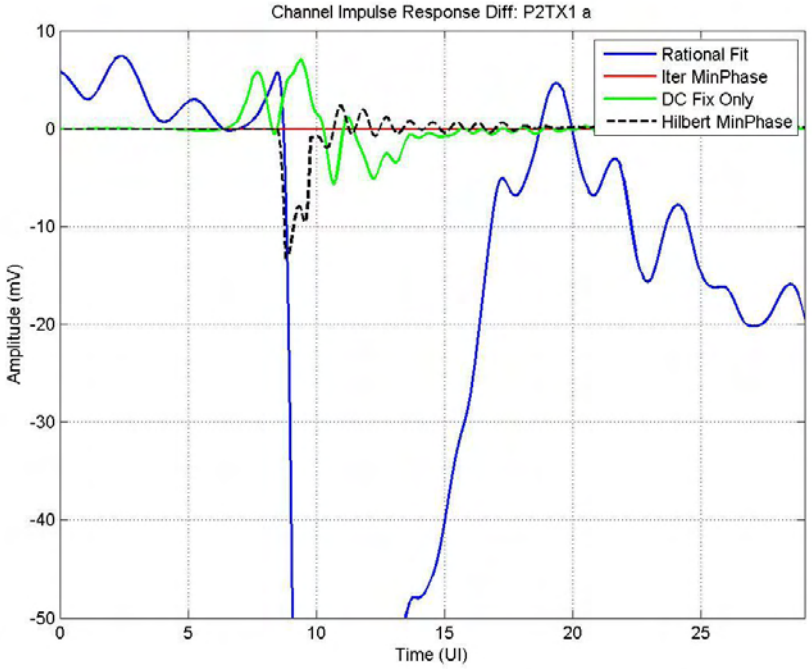
Channel	Fmin	Fmax	Fstep
Molex 5M Cable P2TX1.s4p	50 MHz	40 GHz	10 MHz

Ch5a: Molex 5M Cable P2TX1_a.s4p

Single Bit Response



Single Bit Response (w New Port Assignment)



By assuming another port assignment ((1,3)<->(4,2)), all but rational fitting method work

Channel	Fmin	Fmax	Fstep
Molex 5M Cable P2TX1_a.s4p	50 MHz	40 GHz	10 MHz

Results Summary

CH id / Method	1: Rational Fitting	2: Iter. Min. Phase	3: DC Fix Only	4: Hilbert Min. Phase
Ch 1: TEC_Whisper42p8in_Nelco6_THRU_C8C9	OK	OK	OK	OK
Ch 2: TEC_Whisper42p8in_Meg6_THRU_C8C9	OK	OK	OK	OK
Ch 3: FCI_CC_40in_Through	Failed	OK	Marginal	Marginal
Ch 4: Qlogic IL_ET1_ET2.s4p	OK	OK	OK	OK
Ch 5: Molex 5M Cable P2TX1.s4p	Failed	OK (w/ diff port assignment)	OK (w/ diff port assignment)	OK

OK: Indicate a visually reasonable SBR is generated.

Summary and Conclusion Remarks

- The quality of SBR critically depends on the original S-parameter data quality/configurations
  - Fmin (DC), Fstep, Fmax
  - Meaning of DC values, including both magnitude and phase
- Small SBR difference (e.g., [-3mv 1.5 mv]), large SBR difference (e.g., [-28 mv 47 mv]) are observed for 4 BPs, with 4 known/common S-parameter to SBR transformation methods
- CC S-parameters can be challenging for certain method
  - Rational-fitting method needs further improvement to work with CC due to long-propagation delay/phase wrapping
  - A large difference (e.g., [-13 mv 8 mv]) is observed for 1 CC, with 3 known/common/“working” S-parameter to SBR transformation methods

References

[1] "Modified Rational Function Modeling Technique for High Speed Circuits," R. Zeng and J. Sinsky, *IEEE MTT-S Int. Microwave Symp. Dig.*, San Francisco, CA, June 11–16, 2006

[2] ”Iterative Techniques for Minimum Phase Signal Reconstruction from Phase or Magnitude”, T. Quatieri and A. Oppenheim, *IEEE Trans. On Acoustics, Speech, and Signal Processing*, 1981

[3] “Discrete-Time Signal Processing (3rd Edition)”, A. Oppenheim and R. Schafer”, *Prentice Hall*, 2009

Thank You !