Balancing the 10G-KR link budget

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Simulation conditions

- Thru transmitter
  - Vout: 800mV$_{ppd}$
  - Rise/fall time: 47ps
  - Equalization: optimized within Rpre=[1:1.56] & Rpst=[1:4]
  - Return Loss: Mellitz model - cap changed to 0.63pF and R = 53ohm (meets RL template)
  - Jitter:
    - Rj:0.15 UIpp
    - Dj:0.105 UIpp (0.025UI DCD)

- Xtalk transmitter
  - Vout: 1200mV$_{ppd}$ & 1000mV$_{ppd}$
  - Rise/fall time: 30ps, 37ps
  - Equalization: [Rpre,Rpst] = [1,1] & [1.33,1.33], ([c_{-1},c_0,c_1] = [0,1,0],[-0.125,0.75,-0.125])

- Receiver
  - Return Loss: Mellitz model - cap changed to 0.63pF and R = 53ohm (meets RL template)
  - Jitter:
    - Rj: 0.15 UIpp
    - CDR model
  - 5-tap DFE with quantization
  - 1.46mV RMS external noise

Simulation process

- Equalization optimized in the presence of all noise aggressors
- PDF[1] calculated for each noise aggressor (residual ISI, crosstalk, jitter, AWGN, etc.)
- Final PDF calculated by combining all noise aggressors together
- System BER[2] is the point on the final PDF where the total noise level equals the equalized pulse response

1) PDF = Probability Density Function
2) BER = Bit Error Ratio

Current channel recommendations

Channel	Amax	IL	ILD	RL	ICRf	ICRt	ICRn	SIMf	SIMt	SIMn
'Media/EoBP_DAmbrosia/DAmbrosia_1T'	'Fail'	'Fail'	'PASS'	'PASS'	'Fail'	'Fail'	'PASS'	-5.63	-10.56	-13.92
'Media/EoBP_DAmbrosia/DAmbrosia_2T'	'Fail'	'Fail'	'PASS'	'PASS'	'Fail'	'Fail'	'PASS'	-5.17	-9.26	-12.42
'Media/EoBP_DAmbrosia/DAmbrosia_3T'	'Fail'	'Fail'	'PASS'	'PASS'	'Fail'	'Fail'	'Fail'	-4.37	-8.31	-11.01
'Media/EoBP_DAmbrosia/DAmbrosia_4T'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'Fail'	'PASS'	-6.28	-10.7	-13.21
'Media/EoBP_DAmbrosia/DAmbrosia_5T'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'Fail'	'PASS'	-8.04	-12.02	-13.75
'Media/EoBP_DAmbrosia/DAmbrosia_6T'	'PASS'	'Fail'	'Fail'	'PASS'	'Fail'	'Fail'	'Fail'	-0.31	-4.93	-5.75
'Media/EoBP_DAmbrosia/DAmbrosia_7T'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'PASS'	'PASS'	-7.48	-10.08	-11.25
'Media/EoBP_Molex/Molex_Inthru2'	'Fail'	'PASS'	'PASS'	'PASS'	'Fail'	'Fail'	'Fail'	-0.31	-5.68	-8.01
'Media/EoBP_Molex/Molex_Inthru3'	'Fail'	'PASS'	'PASS'	'PASS'	'Fail'	'Fail'	'Fail'	-0.31	-0.31	-5.34
'Media/EoBP_Molex/Molex_Inthru4'	'Fail'	'Fail'	'PASS'	'PASS'	'Fail'	'Fail'	'Fail'	-0.31	-0.31	-6.13
'Media/EoBP_Molex/Molex_Inthru5'	'Fail'	'PASS'	'PASS'	'PASS'	'Fail'	'Fail'	'Fail'	-0.31	-6.07	-8.73
'Media/EoBP_Molex/Molex_Outthru2'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'PASS'	'PASS'	-4.55	-8.22	-11.6
'Media/EoBP_Molex/Molex_Outthru3'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'Fail'	'Fail'	-0.31	-5.18	-8.18
'Media/EoBP_Molex/Molex_Outthru4'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'Fail'	'Fail'	-0.31	-5.79	-8.49
'Media/EoBP_Molex/Molex_Outthru5'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'PASS'	'PASS'	-4.57	-8.93	-12.49
'Media/EoBP_PetersNew/peters_B12thru'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'PASS'	'PASS'	-7.54	-12.98	-15.38
'Media/EoBP_PetersNew/peters_B1thru'	'PASS'	'PASS'	'Fail'	'PASS'	'Fail'	'Fail'	'PASS'	-8.59	-13.29	-15
'Media/EoBP_PetersNew/peters_B20thru'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'Fail'	'PASS'	-6.49	-12.28	-15.52
'Media/EoBP_PetersNew/peters_M1thru'	'PASS'	'PASS'	'Fail'	'PASS'	'Fail'	'Fail'	'Fail'	-8.74	-12.87	-13.71
'Media/EoBP_PetersNew/peters_M20thru'	'PASS'	'PASS'	'PASS'	'PASS'	'Fail'	'Fail'	'PASS'	-6.61	-11.84	-14.84

Test conditions:
- ICRf is the ICR calculated with PSYS = 5.5
- ICRt is the ICR calculated with PSYS = 1.94
- ICRn is the ICR calculated with PSYS = 0

Simulation Xtlk conditions (Vout, Trf, Tx eq setting):
- SIMf is with Xtlk (1200mV, 30ps, [0,1,0])
- SIMt is with Xtlk (1000mV, 37ps, [-0.125, .75, -0.125]
- SIMn is with Xtlk = Thru

Channel limit modification #1

1. PRI (power of the channel's residual ISI)
   1. Take inverse FFT of the channel insertion loss with Fs = n*signaling speed, n>=5.
   2. Find the peak of the impulse response from 1, IPR.
   3. Zero out the impulse response from -1 UI to 5 UI about the peak, IRZ.
   4. Calculate PRI = $10 * \text{Log}_{10}((\text{IPR}^2)/(\text{sum}(\text{IRZ}^2)/n))$.
   5. PRI >= 18dB.
2. PISI(f) (power spectrum of the channel's residual ISI)
   1. Take the FFT of the result from PRI step 3.
3. ICR modification
   1. Add PISI as a third term in PSXT, eq. 69B-17.
   2. Remove PILD, P. 194 lines 41-51.
   3. Remove ICR fit calculations, P. 195 Lines 16-39.
   4. Change fb = signaling speed.
   5. ICR(f) - PSYS >= 10 for fa <= f <= fb/2 .
   6. ICR(f) - PSYS >= 10 - 4.9e-9*(f-fb/2) for fb/2 <= f <= fb.

Normative channel proposal #1

Channel	PRI	ICRf	ICRt	ICRn	SIMf	SIMt	SIMn
'Media/EoBP_DAmbrosia/DAmbrosia_1T'	'Fail'	'Fail'	'Fail'	'Fail'	-5.6	-10.6	-14
'Media/EoBP_DAmbrosia/DAmbrosia_2T'	'Fail'	'Fail'	'Fail'	'Fail'	-5.1	-9.3	-12.3
'Media/EoBP_DAmbrosia/DAmbrosia_3T'	'Fail'	'Fail'	'Fail'	'Fail'	-0.3	-8.2	-10.9
'Media/EoBP_DAmbrosia/DAmbrosia_4T'	'PASS'	'Fail'	'Fail'	'Fail'	-6.3	-10.9	-13.4
'Media/EoBP_DAmbrosia/DAmbrosia_5T'	'PASS'	'Fail'	'PASS'	'PASS'	-8.2	-12.4	-14.2
'Media/EoBP_DAmbrosia/DAmbrosia_6T'	'PASS'	'Fail'	'Fail'	'Fail'			-5.9
'Media/EoBP_DAmbrosia/DAmbrosia_7T'	'PASS'	'Fail'	'Fail'	'PASS'	-7.7	-10.7	-11.9
'Media/EoBP_Molex/Molex_Inthru2'	'Fail'	'Fail'	'Fail'	'PASS'			-8.3
'Media/EoBP_Molex/Molex_Inthru3'	'Fail'	'Fail'	'Fail'	'Fail'			-5.5
'Media/EoBP_Molex/Molex_Inthru4'	'Fail'	'Fail'	'Fail'	'Fail'			-6.3
'Media/EoBP_Molex/Molex_Inthru5'	'Fail'	'Fail'	'Fail'	'PASS'			-8.9
'Media/EoBP_Molex/Molex_Outthru2'	'Fail'	'Fail'	'Fail'	'PASS'	-4.6	-8.5	-11.9
'Media/EoBP_Molex/Molex_Outthru3'	'Fail'	'Fail'	'Fail'	'Fail'			-8.3
'Media/EoBP_Molex/Molex_Outthru4'	'Fail'	'Fail'	'Fail'	'PASS'			-8.7
'Media/EoBP_Molex/Molex_Outthru5'	'Fail'	'Fail'	'Fail'	'PASS'	-4.1	-9.2	-14
'Media/EoBP_PetersNew/peters_B12thru'	'PASS'	'Fail'	'PASS'	'PASS'	-7.6	-13.6	-15.9
'Media/EoBP_PetersNew/peters_B1thru'	'PASS'	'Fail'	'PASS'	'PASS'	-8.9	-14.2	-15.8
'Media/EoBP_PetersNew/peters_B20thru'	'PASS'	'Fail'	'PASS'	'PASS'	-6.5	-12.7	-15.8
'Media/EoBP_PetersNew/peters_M1thru'	'PASS'	'Fail'	'PASS'	'PASS'	-8.9	-13.2	-14.3
'Media/EoBP_PetersNew/peters_M20thru'	'PASS'	'Fail'	'PASS'	'PASS'	6.7	-12.2	-15.2

Test conditions:
- ICRf is the ICR calculated with PSYS = 5.5
- ICRt is the ICR calculated with PSYS = 1.94
- ICRn is the ICR calculated with PSYS = 0

Simulation Xtlk conditions (Vout, Trf, Tx eq setting):
- SIMf is with Xtlk (1200mV, 30ps, [0,1,0])
- SIMt is with Xtlk (1000mV, 37ps, [-0.125, .75, -0.125]
- SIMn is with Xtlk = Thru

Channel limit modification #2

1. PISI(f) (power spectrum of the channel's residual ISI)
   1. Take inverse FFT of the channel insertion loss with Fs = n*signaling speed, n>=5.
   2. Find the peak of the impulse response from 1, IPR.
   3. Zero out the impulse response from -1 UI to 5 UI about the peak, IRZ.
   4. Take the FFT of the result from step3.
2. ICR modification
   1. Calculate $Pnoise(f) = 10*\log_{10}(10^{(-(PSXT(f)-PSYS)/10)}+10^{(-PISI(f)/10)})$
   2. Remove PILD, P. 194 lines 41-51.
   3. ICR(f) = Pnoise(f) - IL(f)
   4. Perform the ICR_{fit} calculations
   5. Change fb = signaling speed.
   6. $ICR_{fit}(f) >= 25.7 - 2.97e\text{-}9*f$ for fa <= f <= fb.

Normative channel proposal #2

Channel	ICRf	ICRt	ICRn	SIMf	SIMt	SIMn
'Media/EoBP_DAmbrosia/DAmbrosia_1T'	'Fail'	'Fail'	'Fail'	-5.6	-10.6	-14
'Media/EoBP_DAmbrosia/DAmbrosia_2T'	'Fail'	'Fail'	'Fail'	-5.1	-9.3	-12.3
'Media/EoBP_DAmbrosia/DAmbrosia_3T'	'Fail'	'Fail'	'Fail'	-0.3	-8.2	-10.9
'Media/EoBP_DAmbrosia/DAmbrosia_4T'	'Fail'	'Fail'	'PASS'	-6.3	-10.9	-13.4
'Media/EoBP_DAmbrosia/DAmbrosia_5T'	'Fail'	'PASS'	'PASS'	-8.2	-12.4	-14.2
'Media/EoBP_DAmbrosia/DAmbrosia_6T'	'Fail'	'Fail'	'Fail'			-5.9
'Media/EoBP_DAmbrosia/DAmbrosia_7T'	'Fail'	'Fail'	'PASS'	-7.7	-10.7	-11.9
'Media/EoBP_Molex/Molex_Inthru2'	'Fail'	'Fail'	'Fail'			-8.3
'Media/EoBP_Molex/Molex_Inthru3'	'Fail'	'Fail'	'Fail'			-5.5
'Media/EoBP_Molex/Molex_Inthru4'	'Fail'	'Fail'	'Fail'			-6.3
'Media/EoBP_Molex/Molex_Inthru5'	'Fail'	'Fail'	'Fail'			-8.9
'Media/EoBP_Molex/Molex_Outthru2'	'Fail'	'Fail'	'Fail'	-4.6	-8.5	-11.9
'Media/EoBP_Molex/Molex_Outthru3'	'Fail'	'Fail'	'Fail'			-8.3
'Media/EoBP_Molex/Molex_Outthru4'	'Fail'	'Fail'	'Fail'			-8.7
'Media/EoBP_Molex/Molex_Outthru5'	'Fail'	'Fail'	'Fail'	-4.1	-9.2	-14
'Media/EoBP_PetersNew/peters_B12thru'	'Fail'	'PASS'	'PASS'	-7.6	-13.6	-15.9
'Media/EoBP_PetersNew/peters_B1thru'	'Fail'	'PASS'	'PASS'	-8.9	-14.2	-15.8
'Media/EoBP_PetersNew/peters_B20thru'	'Fail'	'PASS'	'PASS'	-6.5	-12.7	-15.8
'Media/EoBP_PetersNew/peters_M1thru'	'Fail'	'PASS'	'PASS'	-8.9	-13.2	-14.3
'Media/EoBP_PetersNew/peters_M20thru'	'Fail'	'PASS'	'PASS'	6.7	-12.2	-15.2

Test conditions:
- ICRf is the ICR calculated with PSYS = 5.5
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- ICRn is the ICR calculated with PSYS = 0

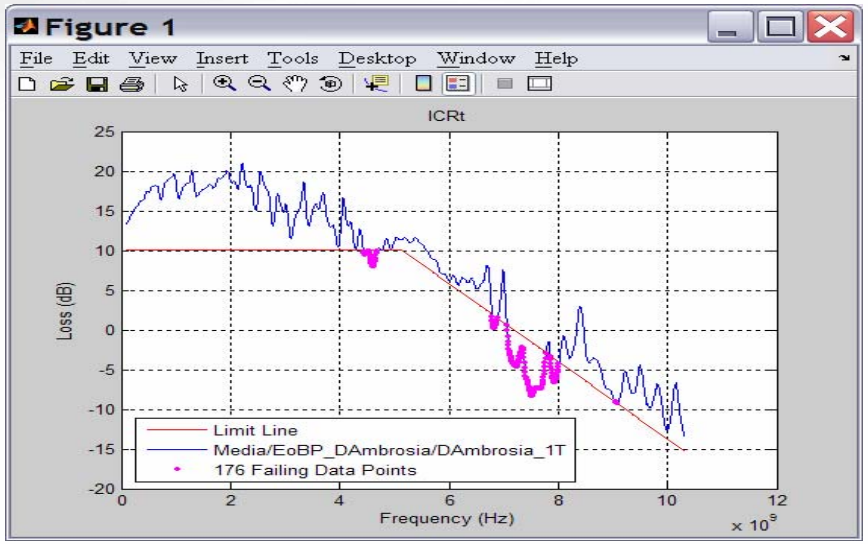
Simulation Xtlk conditions (Vout, Trf, Tx eq setting):
- SIMf is with Xtlk (1200mV, 30ps, [0,1,0])
- SIMt is with Xtlk (1000mV, 37ps, [-0.125, .75, -0.125]
- SIMn is with Xtlk = Thru

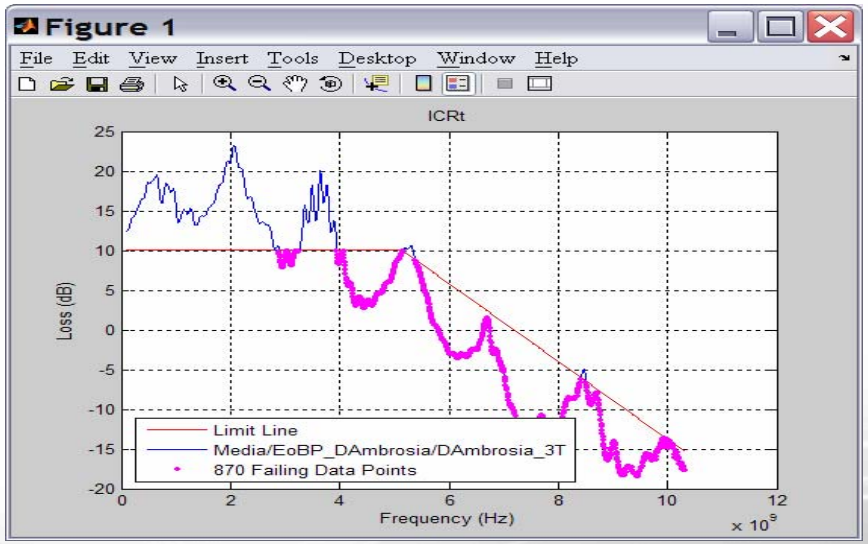
Summary

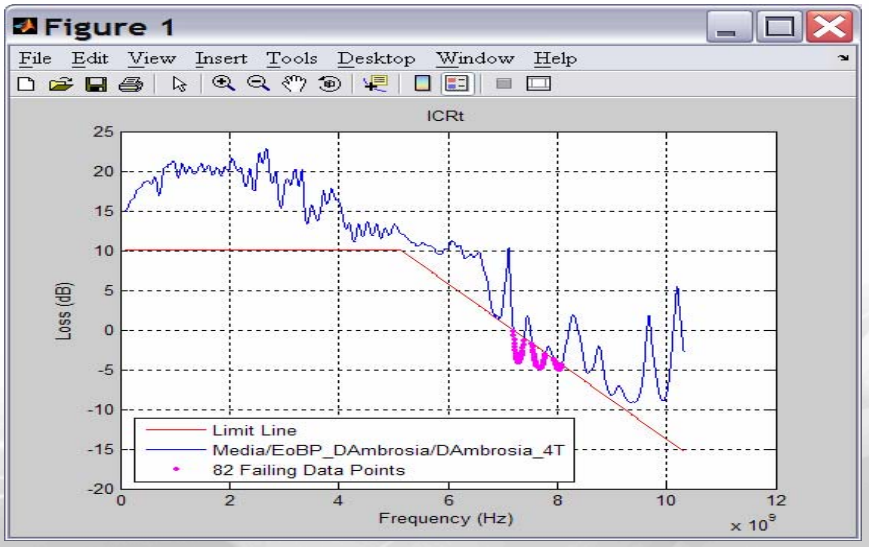
- Defined a channel SNR (PRI) of the channel impulse response peek to the channel residual ISI.
- Defined a channel residual ISI noise power spectrum (PISI)
- Presented two options to modify ICR for use as a normative channel specification
  - Option 1: PRI <= 18dB, add in PISI as a 3rd term in the PSXT calculation removed PILD and ICR fit calculations.
    - ICR - PSYS >= 10 for fa<=f<=fb/2
    - ICR - PSYS >= 10 + 4.9e-9*(f-fb/2) for fb/2<f<=fb.
  - Option 2: remove PILD, define
    - $Pnoise(f) = 10*\log_{10}(10^{(-(PSXT(f)-PSYS)/10)}+10^{(-PISI(f)/10)})$
    - ICR(f) = Pnoise(f) - IL(f)
    - $ICR_{fit}(f) >= 25.7 - 2.97e\text{-}9*f$ for fa <= f <= fb
- Recommend Option #2 as a normative channel specification.

Backup Slides

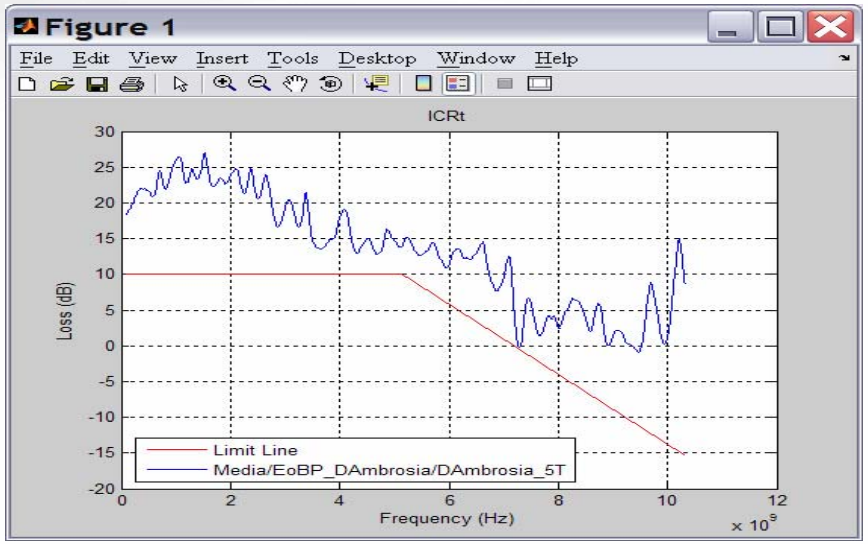
ICR vs. Limit, PSYS=1.94dB

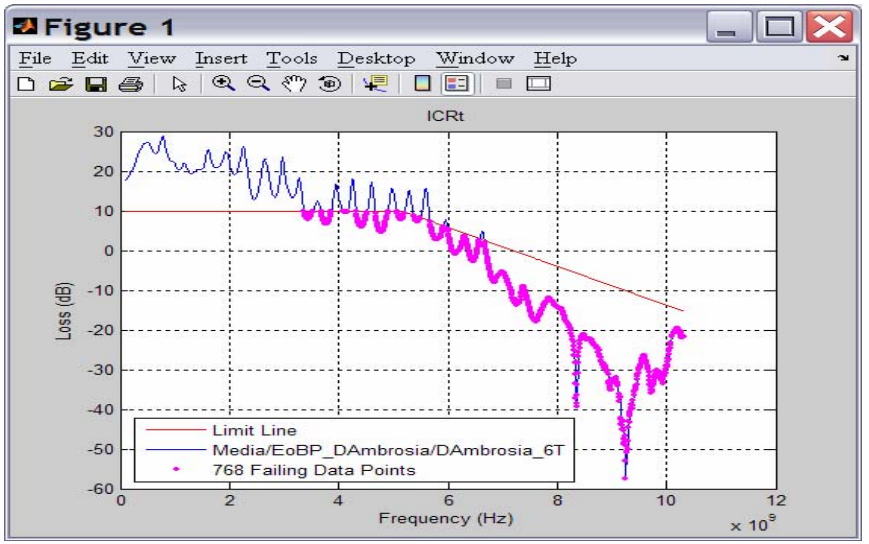


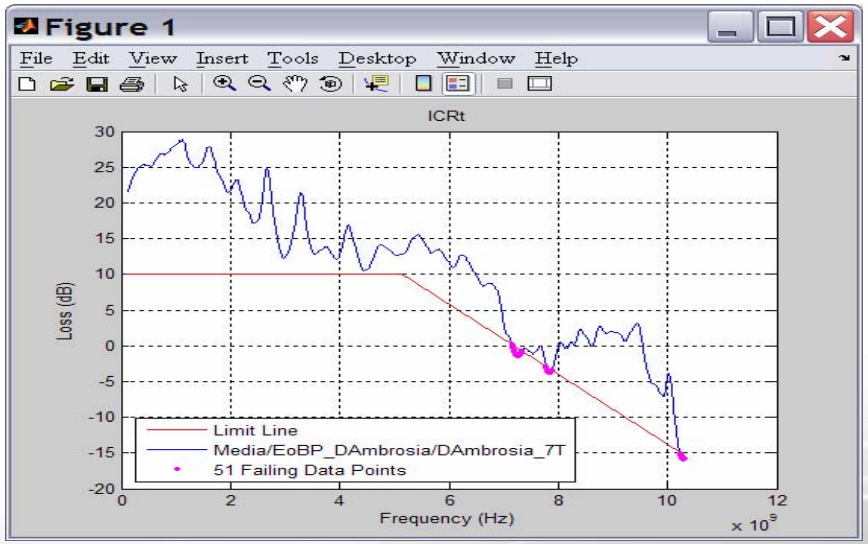


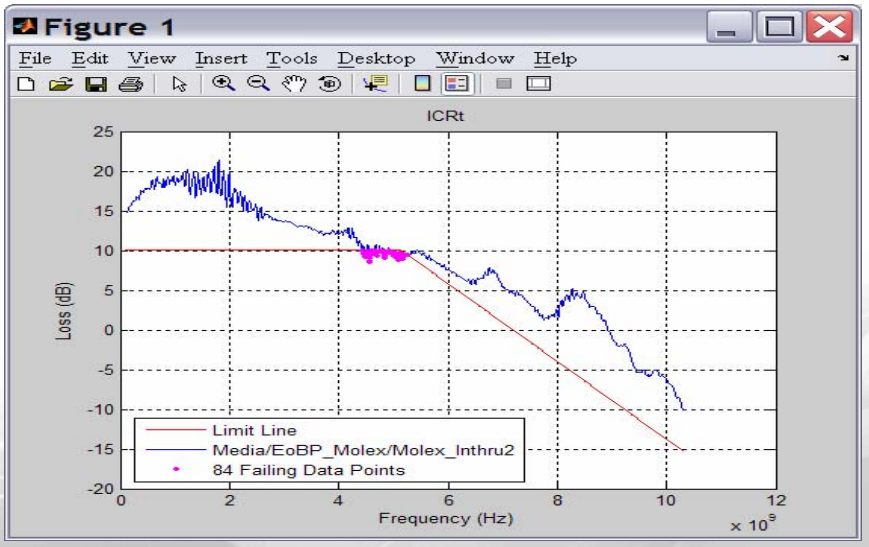


ICR vs. Limit, PSYS=1.94dB

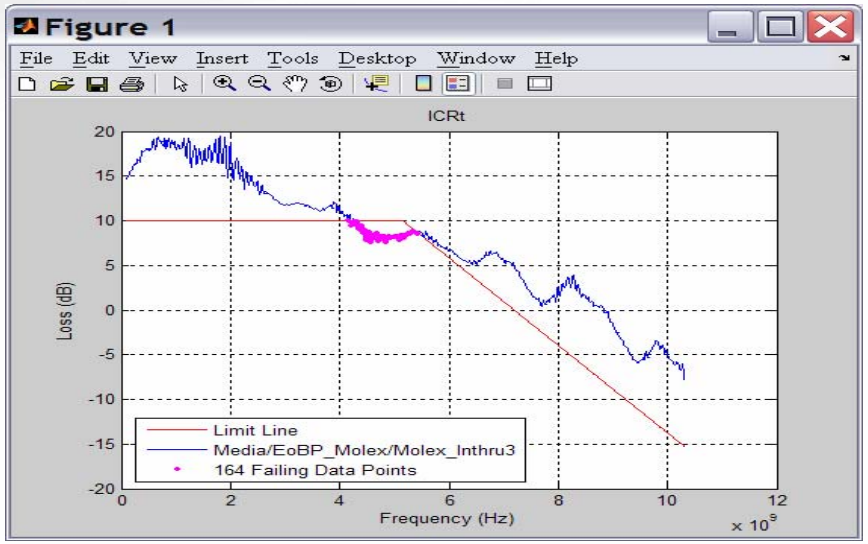


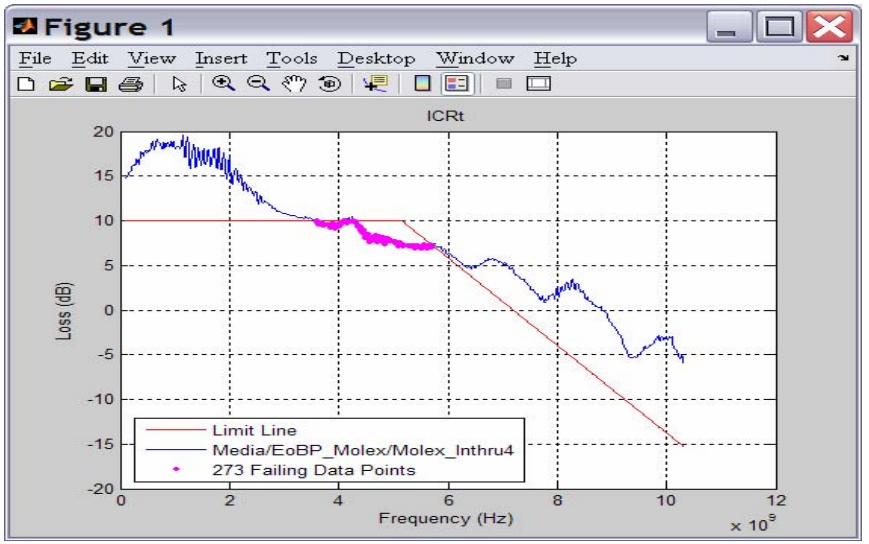


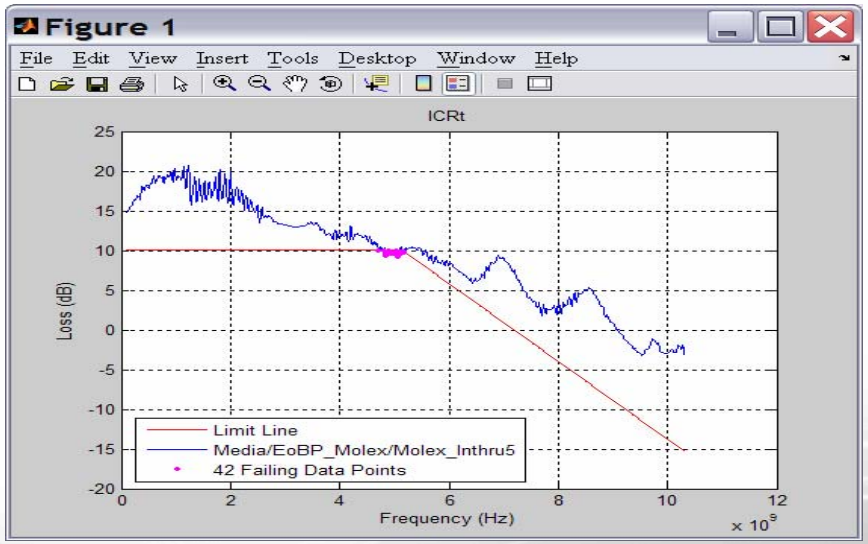


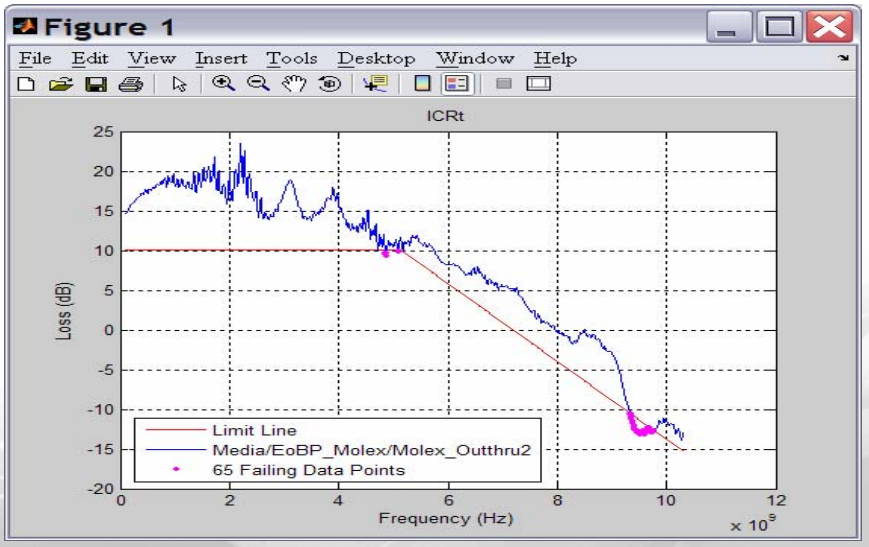


ICR vs. Limit, PSYS=1.94dB

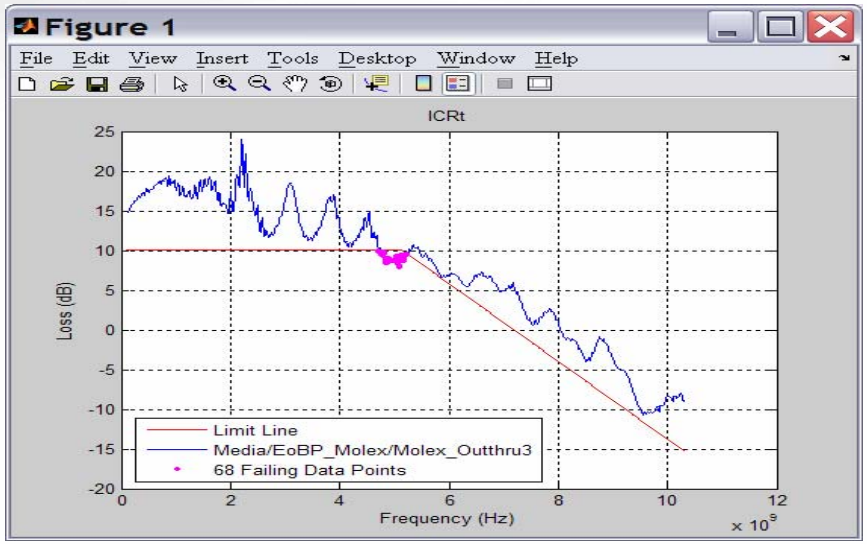


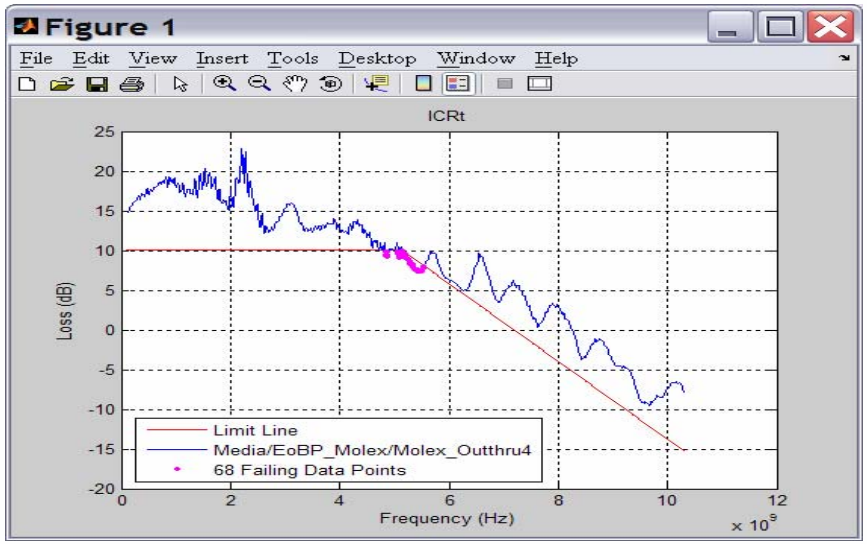


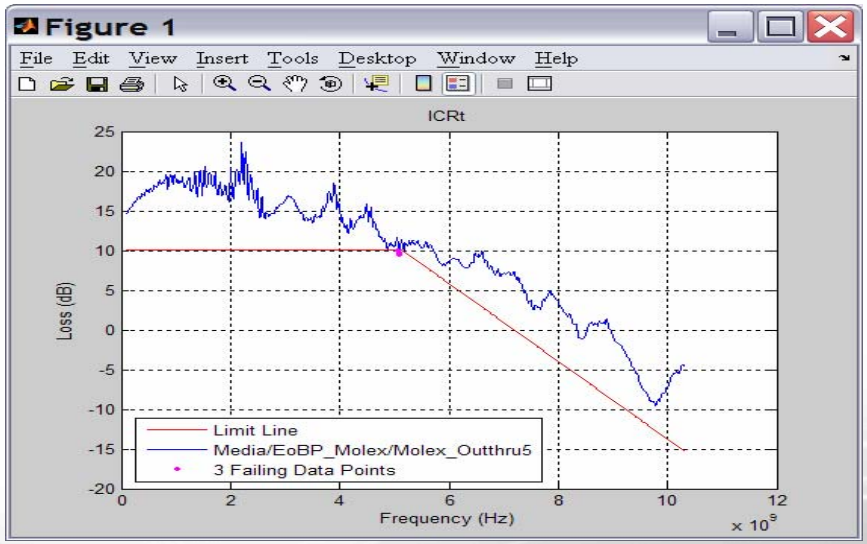


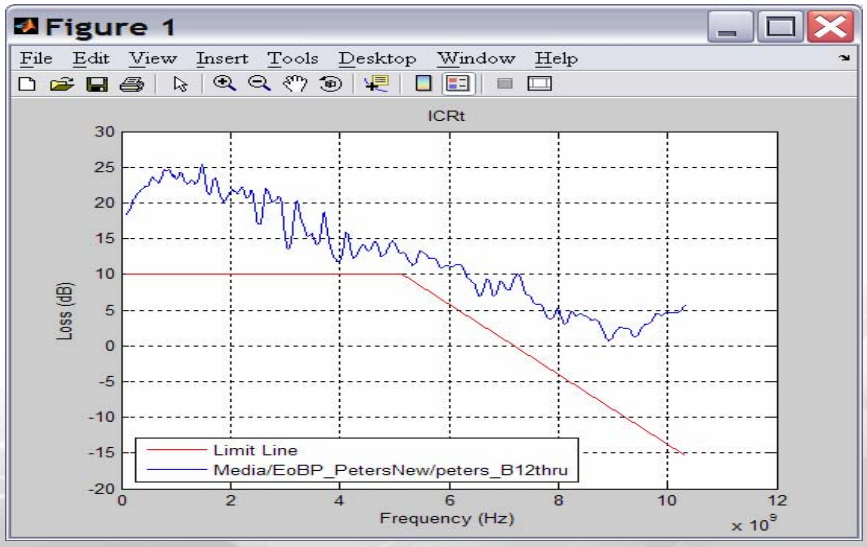


ICR vs. Limit, PSYS=1.94dB

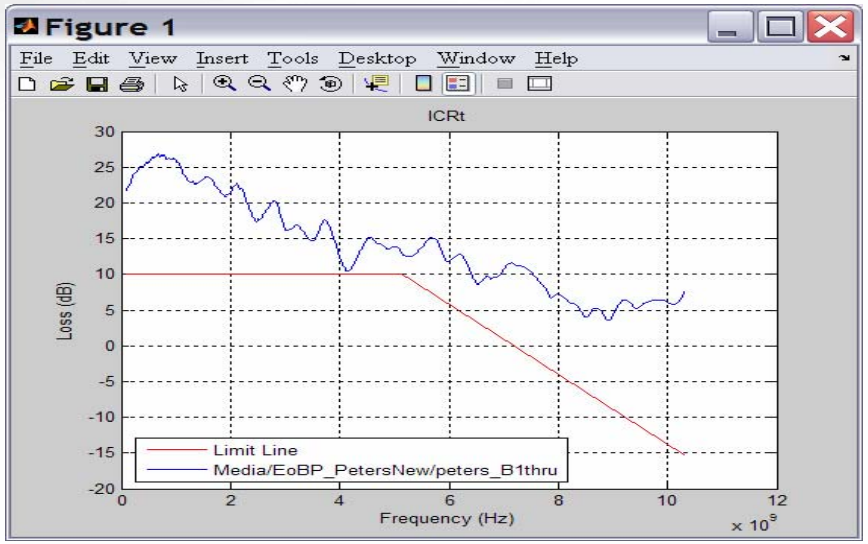


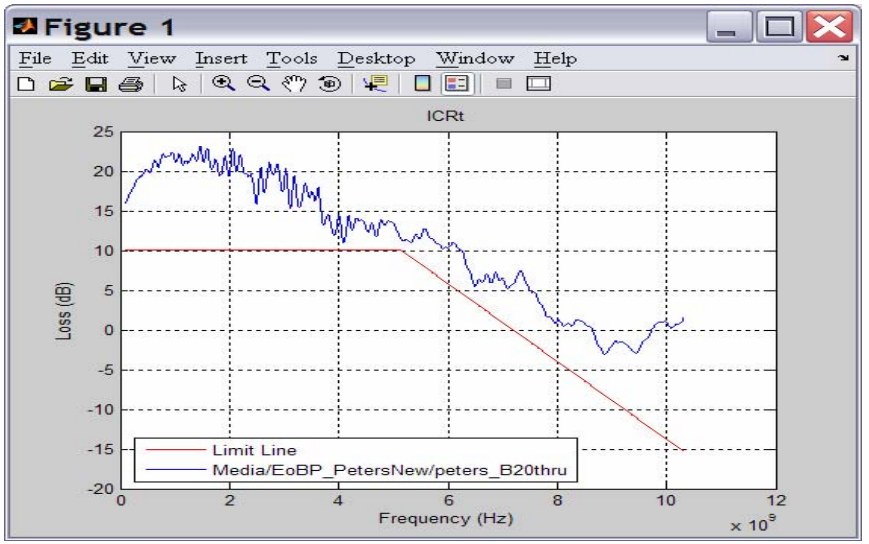


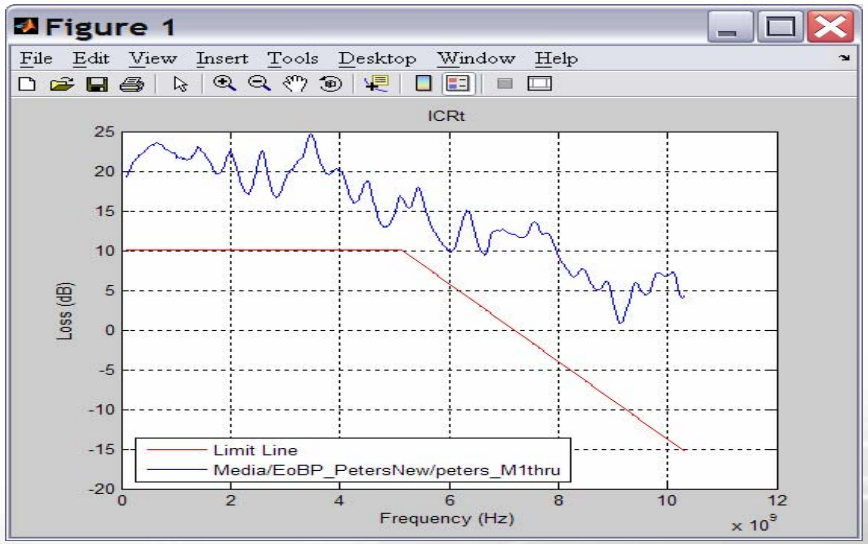


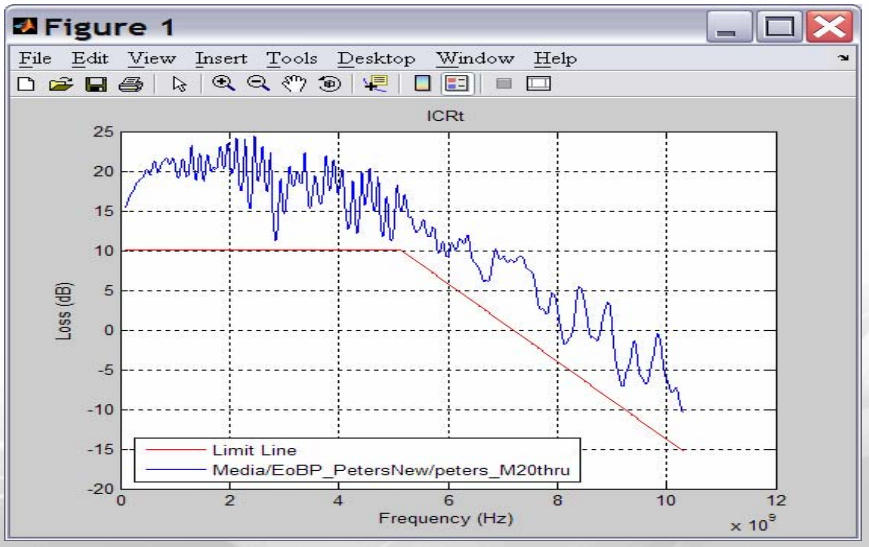


ICR vs. Limit, PSYS=1.94dB

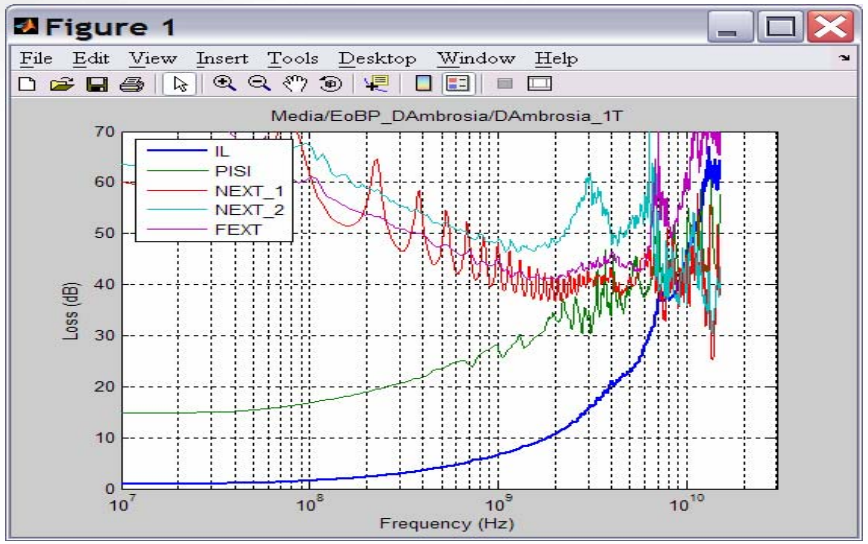


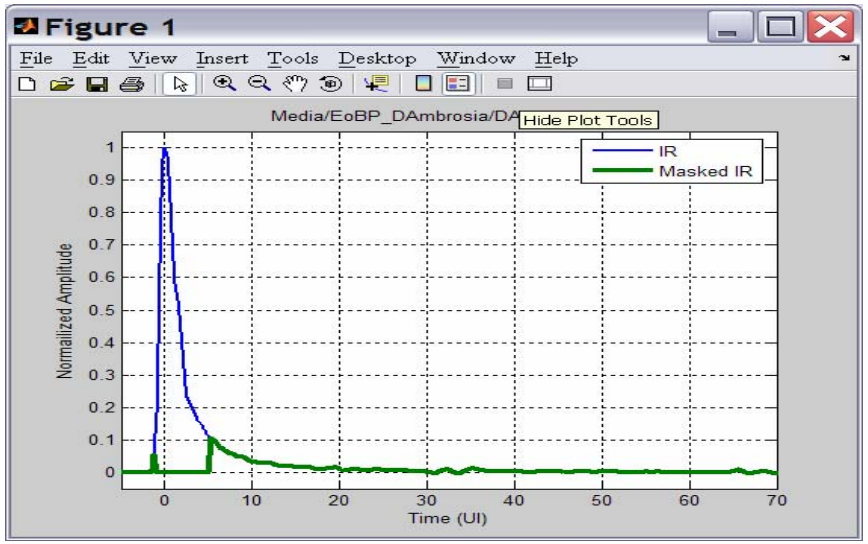


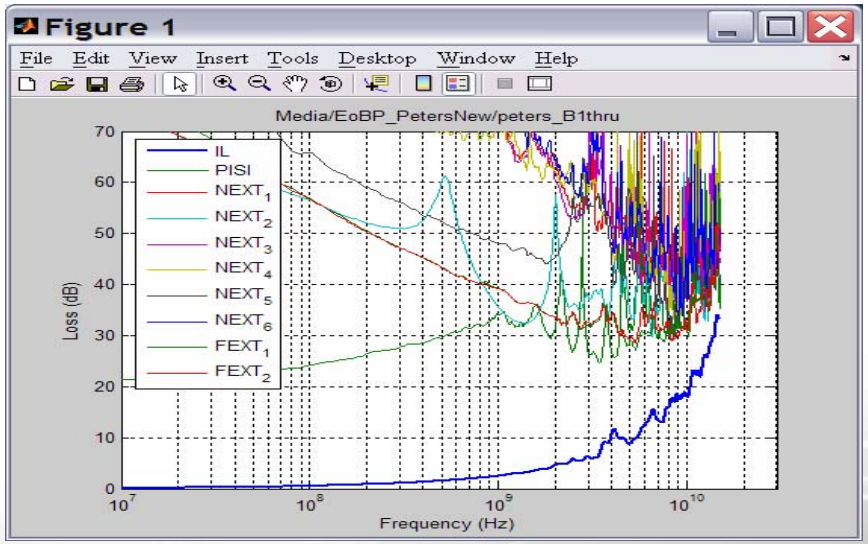


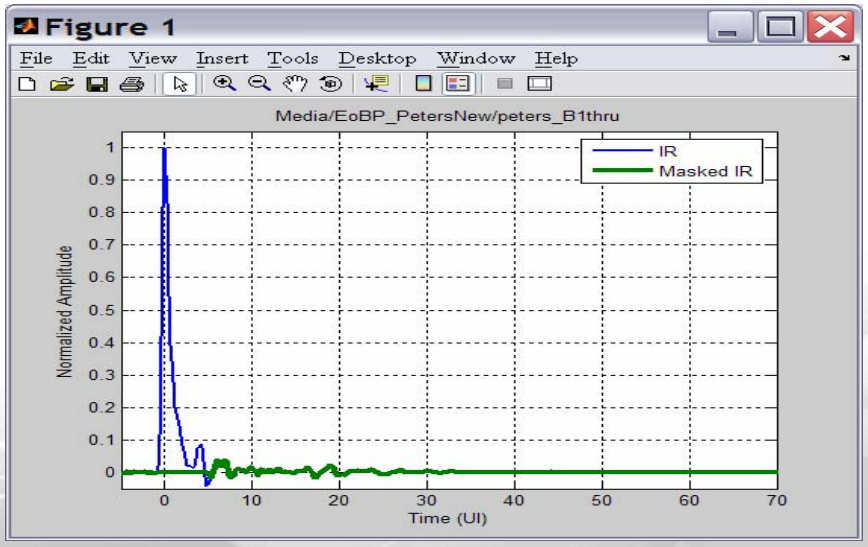


Example Channels

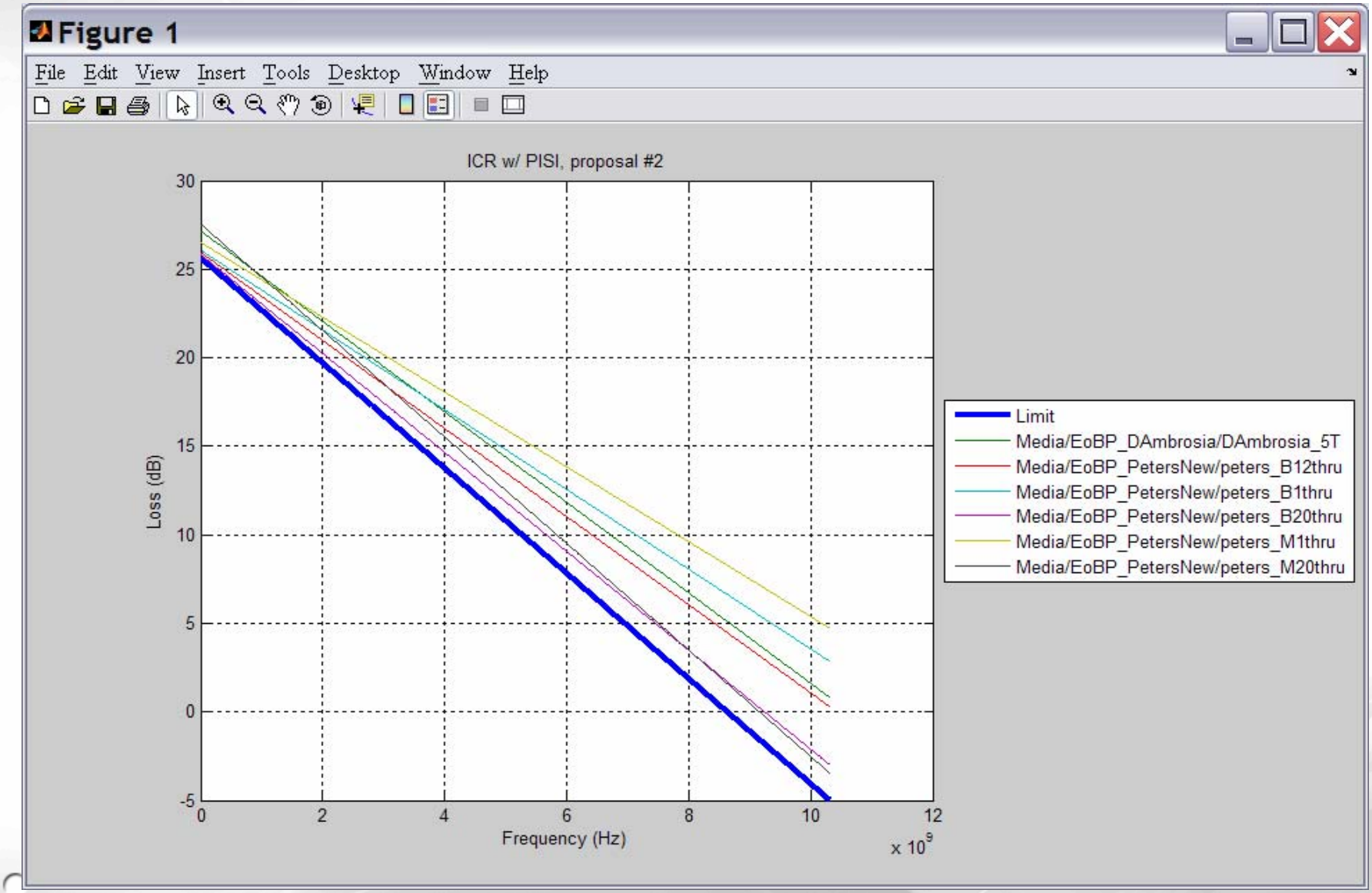




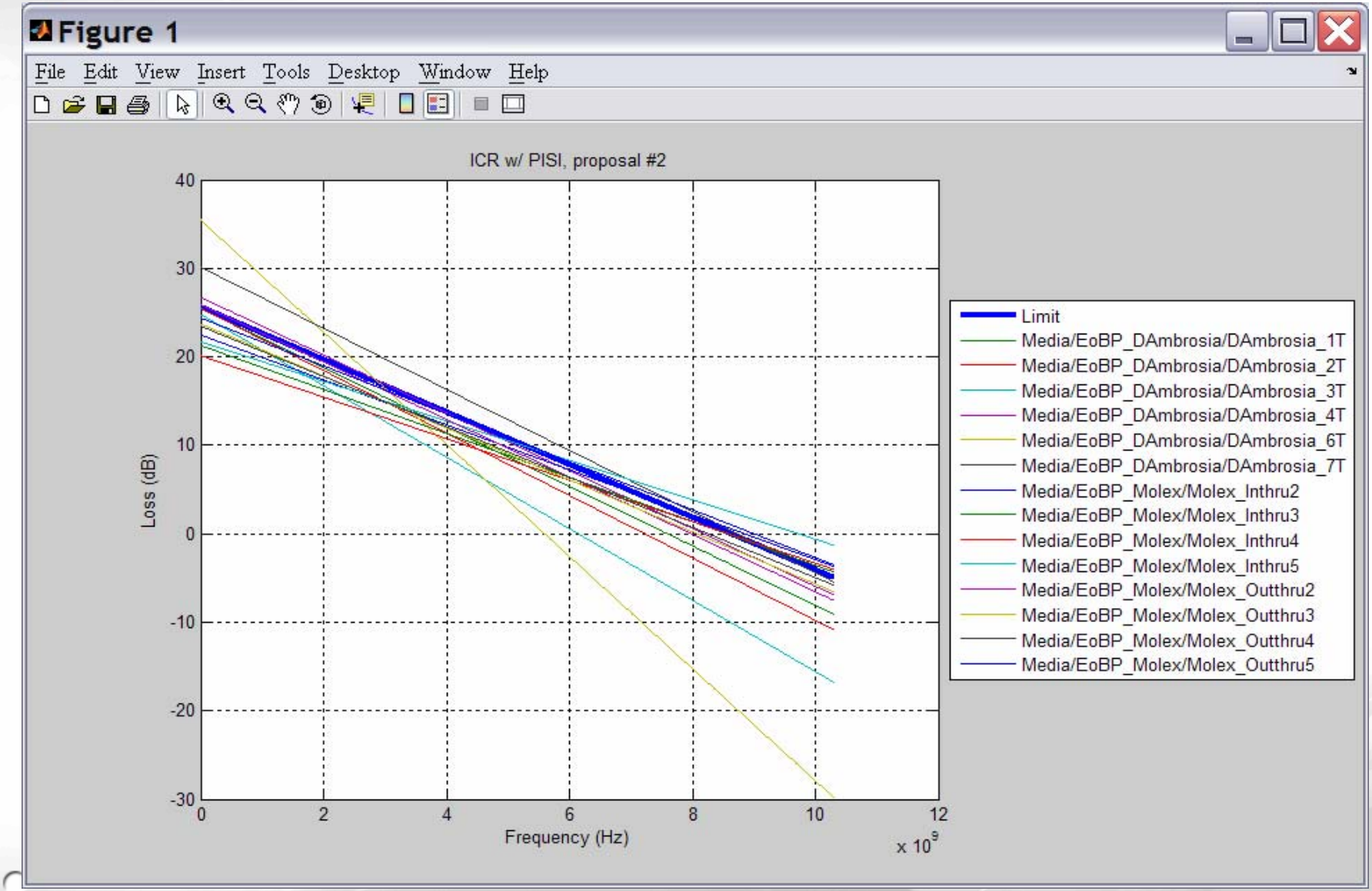




Good channels, ICR proposal #2



Bad channels, ICR proposal #2



ICR 1 vs. ICR 2

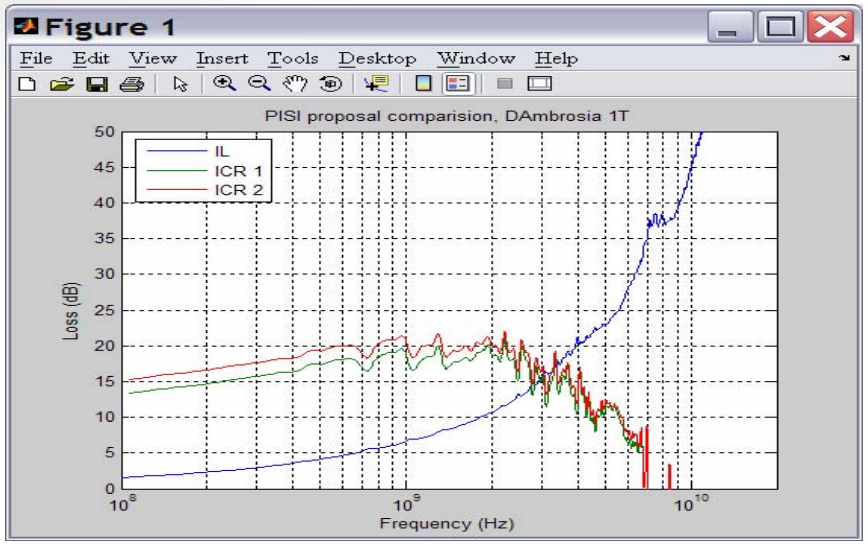


Figure 1
File Edit View Insert Tools Desktop Window Help
PISI proposal comparision, DAmbrosia 1T
IL
ICR 1
ICR 2
Loss (dB)
Frequency (Hz)

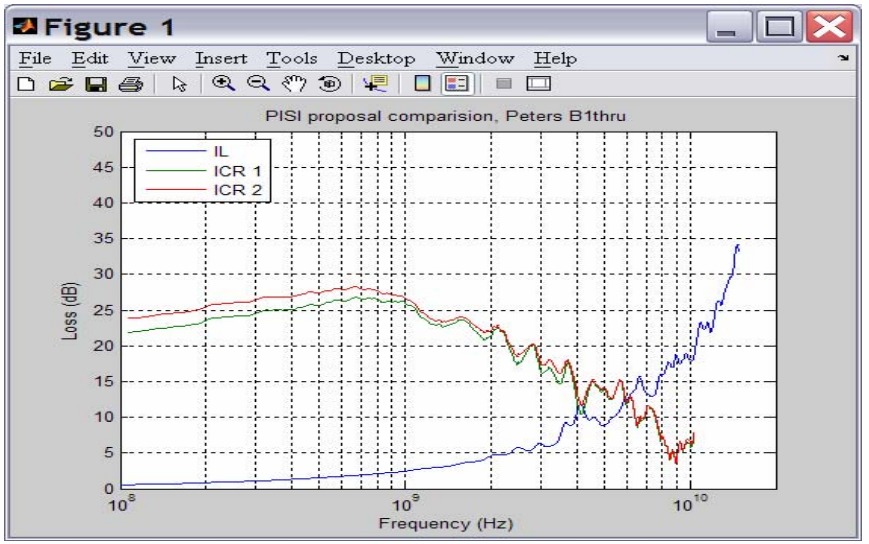


Figure 1
File Edit View Insert Tools Desktop Window Help
PISI proposal comparision, Peters B1thru
IL
ICR 1
ICR 2
Loss (dB)
Frequency (Hz)

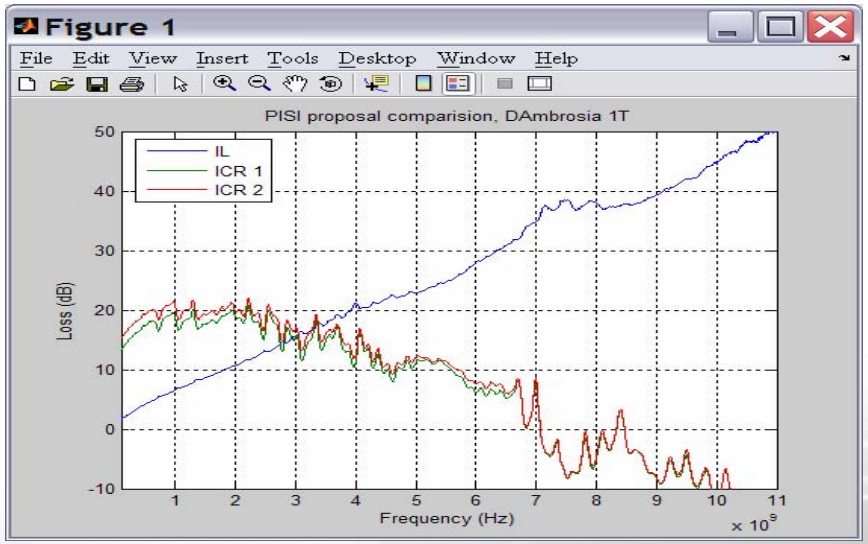


Figure 1
File Edit View Insert Tools Desktop Window Help
PISI proposal comparision, DAmbrosia 1T
IL
ICR 1
ICR 2
Loss (dB)
Frequency (Hz)
x 10^9

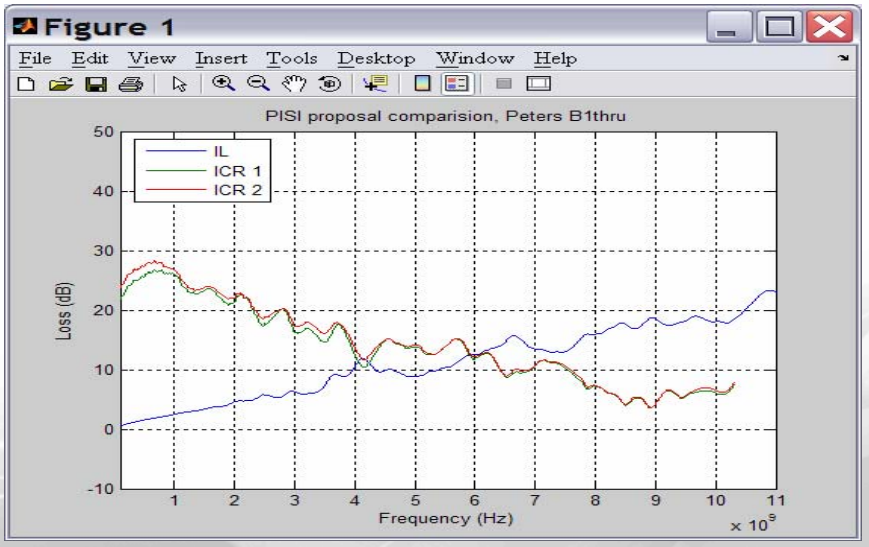


Figure 1
File Edit View Insert Tools Desktop Window Help
PISI proposal comparision, Peters B1thru
IL
ICR 1
ICR 2
Loss (dB)
Frequency (Hz)
x 10^9