Link Segment
Limit Line Scaling

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Supporters

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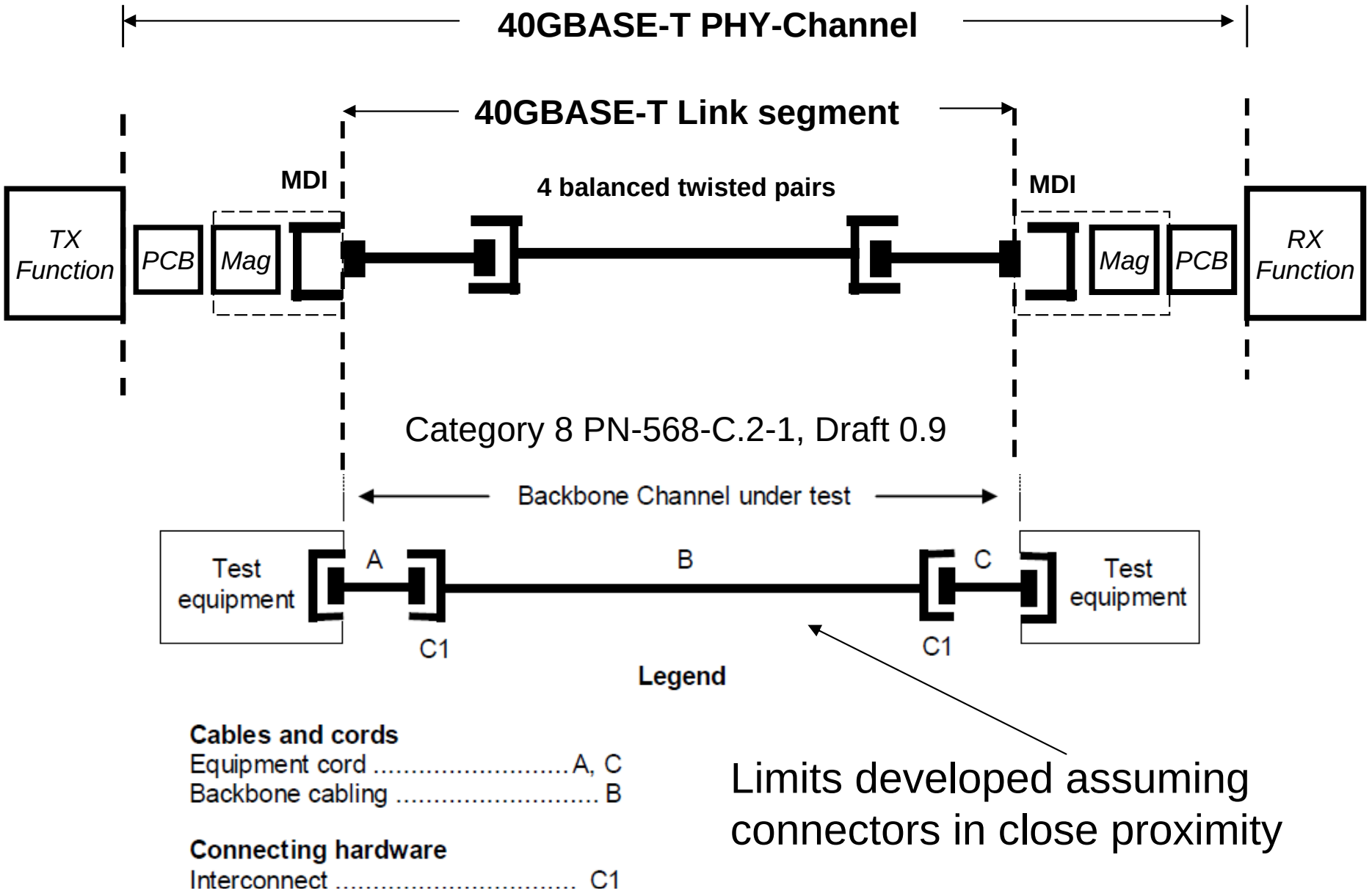
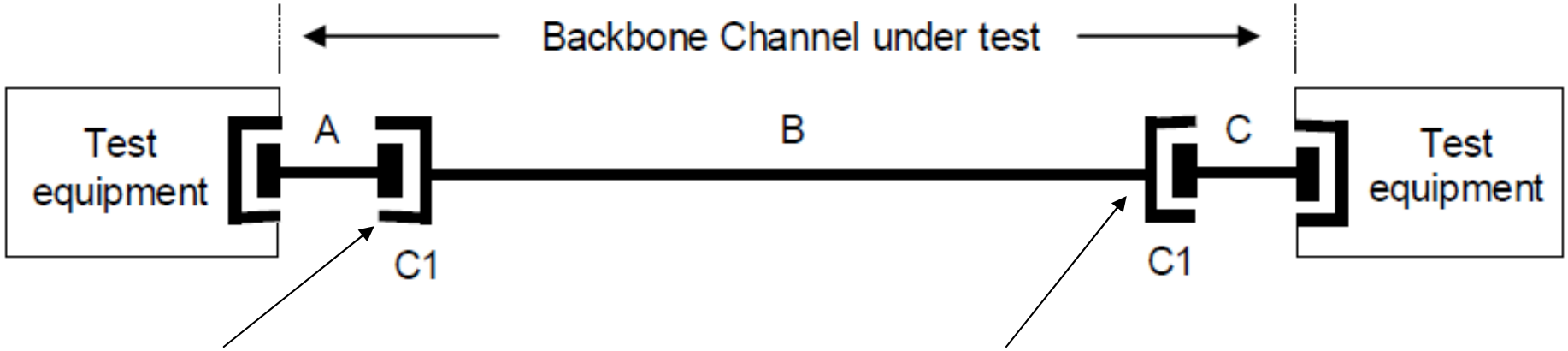
Background/Purpose

- To enable broader set of topologies to be considered for PHY-modeling, scaling measurement data to limit lines proposed in 802.3bq.
- Crosstalk and return loss cabling limits developed assuming connectors at each end of the channel in close proximity.
- Link segment cabling parameters length dependent.
- Scaling all measurement data to these limits (long channels to short limits) for PHY-modeling artificially imposes pessimism for longer channels.
- Help circumvent creation of unrealistic test channels to exercise worse case limits.
- Potential problems with phase scaling for time domain (digital analysis)
- Length dependent limits proposed for measurement scaling.

Link Segment and Cabling Channel



Link Segment and Cabling Channel



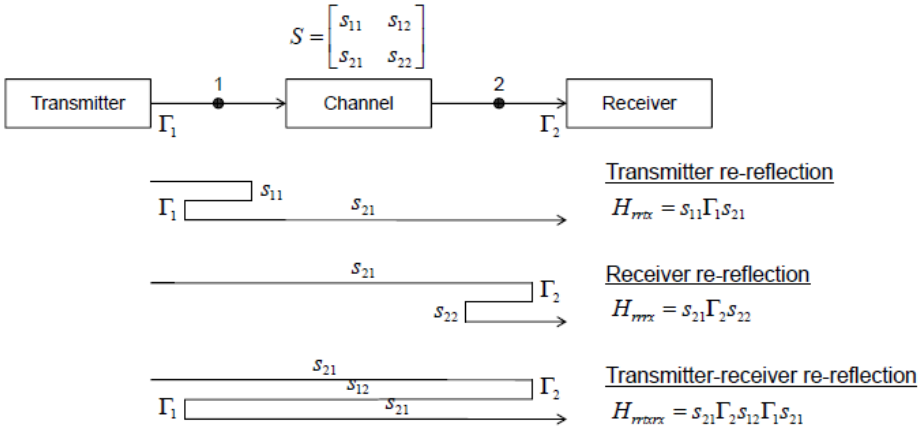
•Cabling Channel limits developed assuming connectors in close proximity to impose worse case.

•Proposal to introduce cable insertion loss in limit line equation to enable more accurate representation of the cabling topology for the purpose of scaling measurements used in PHY-channel modeling.

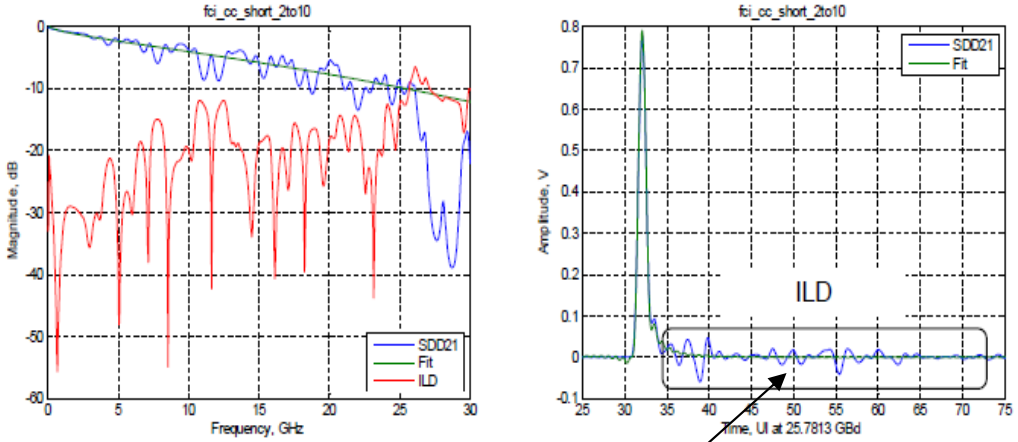
Residual inter-symbol interference*

Re-reflection interference (noise)

- Transmitter, receiver, and channel return loss influence the transfer function of the assembled link



ILD noise example



•Residual inter-symbol interference

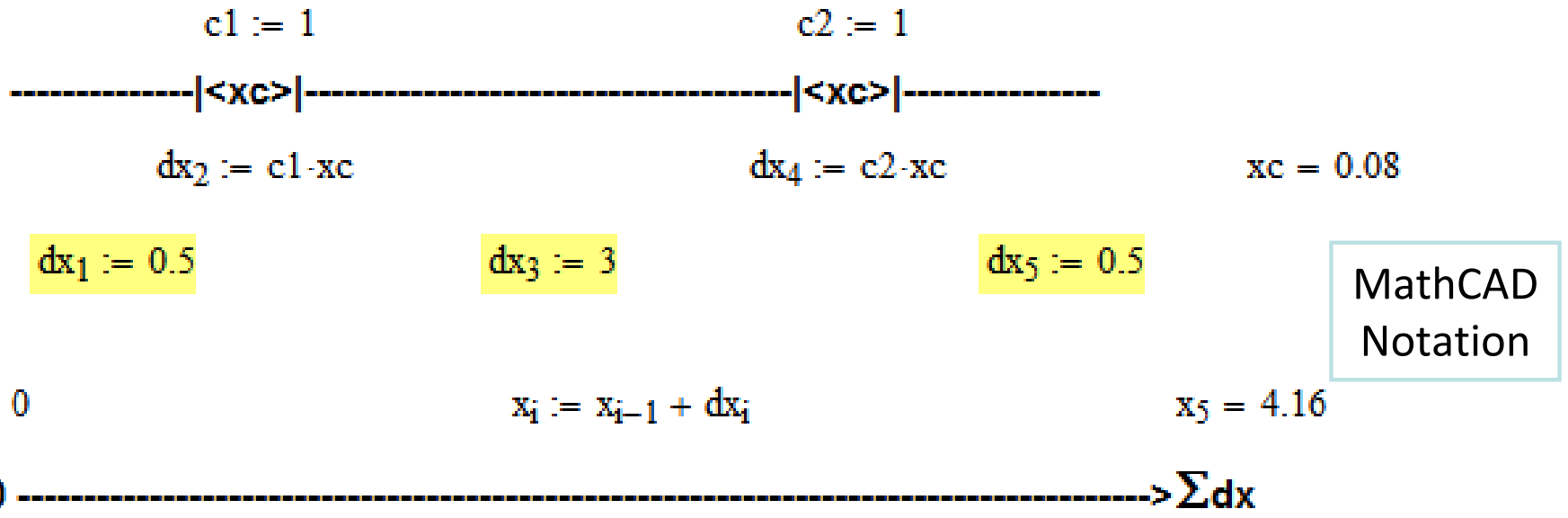
*Material extracted from:>> A method for evaluating channels, Charles Moore, Avago Technologies, Adam Healey, LSI Corporation
100 Gb/s Backplane and Copper Study Group Singapore, March 2011
http://www.ieee802.org/3/100GCU/public/mar11/moore_01_0311.pdf

Length dependent limits

- Length dependent limits proposed for measurement scaling.
  - Return Loss
  - PSNEXT
  - PSFEXT (PSACRF)

Channel Configurations

Channel Configuration **Connectors: c1, c2 Patch cord lengths: dx1, dx5**
Cable lengths: dx3 Connector equivalent length: xc



Transmission Parameters

Cable transmission line constants

$$Att\_Cbl_k := \frac{\left(1.80\cdot\sqrt{f_k} + 0.005\cdot f_k + \frac{0.25}{\sqrt{f_k}}\right)}{100} \qquad Att\_Crd_k := 1.2\cdot Att\_Cbl_k \qquad Vp_k := \frac{100}{\left(494 + \frac{36}{f_k}\right)\cdot 10^{-9}}$$

$$\alpha_k := \frac{Att\_Cbl_k}{20\cdot\log(e)} \qquad \alpha 1_k := \frac{Att\_Crd_k}{20\cdot\log(e)} \qquad \alpha 3_k := \frac{\left(Att\_Crd_k\cdot dx_1 + 0.02\cdot\sqrt{f_k}\cdot dx_2 + Att\_Cbl_k\cdot dx_3\right)}{\left(dx_1 + dx_2 + dx_3\right)}}{20\cdot\log(e)}$$

$$\beta_k := \frac{2\cdot\pi\cdot f_k\cdot 10^6}{Vp_k} \qquad \gamma_k := \alpha_k + j\cdot\beta_k \qquad \gamma 1_k := \alpha 1_k + j\cdot\beta_k \qquad \gamma 3_k := \alpha 3_k + j\cdot\beta_k$$

Return Loss Limit Line Equations for Cable and Connectors

$$RLcbl_k := (20 + 5\cdot\log(f_k))\cdot\Phi(9.99 - f_k) + (\Phi(f_k - 9.99)\cdot\Phi(39.99 - f_k))\cdot 25 + \Phi(f_k - 39.99)\cdot\left(25 - 7\cdot\log\left(\frac{f_k}{40}\right)\right)$$

$$RLconn_k := \text{if}\left(f_k \le 1000, 32 - 20\cdot\log\left(\frac{f_k}{100}\right), 12\right) \qquad RLconn_k := \text{if}(30 \le RLconn_k, 30, RLconn_k)$$

Return Loss Limit Line Equations for Channel (not scaled)

$$R1_k := \Phi(9.99 - f_k) \qquad R2_k := \Phi(f_k - 9.99)\cdot\Phi(39.99 - f_k)$$

$$R3_k := \Phi(f_k - 39.99)\cdot\Phi(129.99 - f_k) \qquad R4_k := \Phi(f_k - 129.99)\cdot\Phi(999.99 - f_k) \qquad R5_k := \Phi(f_k - 999.99)$$

$$RL\_Ch\_lim_k := 19\cdot R1_k + R2_k\cdot(24 - 5\cdot\log(f_k)) + R3_k\cdot 16.0 + R4_k\cdot(35 - 9\cdot\log(f_k)) + 8\cdot R5_k$$

Return Loss Limit Line Equations for Channel (scaled)

Includes Phase Effects of connectors

$$RLcnx_k := -20 \cdot \log\left[\left|\exp\left(-2 \cdot \gamma_k \cdot x_1\right) \cdot 10^{-\left(\frac{RLconn_k}{20}\right)} + \exp\left(-2 \cdot \gamma_k \cdot x_3\right) \cdot 10^{-\frac{RLconn_k}{20}}\right|\right]$$

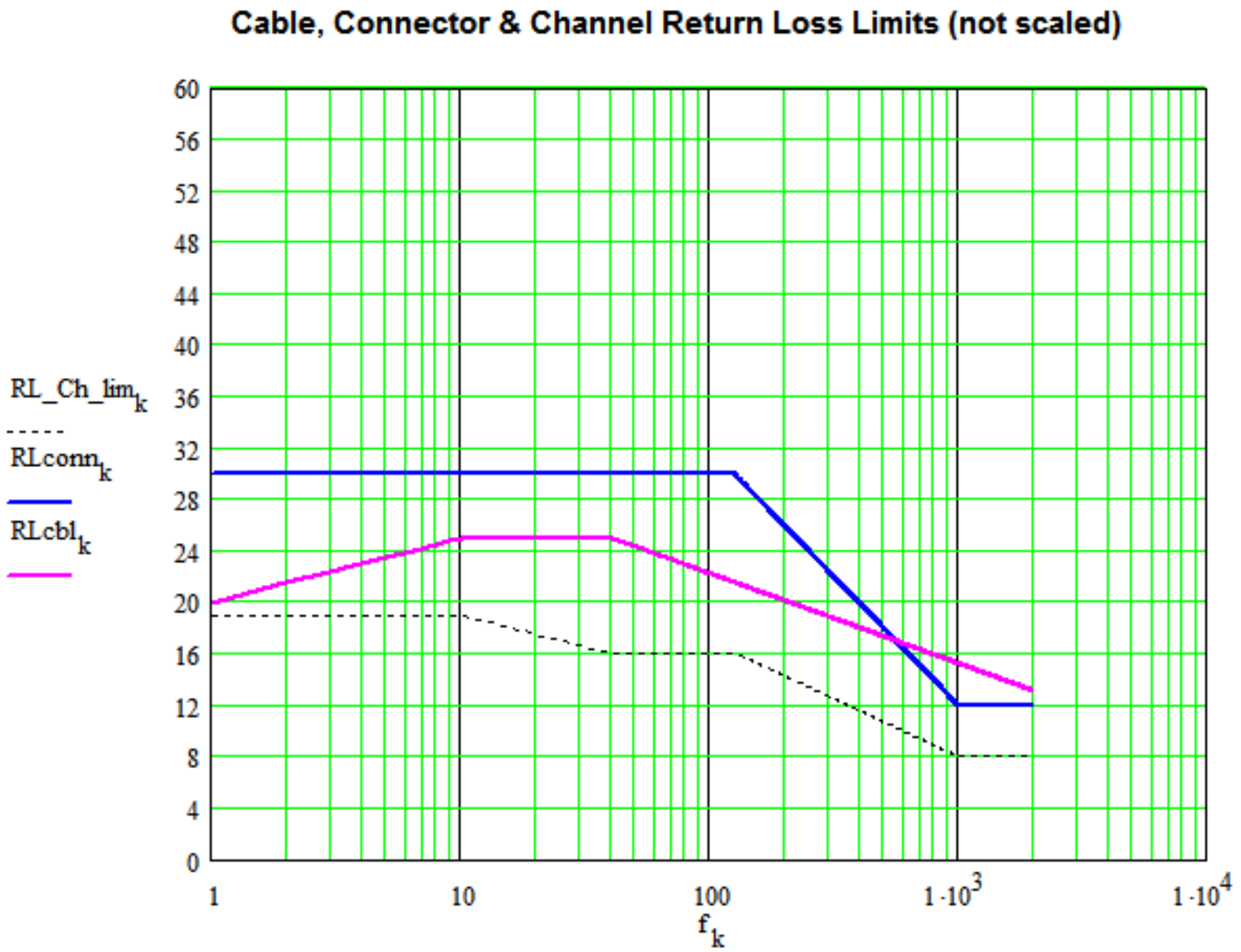
$$RLch_k := -10 \cdot \log\left[10^{-\left(\frac{RLcbl_k}{10}\right)} + 10^{-\left(\frac{RLcnx_k}{10}\right)}\right]$$

Envelope

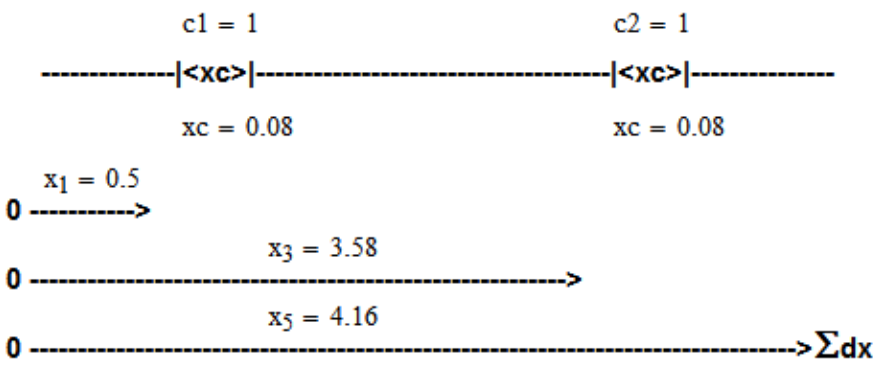
$$RLcne_k := -20 \cdot \log\left[\left|\exp\left(-2 \cdot \alpha_{1k} \cdot x_1\right) \cdot 10^{-\left(\frac{RLconn_k}{20}\right)} + \exp\left(-2 \cdot \alpha 3_k \cdot x_3\right) \cdot 10^{-\frac{RLconn_k}{20}}\right|\right]$$

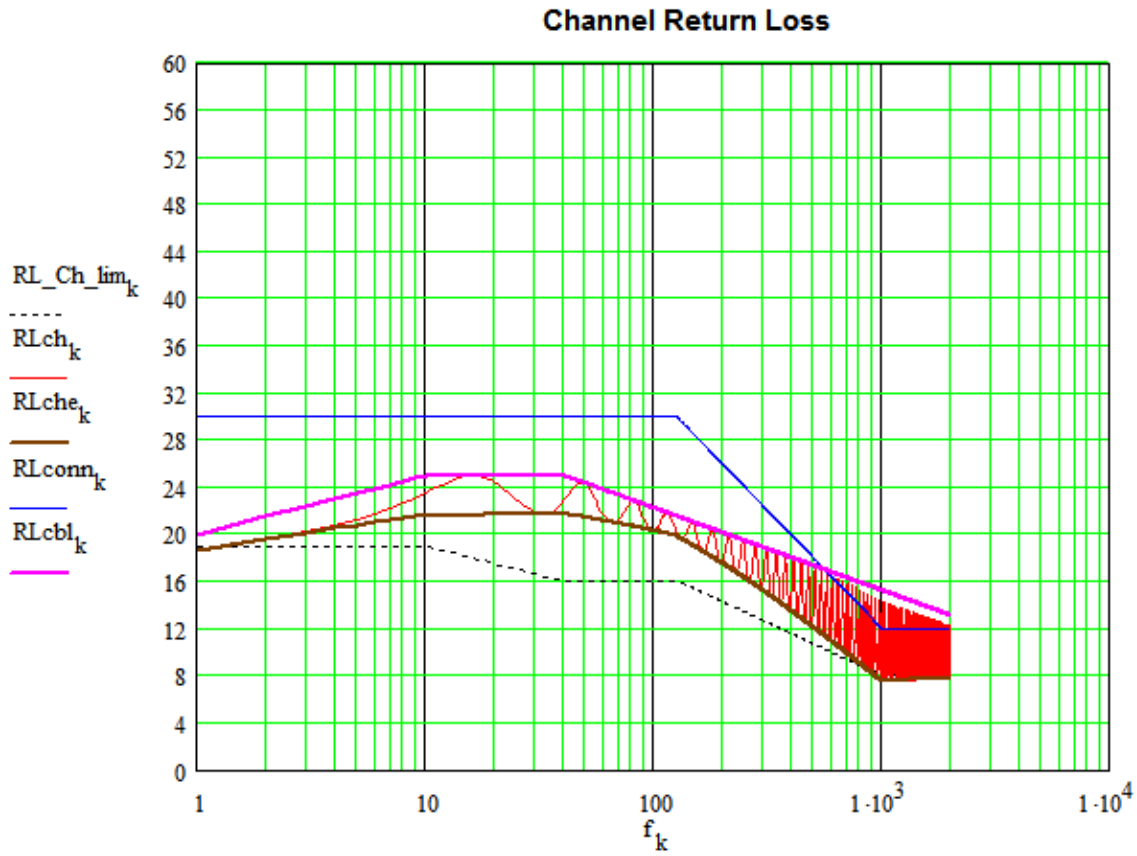
$$RLche_k := -10 \cdot \log\left[10^{-\left(\frac{RLcbl_k}{10}\right)} + 10^{-\left(\frac{RLcne_k}{10}\right)}\right]$$

Return Loss Limits

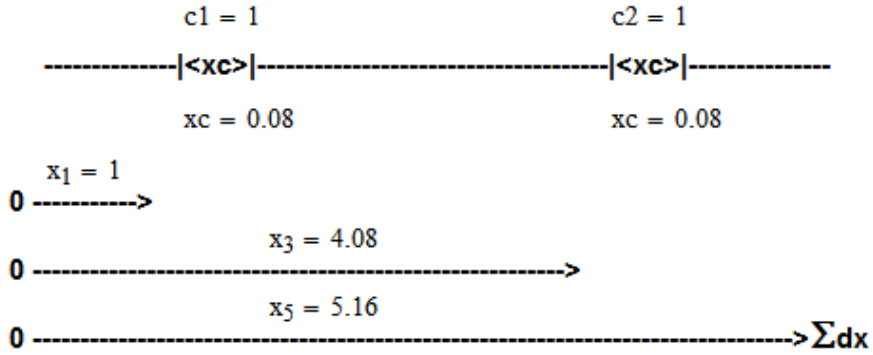


Channel 0.5-3-0.5





Channel 1-3-1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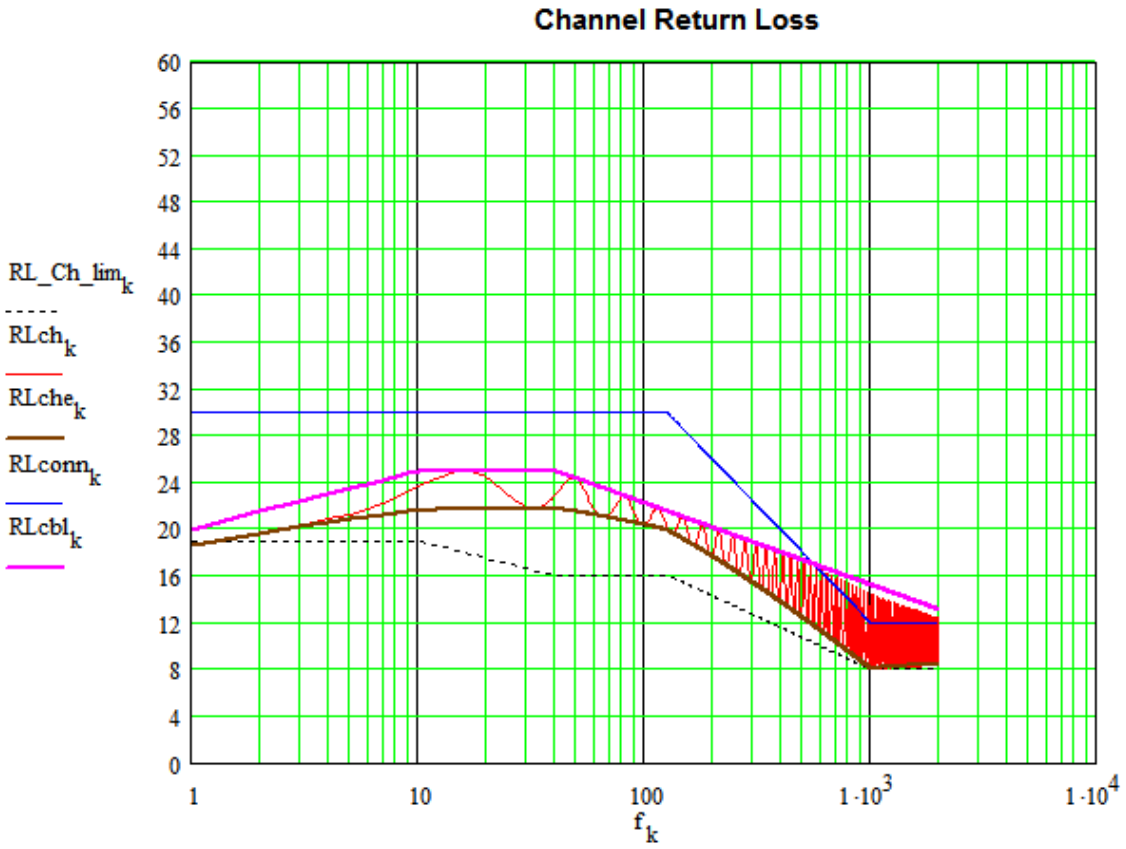
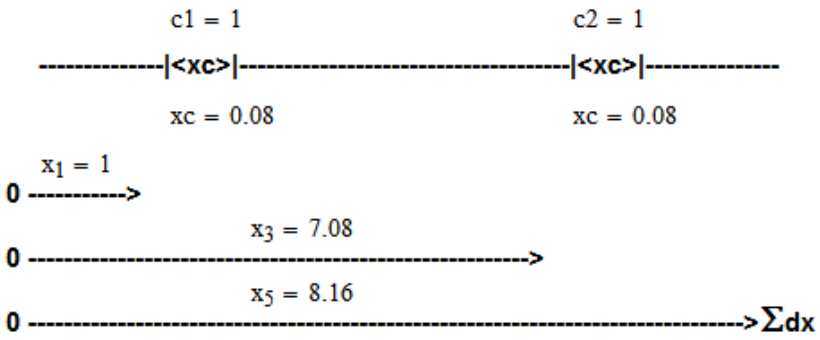
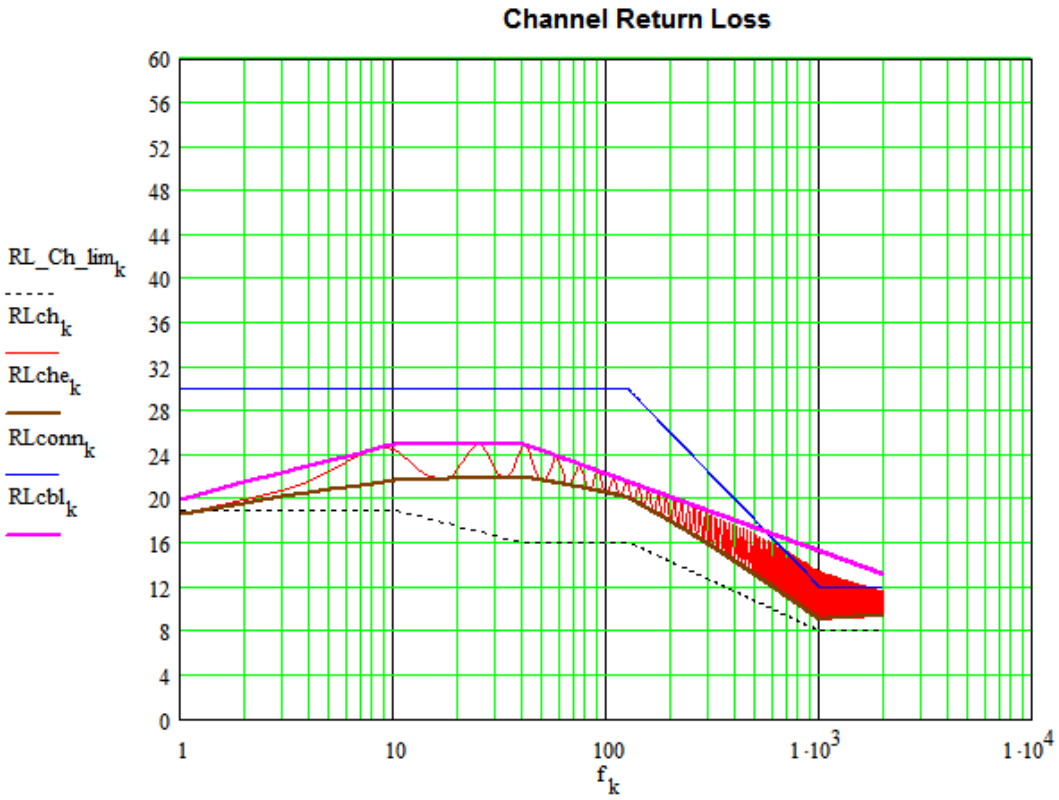
c2 = 1
|<xc>|
|<xc>|
xc = 0.08
xc = 0.08
x1 = 1
0
x3 = 4.08
0
x5 = 5.16
0
Σdx

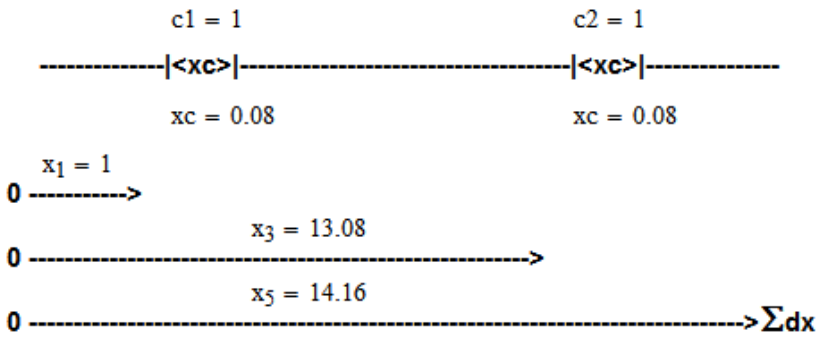

Channel Return Loss
RL_Ch_lim_k
RLch_k
RLche_k
RLconn_k
RLcbl_k
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
1
10
100
1·10^3
1·10^4
f_k

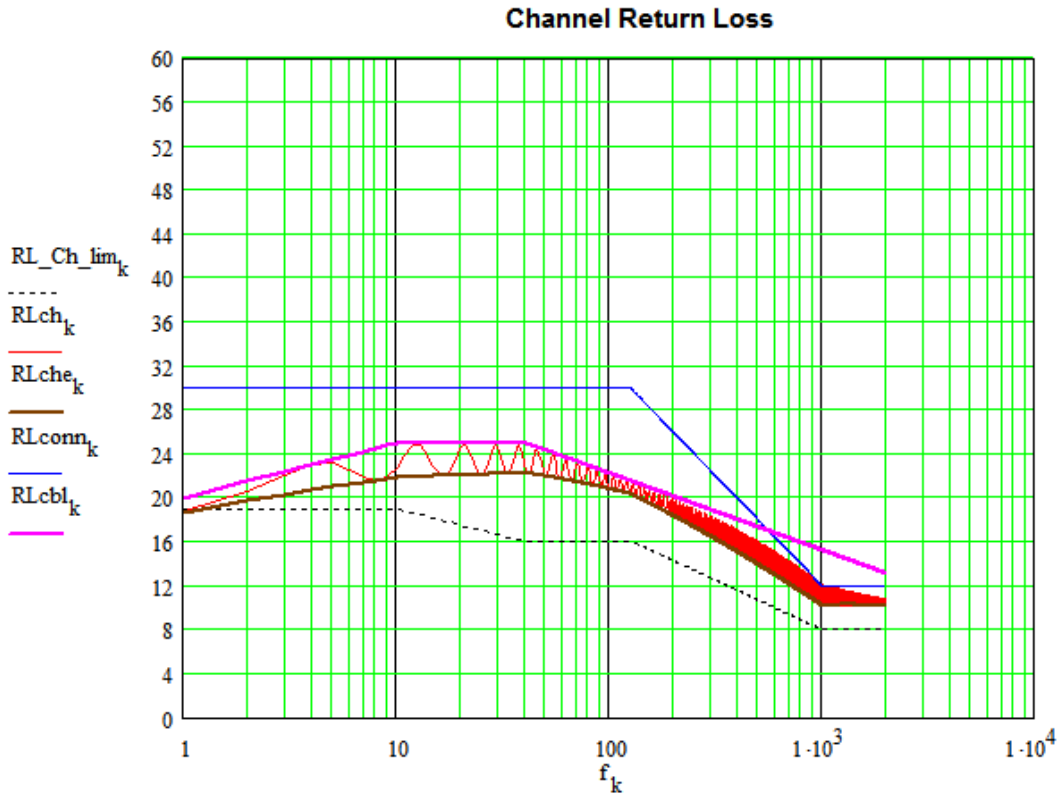
Channel 1-6-1


c1 = 1
c2 = 1
|<xc>|
|<xc>|
xc = 0.08
xc = 0.08
x1 = 1
0
x3 = 7.08
0
x5 = 8.16
0
Σdx

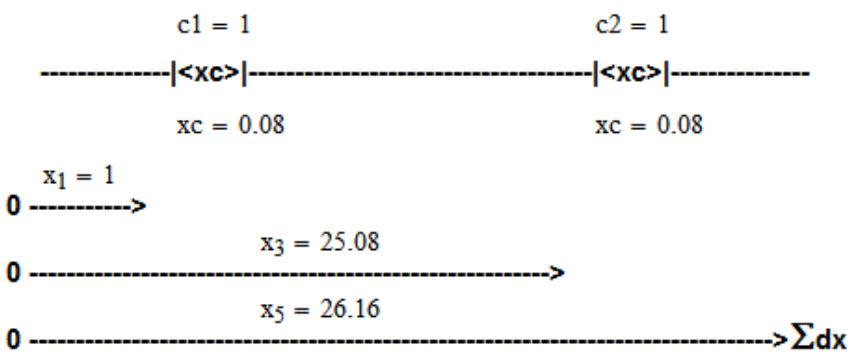

Channel Return Loss
RL_Ch_lim_k
RLch_k
RLche_k
RLconn_k
RLcbl_k
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
1
10
100
1·10^3
1·10^4
f_k

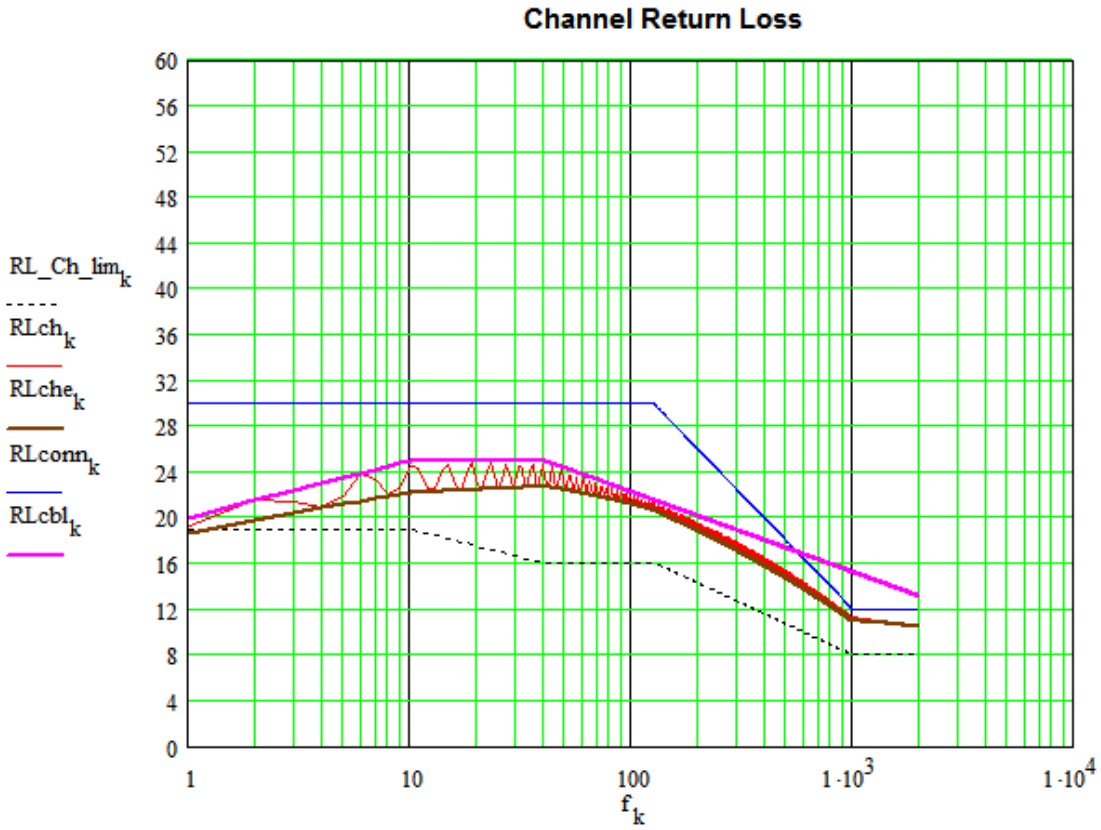
Channel 1-12-1



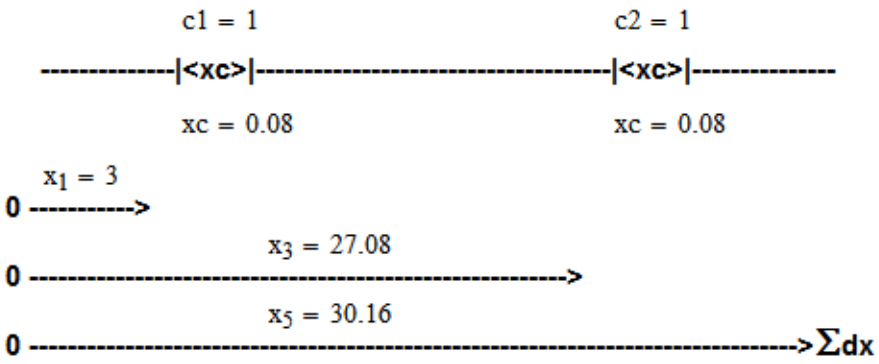


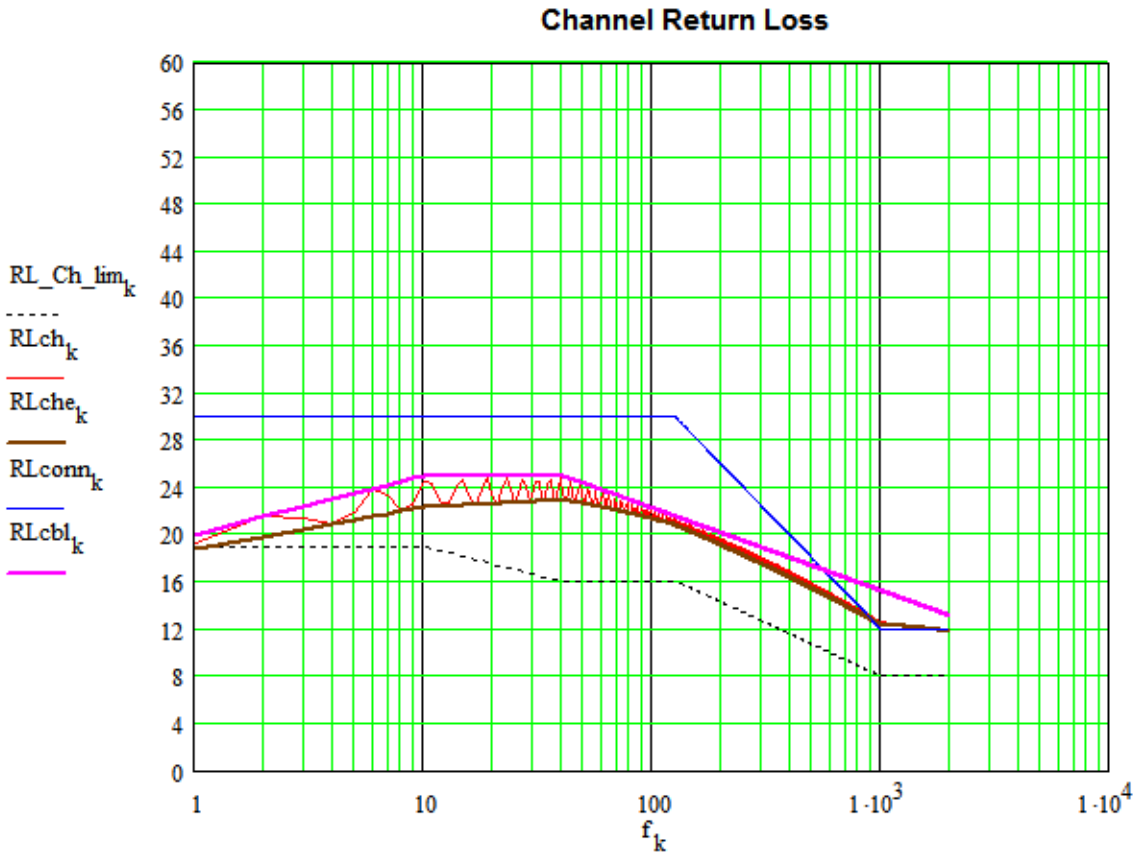
Channel 1-24-1





Channel 3-24-3





PSNEXT and PSFEXT Length Scaled Limits

PSNEXT Limit Line Equations for Cable & Connectors

$$PSNEXT\_Cbl\_lim_k := if\left(75 \le 42.3 - 15\cdot\log\left(\frac{f_k}{100}\right), 75, 42.3 - 15\cdot\log\left(\frac{f_k}{100}\right)\right)$$

$$PSNEXT\_Con\_lim_k := 0$$

$$Eq1_k := 50 - 20\cdot\log\left(\frac{f_k}{100}\right) \qquad Eq2_k := 42.04 - 30\cdot\log\left(\frac{f_k}{250}\right) \qquad Eq3_k := 33 - 40\cdot\log\left(\frac{f_k}{500}\right)$$

$$PSNEXT\_Con\_lim_k := if\left[f_k \le 250, Eq1_k, \left[if\left[250 < f_k \le 500, Eq2_k, \left(if\left(500 < f_k, Eq3_k, PSNEXT\_Con\_lim_k\right)\right)\right]\right]\right]$$

$$PSNEXT\_Con\_lim_k := if\left(72 \le PSNEXT\_Con\_lim_k, 72, PSNEXT\_Con\_lim_k\right)$$

PSNEXT Limit Line Equations for Channel

Includes phase effects of connectors

$$PSNEXTcnx_k := -20\cdot\log\left[\left|\exp\left(-2\cdot\gamma 1_k\cdot x_1\right)\cdot 10^{-\left(\frac{PSNEXT\_Con\_lim_k}{20}\right)} + \exp\left(-2\cdot\gamma 3_k\cdot x_3\right)\cdot 10^{-\frac{PSNEXT\_Con\_lim_k}{20}}\right|\right]$$

$$PSNEXTch_k := -10\cdot\log\left[10^{-\left(\frac{PSNEXT\_Cbl\_lim_k}{10}\right)} + 10^{-\left(\frac{PSNEXTcnx_k}{10}\right)}\right]$$

$$PSNEXTch_k := \text{if}\left(62 \le PSNEXTch_k, 62, PSNEXTch_k\right)$$

Envelope

$$PSNEXTcne_k := -20\cdot\log\left[\exp\left(-2\cdot\alpha 1_k\cdot x_1\right)\cdot 10^{-\left(\frac{PSNEXT\_Con\_lim_k}{20}\right)} + \exp\left(-2\cdot\alpha 3_k\cdot x_3\right)\cdot 10^{-\left(\frac{PSNEXT\_Con\_lim_k}{20}\right)}\right]$$

$$PSNEXTche_k := -10\cdot\log\left[10^{-\left(\frac{PSNEXT\_Cbl\_lim_k}{10}\right)} + 10^{-\left(\frac{PSNEXTcne_k}{10}\right)}\right]$$

$$PSNEXTche_k := \text{if}\left(62 \le PSNEXTche_k, 62, PSNEXTche_k\right)$$

PSFEXT Limit Line Equations for Cable, Connectors and Channel

$$PSACRF\_Ch\_lim_k := -20 \cdot \log\left[10^{-\left[\frac{\left(36-20\cdot\log\left(\frac{f_k}{100}\right)-10\cdot\log\left(\frac{x_5}{30}\right)\right)}{20}\right]} + 2\cdot 10^{-\left[\frac{\left(40.1-20\cdot\log\left(\frac{f_k}{100}\right)\right)}{20}\right]}\right]$$

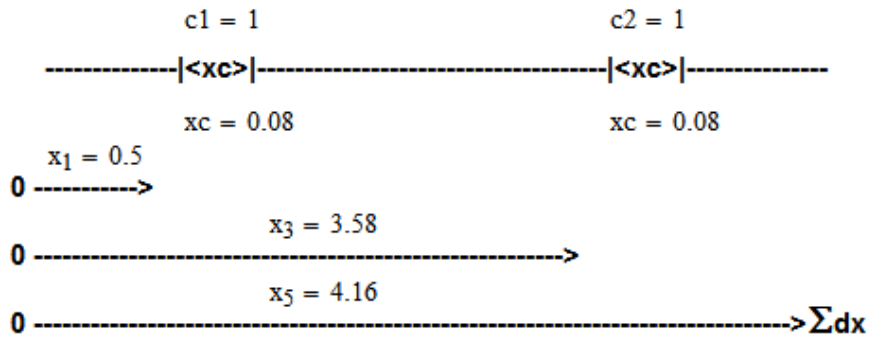
$$PSACRF\_Ch\_lim_k := \text{if}\left(62 \le PSACRF\_Ch\_lim_k, 62, PSACRF\_Ch\_lim_k\right)$$

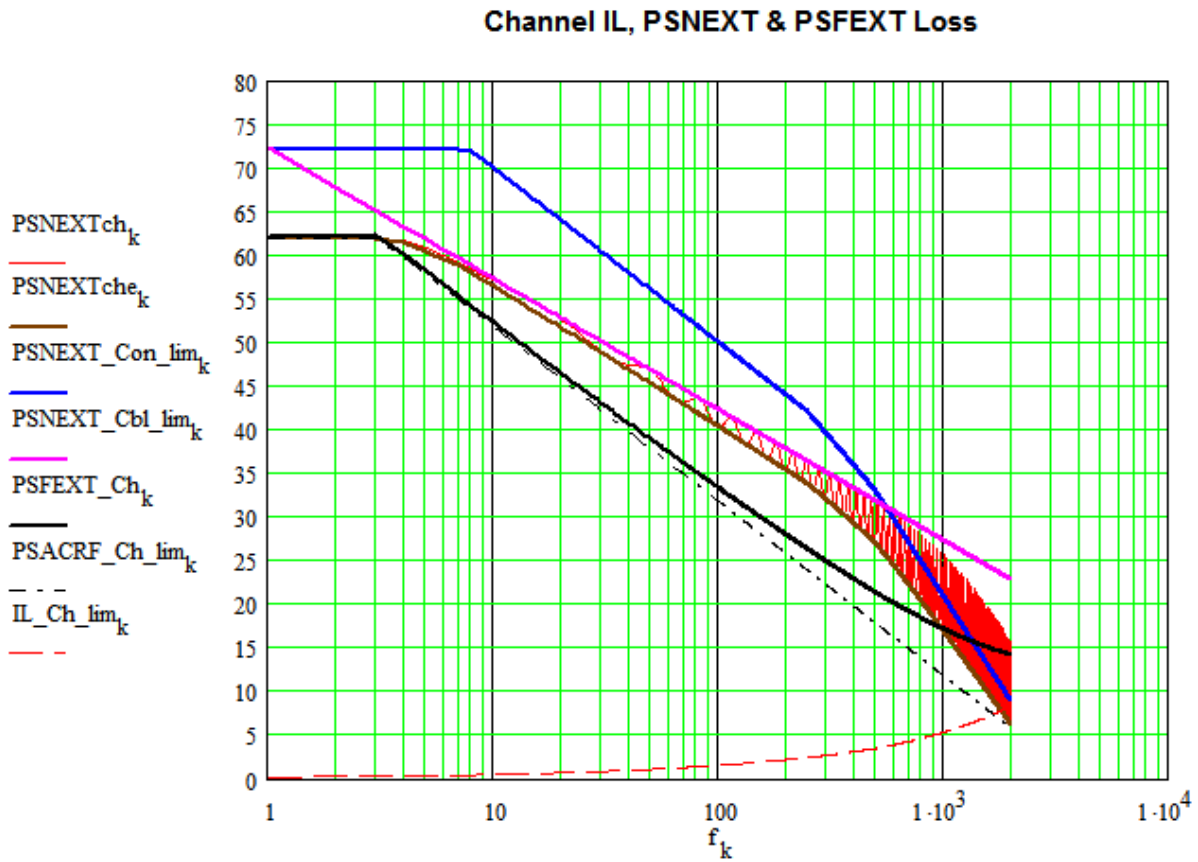
$$IL\_Con\_lim_k := \text{if}\left[\left(500 \le f_k\right), 0.00649\cdot\sqrt{f_k} + 0.000605\cdot f_k, 0.02\cdot\sqrt{f_k}\right]$$

$$IL\_Ch\_lim_k := 0.312\cdot\left(1.80\cdot\sqrt{f_k} + 0.005\cdot f_k + \frac{0.25}{\sqrt{f_k}}\right)\cdot\left(\frac{x_5}{30}\right) + 2\cdot IL\_Con\_lim_k + 0.0324\cdot\sqrt{f_k}$$

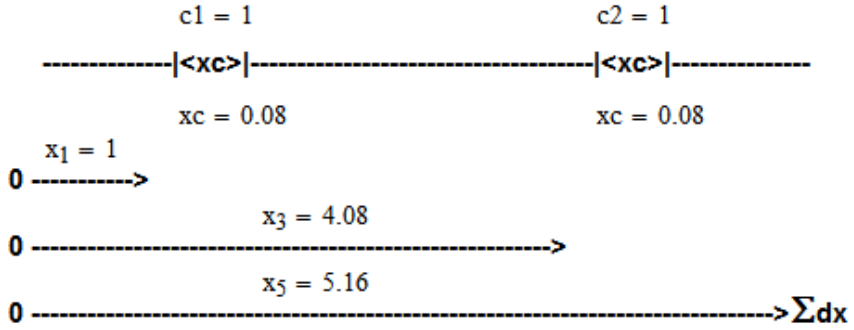
$$PSFEXT\_Ch_k := PSACRF\_Ch\_lim_k + IL\_Ch\_lim_k$$

Channel 0.5-3-0.5





Channel 1-3-1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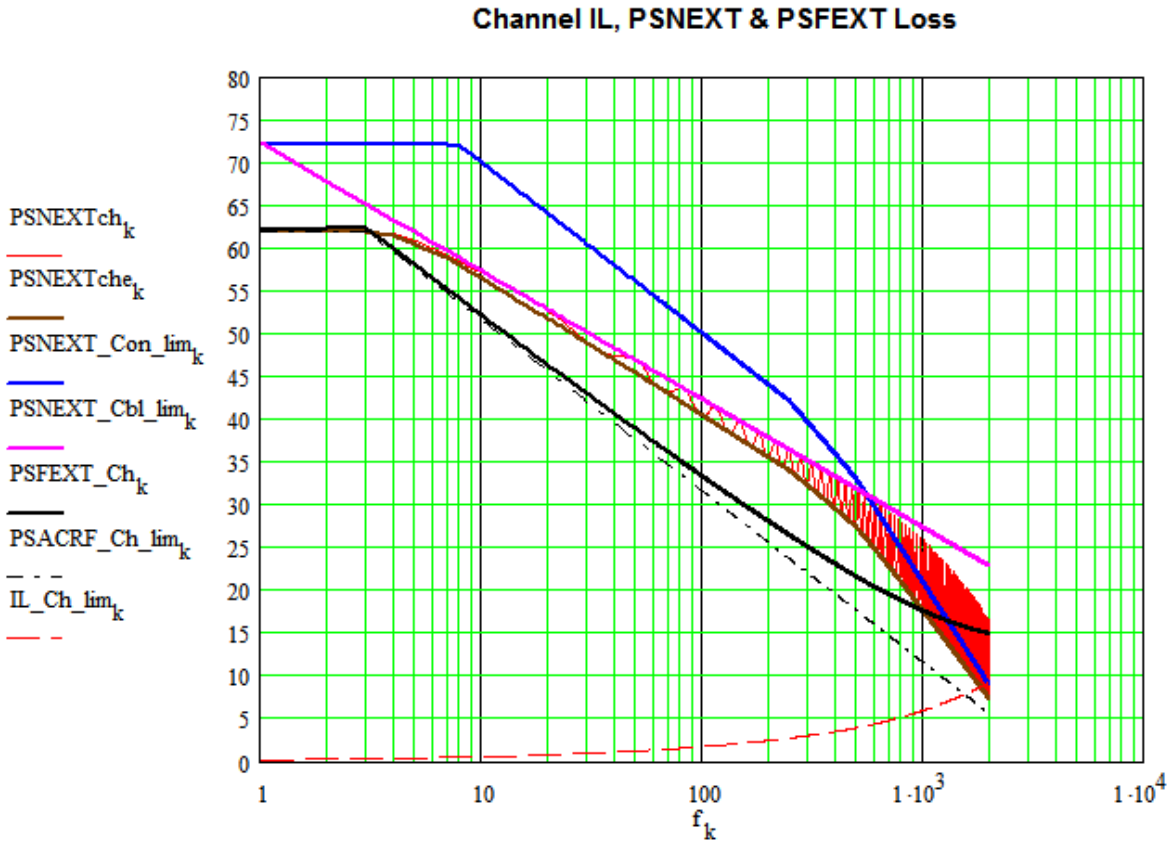
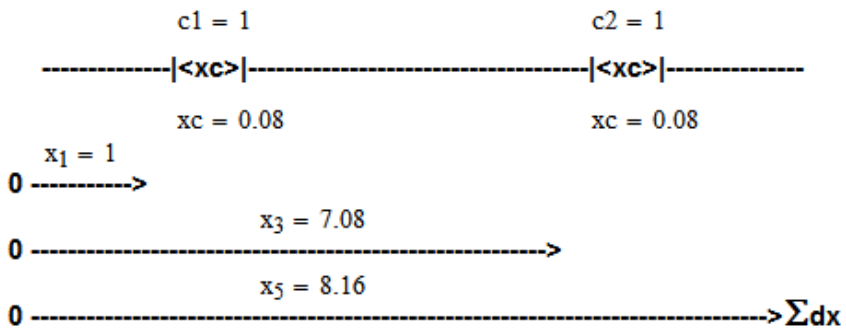
Σdx


Channel IL, PSNEXT & PSFEXT Loss
PSNEXTch_k
PSNEXTche_k
PSNEXT_Con_lim_k
PSNEXT_Cbl_lim_k
PSFEXT_Ch_k
PSACRF_Ch_lim_k
IL_Ch_lim_k
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1
10
100
1·10^3
1·10^4
f_k

Channel 1-6-1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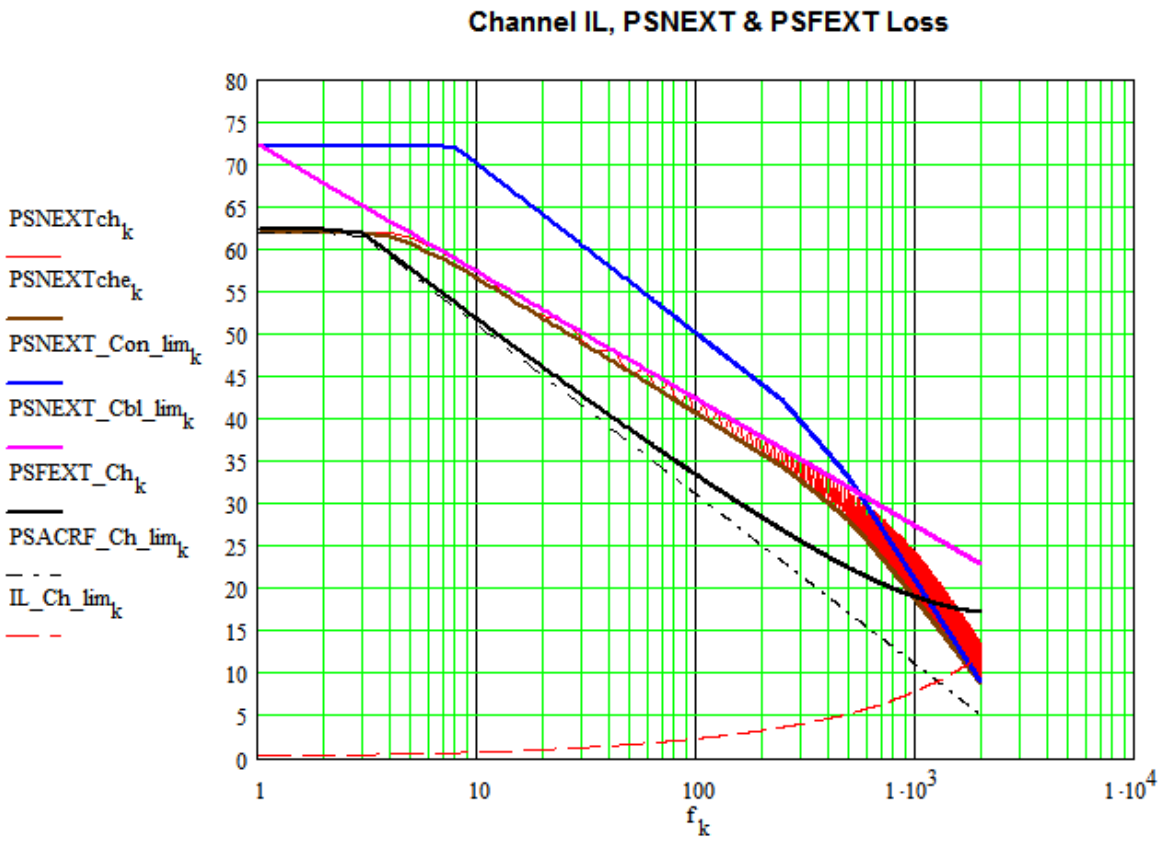
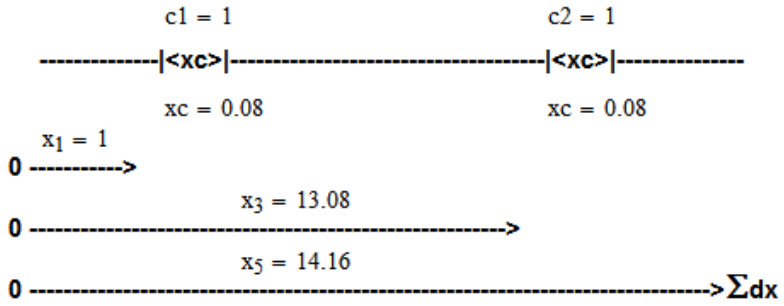
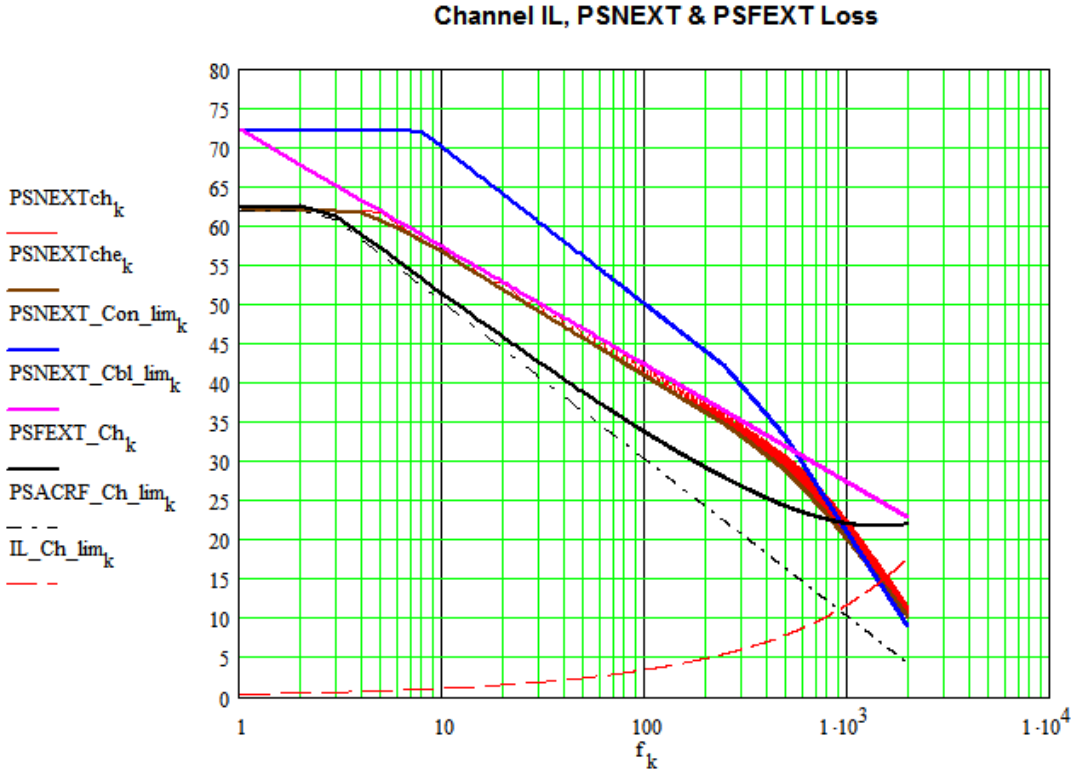
0
Σdx

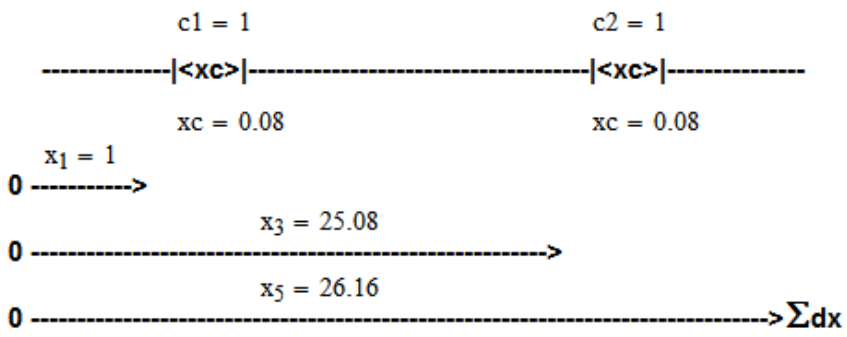

Channel IL, PSNEXT & PSFEXT Loss
PSNEXTch_k
PSNEXTche_k
PSNEXT_Con_lim_k
PSNEXT_Cbl_lim_k
PSFEXT_Ch_k
PSACRF_Ch_lim_k
IL_Ch_lim_k
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1
10
100
1·10^3
1·10^4
f_k

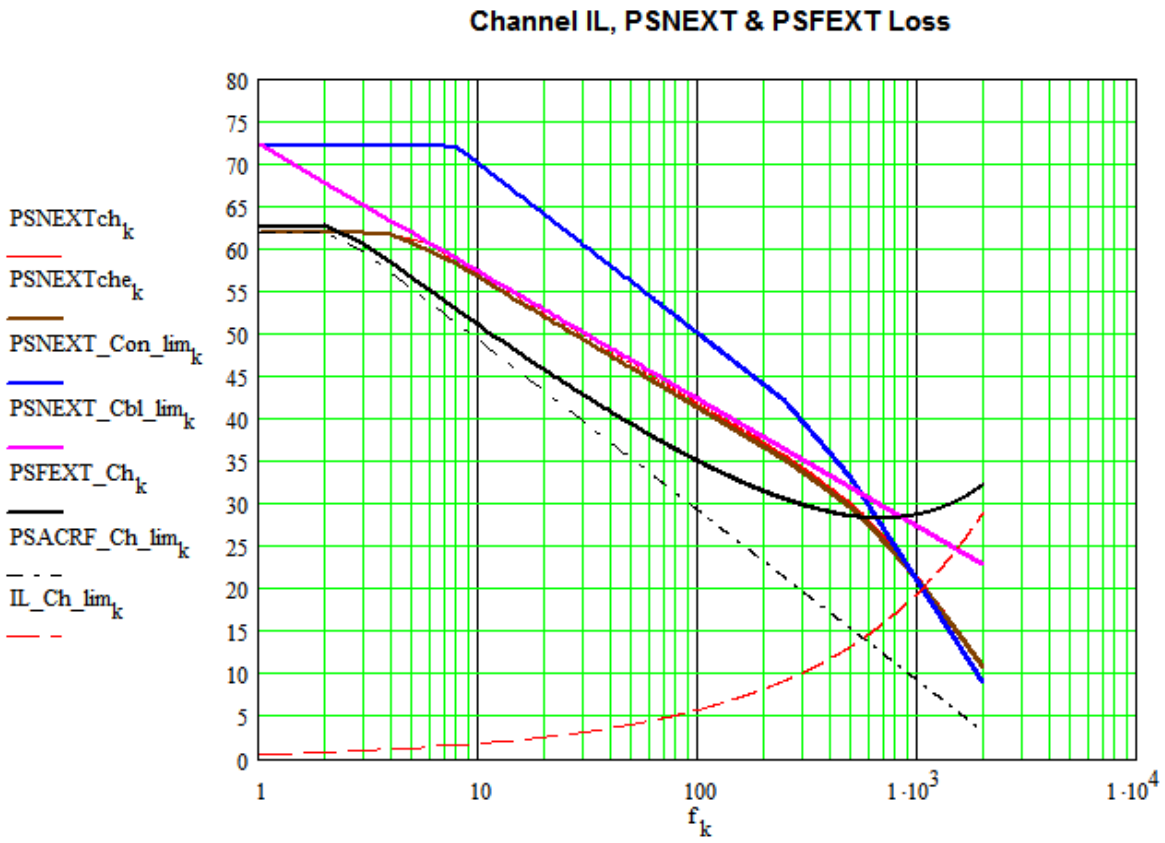
Channel 1-12-1





Channel 1-24-1





Channel 3-24-3