

# Enhanced Approximation for RBIR PHY Abstraction in TGM

## IEEE 802.16 Presentation Submission

Document Number:

IEEE C80216m-08/067r1

Date Submitted:

2008-01-16

Source:

Thierry Lestable, Alain Mourad, Ming Jiang,  
Youngkwon Cho  
Samsung Electronics Research Institute, UK

Voice: +44. 1784.428600 Ext 720

E-mail: {thierry.lestable, alain.mourad, ming.jiang, youngkn}@samsung.com

Hyunky Yu, Taeyoung Kim, Jaeweon Cho  
Samsung Electronics

Voice:

E-mail: {hk.yu, ty33.kim, jaeweon.cho}@samsung.com

\*<<http://standards.ieee.org/faqs/affiliationFAQ.html>>

Venue:

IEEE 802.16m-07/48 – Call for Comments on Draft 802.16m Evaluation Methodology Document IEEE 802.16m-07/037r2

Base Contribution:

None

Purpose:

To modify the 802.16m EVM document related with Approximation part for RBIR PHY Abstractions

Notice:

*This document does not represent the agreed views of the IEEE 802.16 Working Group or any of its subgroups. It represents only the views of the participants listed in the “Source(s)” field above. It is offered as a basis for discussion. It is not binding on the contributor(s), who reserve(s) the right to add, amend or withdraw material contained herein.*

Release:

The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE’s name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE’s sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.

Patent Policy:

The contributor is familiar with the IEEE-SA Patent Policy and Procedures:

<<http://standards.ieee.org/guides/bylaws/sect6-7.html#6>> and <<http://standards.ieee.org/guides/opman/sect6.html#6.3>>.

Further information is located at <<http://standards.ieee.org/board/pat/pat-material.html>> and <<http://standards.ieee.org/board/pat>>.

# Outline

- Numerical Integration RBIR
  - Current proposal
  - New proposal
  - Comparisons
  - Conclusions

# Numerical Integration within RBIR PHY Abstraction

- Exact Expression:

$$SI = \int_{-\infty}^{+\infty} p(LLR) \log_2 \left( \frac{M}{1 + \exp(-LLR)} \right) dLLR = \log_2(M) - \frac{1}{\log_e(2)} J(AVE, VAR)$$

- Beceem Approximation (current EVM)

$$J_B = \frac{2}{3} f_1(AVE) + \frac{1}{6} f_1(AVE + \sqrt{3VAR}) + \frac{1}{6} f_1(AVE - \sqrt{3VAR})$$
$$f_1(x) = \log_e(1 + \exp(-x))$$

# Numerical Integration within RBIR PHY Abstraction

- Asymptotic Approximation (new)

$$J_A = \sqrt{VAR} \cdot \left\{ \eta \cdot \left[ 1 + \frac{1}{2} \cdot \text{Erfc} \left( \frac{\eta}{\sqrt{2}} \right) \right] + \frac{1}{\sqrt{2\pi}} \cdot \exp \left( -\frac{\eta^2}{2} \right) \right\} \quad \eta = \frac{AVE}{\sqrt{VAR}}$$

- NEW Proposal:

– **Hybrid {Beceem + Asymptotic}**

$$J = \left( \frac{J_A + J_B}{2} \right) + \left( \frac{J_A - J_B}{2} \right) \text{sign}(J_A - T) \quad ; \quad T \approx 0.65$$

# Numerical Integration within RBIR PHY Abstraction

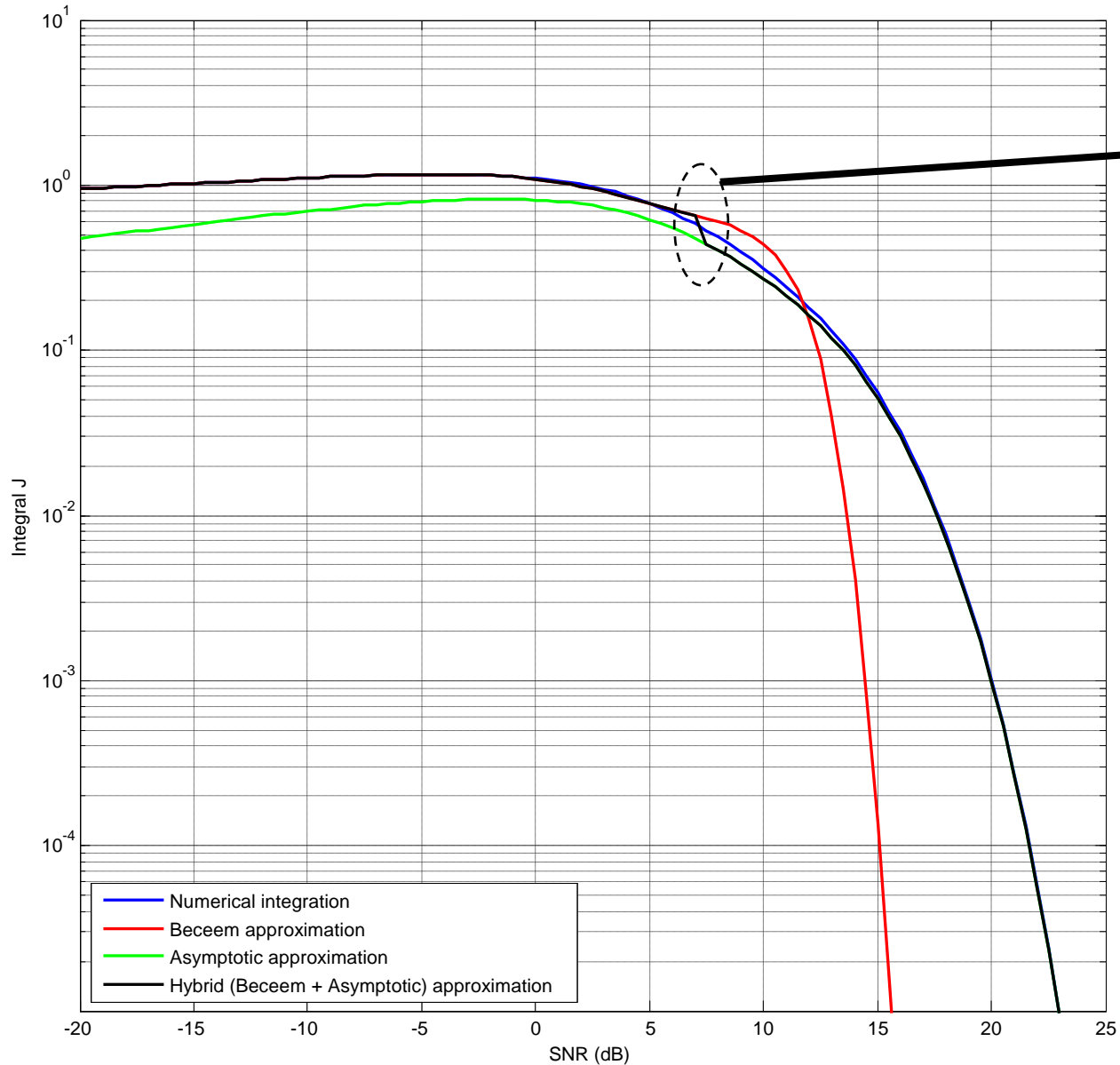
$$\text{Erfc}(x) = \frac{\exp(-x^2)}{\sqrt{\pi}} \cdot \sum_{n=0}^{+\infty} \frac{(-1)^n}{2^n} (2n-1)!! \cdot x^{-(2n+1)}$$

$$J_A = \sqrt{\text{VAR}} \cdot \psi(\eta) \quad (2n-1)!! = \frac{(2n)!}{2^n \cdot n!}$$

$$\psi(\eta) = \eta + \frac{\exp(-\eta^2)}{\sqrt{2\pi}} \cdot \left[ 1 + \sum_{n=0}^{+\infty} (-1)^n \cdot (2n-1)!! \cdot \eta^{-2n} \right]$$

$$J_A = \sqrt{\text{VAR}} \cdot \left\{ \eta + \frac{\exp(-\eta^2)}{\sqrt{2\pi}} \cdot \left[ 1 + \sum_{n=0}^{+\infty} (-1)^n \cdot (2n-1)!! \cdot \eta^{-2n} \right] \right\}$$

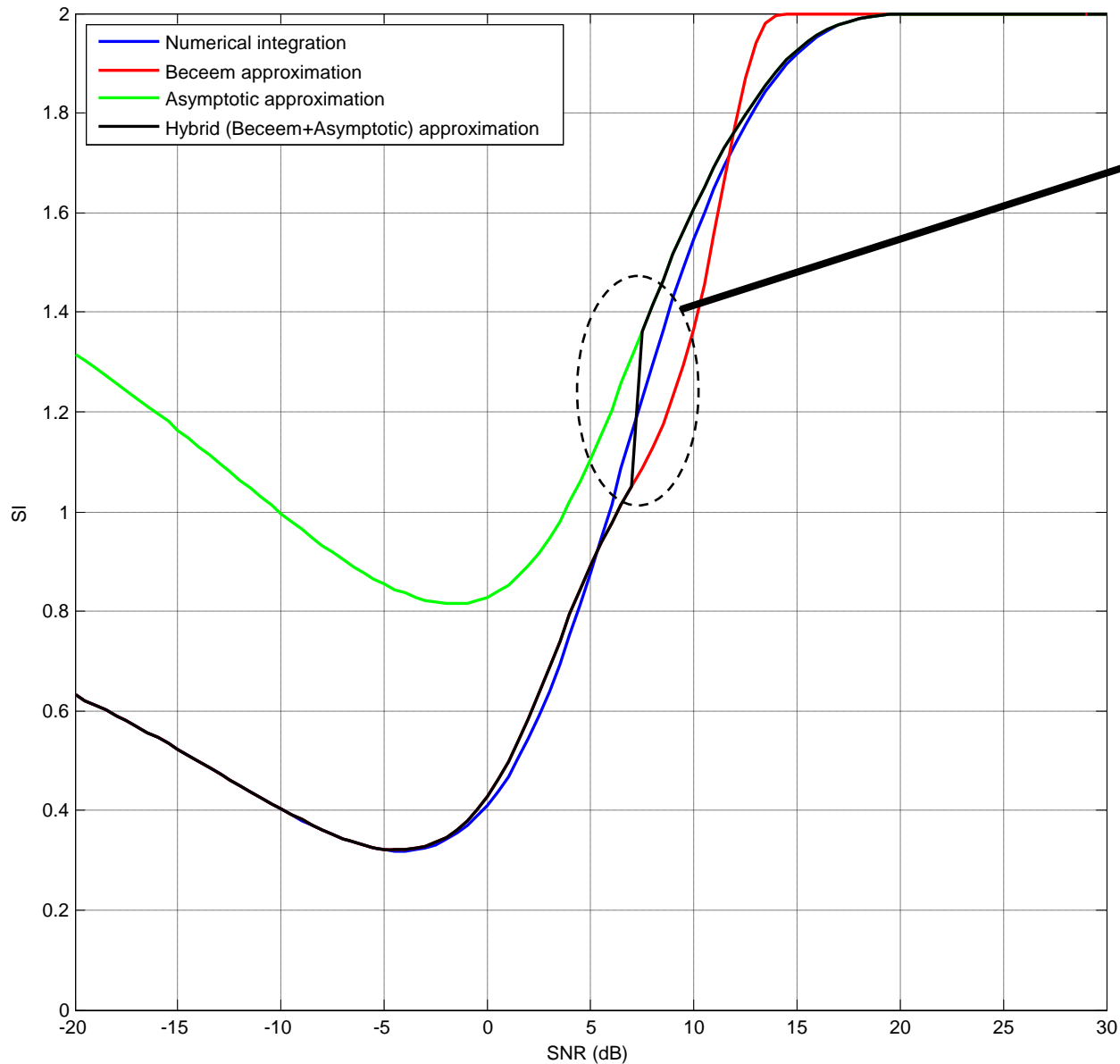
# Accuracy of J approximation



**Switching point  
( $J \approx 0.65$ )**

**Perfect matching  
of hybrid scheme**

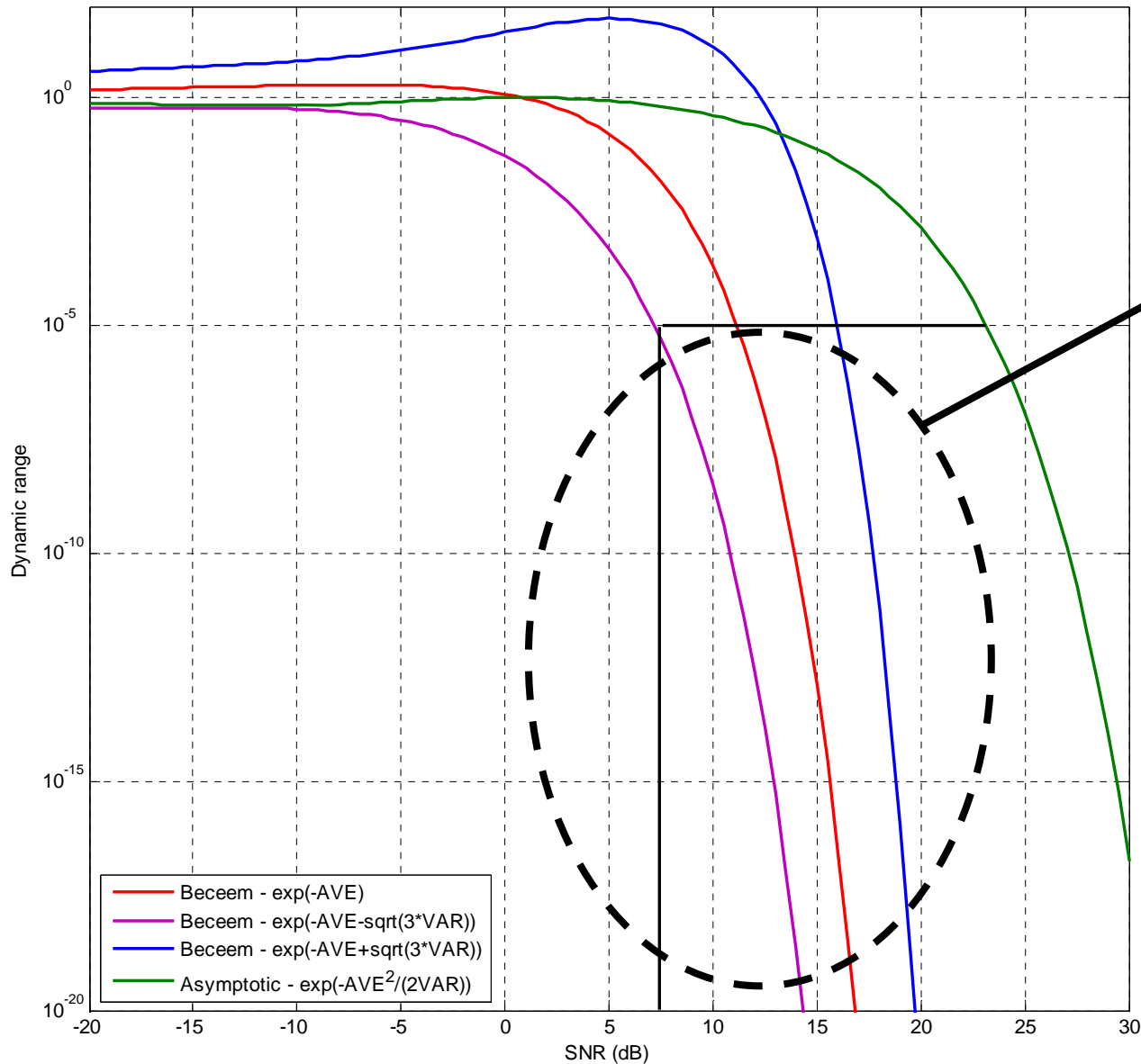
# Accuracy of SI approximation



**Switching point  
( $J \approx 0.65$ )**

**Perfect matching  
of hybrid scheme**

# Accuracy of Implementation







**Region of high dynamic range for Beceem elementary functions**

**Avoided by Hybrid scheme**



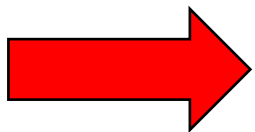
# Computation Time

Function Name	Calls	Total Time	Self Time*	Total Time Plot (dark band = self time)
<a href="#">Hybrid</a>	100001	4.866 s	2.339 s	
<a href="#">erfc</a>	100001	2.527 s	1.872 s	
<a href="#">beceem</a>	100001	1.201 s	1.201 s	
<a href="#">erfc</a> (MEX-function)	100001	0.655 s	0.655 s	

**Self time** is the time spent in a function excluding the time spent in its child functions.  
Self time also includes overhead resulting from the process of profiling.

## Impact on adjustment parameters $(a, p_1, p_2)$

- The proposal **does not impact the concept** behind introducing parameters  $(a, p_1, p_2)$ 
  - $a$  introduced to enhance the accuracy of derivation of AVE and VAR
  - $p_1$  and  $p_2$  introduced for the mixture of two LLR Gaussians in MIMO Matrix B + vertical encoding
- But as far as **SINR-RBIR mapping** is used for calibration, the **values of  $(a, p_1, p_2)$  might be affected**



It might be interesting to agree also about the numerical integration itself.

# Conclusions RBIR

- Proposal to replace current EVM RBIR Numerical Approximation of SI given by Equation (43), p.70:

11

$$SI \approx \log_2 M - \frac{1}{\log_e 2} \left[ \begin{array}{l} \frac{2}{3} f_1(AVE) \\ + \frac{f_1(AVE + \sqrt{3VAR})}{6} \\ + \frac{f_1(AVE - \sqrt{3VAR})}{6} \end{array} \right] \quad (43)$$

- With

$$SI \approx \log_2(M) - \frac{1}{\log_2(2)} \cdot J$$

$$J = \left( \frac{J_A + J_B}{2} \right) + \left( \frac{J_A - J_B}{2} \right) \text{sign}(J_A - T) \quad ; \quad T \approx 0.65$$

where

$$\left\{ \begin{array}{l} J_A = \sqrt{VAR} \cdot \left\{ \eta \cdot \left[ 1 + \frac{1}{2} \cdot \text{Erfc} \left( \frac{\eta}{\sqrt{2}} \right) \right] + \frac{1}{\sqrt{2\pi}} \cdot \exp \left( -\frac{\eta^2}{2} \right) \right\} \\ J_B = \frac{2}{3} f_1(AVE) + \frac{1}{6} f_1(AVE + \sqrt{3VAR}) + \frac{1}{6} f_1(AVE - \sqrt{3VAR}) \end{array} \right. \quad \eta = \frac{AVE}{\sqrt{VAR}}$$

$$f_1(x) = \log_e(1 + \exp(-x))$$