Enhanced Approximation for RBIR PHY Abstraction in TGm

IEEE 802.16 Presentation Submission

Document Number:
IEEE C80216m-08/067r4

Date Submitted:
2008-03-04

Source:

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Venue:
IEEE 802.16m Session#54, Orlando, USA

Base Contribution:
C80216m-08

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

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)

$$J_B = \frac{2}{3} f_1(AVE) + \frac{1}{6} f_1\left(AVE + \sqrt{3VAR}\right) + \frac{1}{6} f_1\left(AVE - \sqrt{3VAR}\right)$$

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

Numerical Integration within RBIR PHY Abstraction

- Asymptotic Approximation (new)

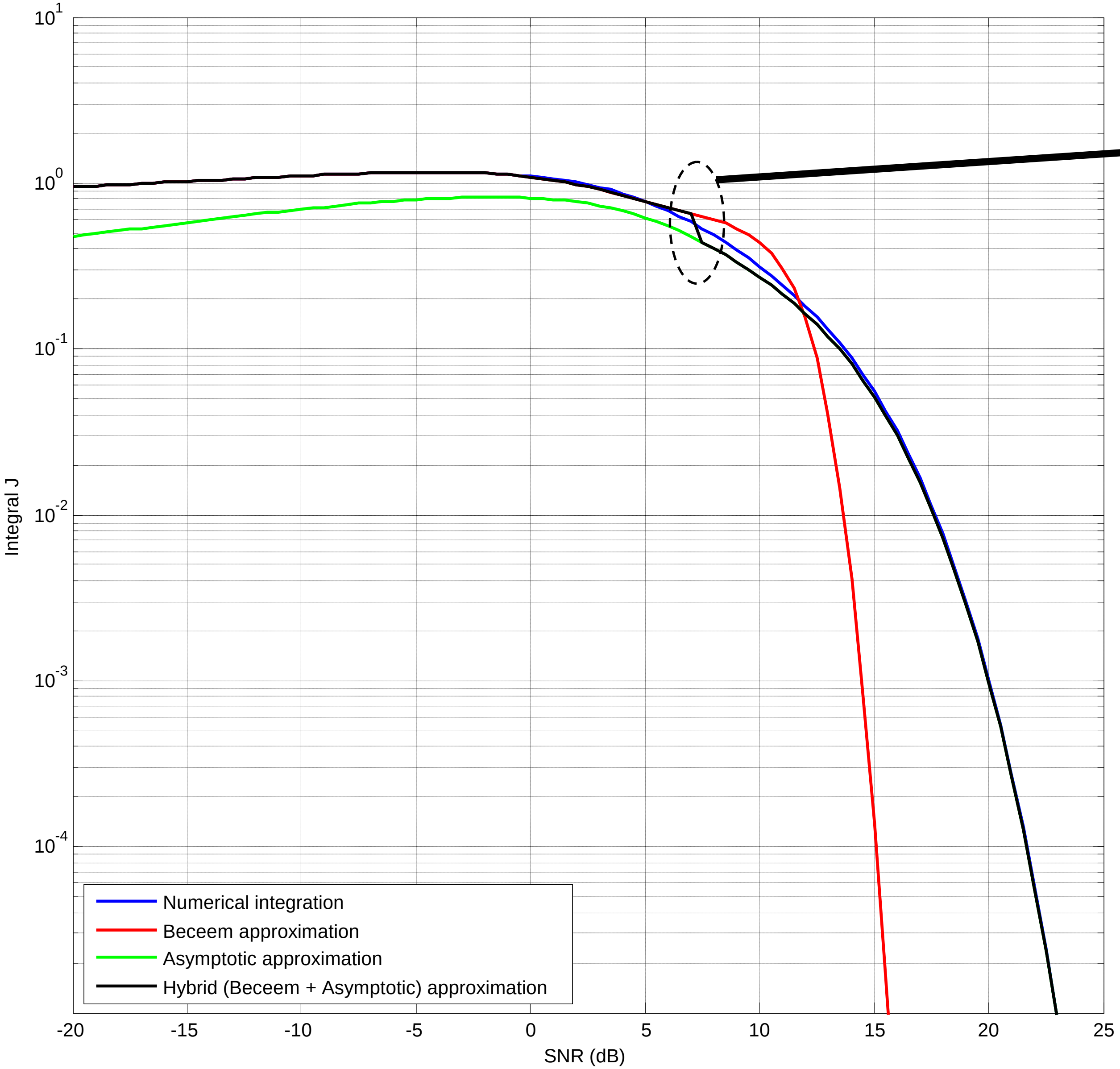
$$J_A = \sqrt{VAR} \cdot \left\{ \frac{-\eta}{2} \cdot Erfc\left(\frac{\eta}{\sqrt{2}} \right) + \frac{1}{\sqrt{2\pi}} \cdot \exp\left(-\frac{\eta^2}{2} \right) \right\} \qquad \eta = \frac{AVE}{\sqrt{VAR}}$$

- NEW Proposal:
  - ***Hybrid* {Beceem + Asymptotic}**

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

$$\mathrm{sign}(x) = \begin{cases} +1 & ; \quad x \geq 0 \\ -1 & ; \quad x < 0 \end{cases}$$

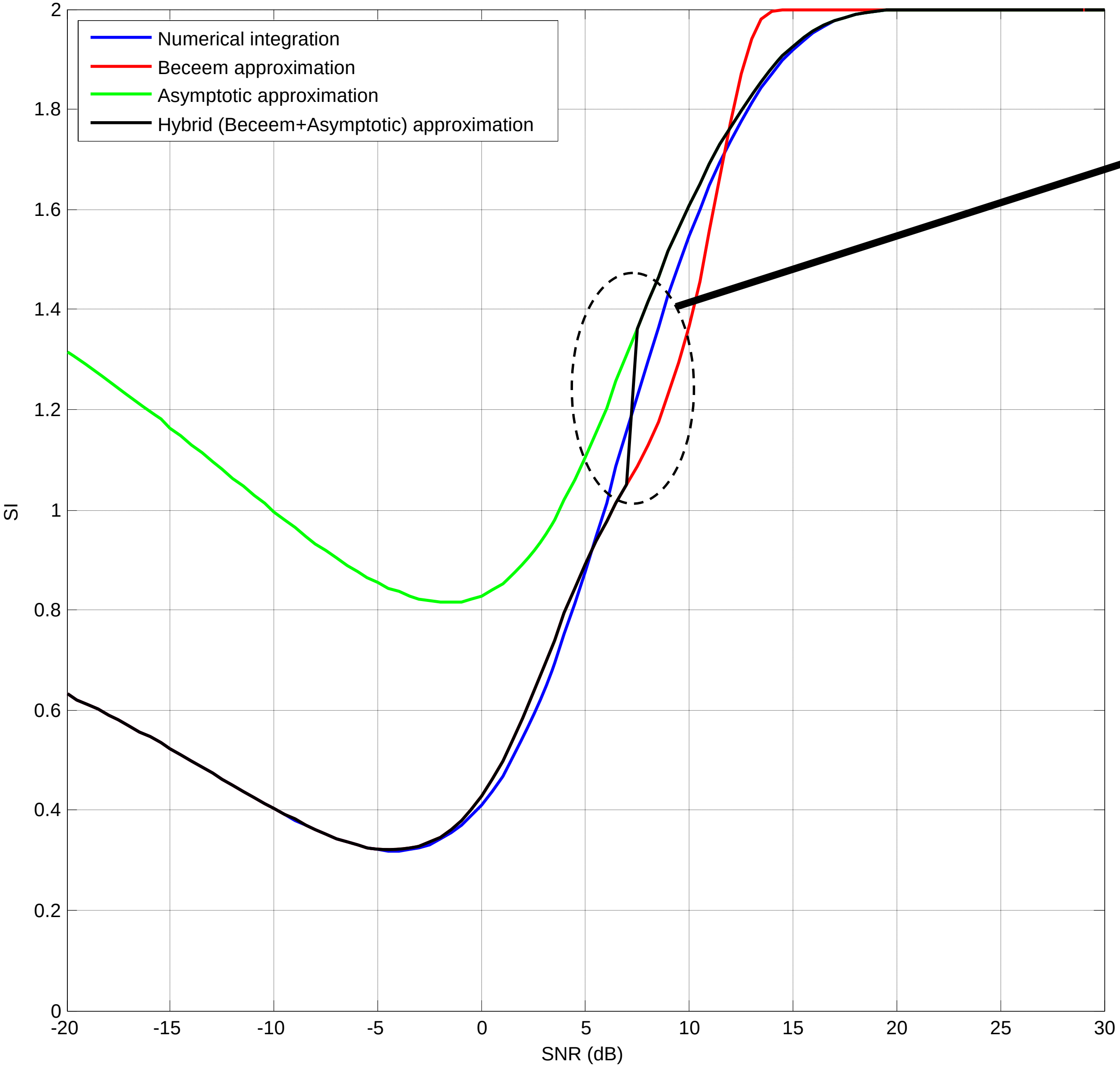
Accuracy of J approximation



Switching point (J ≈ 0.65)

Perfect matching of hybrid scheme

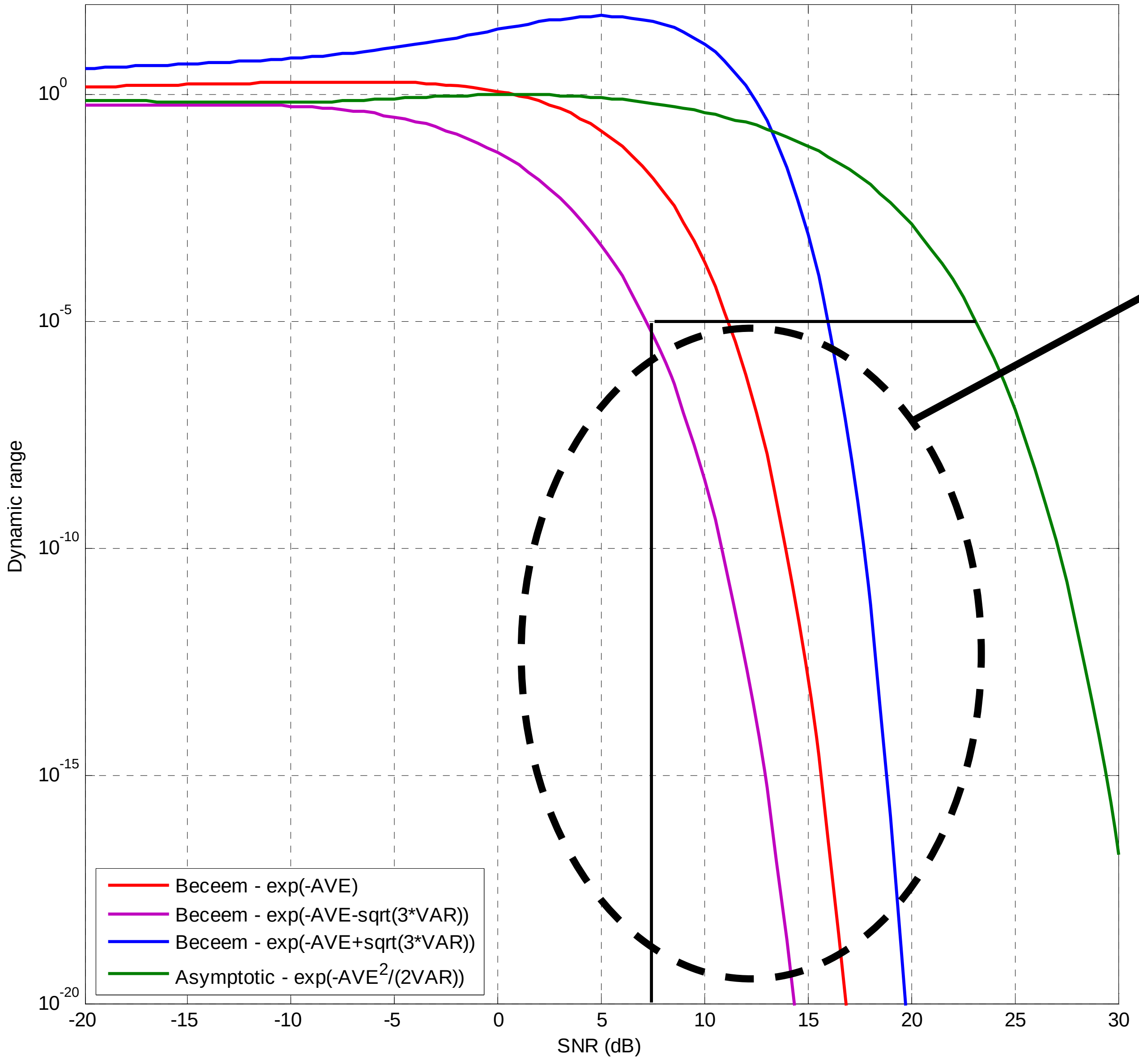
Accuracy of SI approximation



Switching point (J ≈ 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)
Hybrid	100001	4.866 s	2.339 s	
erfc	100001	2.527 s	1.872 s	
beceem	100001	1.201 s	1.201 s	
erfcore (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.

Continued Fraction

- Property of Erfc

$$Erfc(x) = Q(1/2, x^2) = \frac{\Gamma(0.5, x^2)}{\Gamma(0.5)}$$

$$\Gamma(0.5) = \sqrt{\pi}$$

$$Q(a,x) = \frac{\Gamma(a,x)}{\Gamma(a)}$$

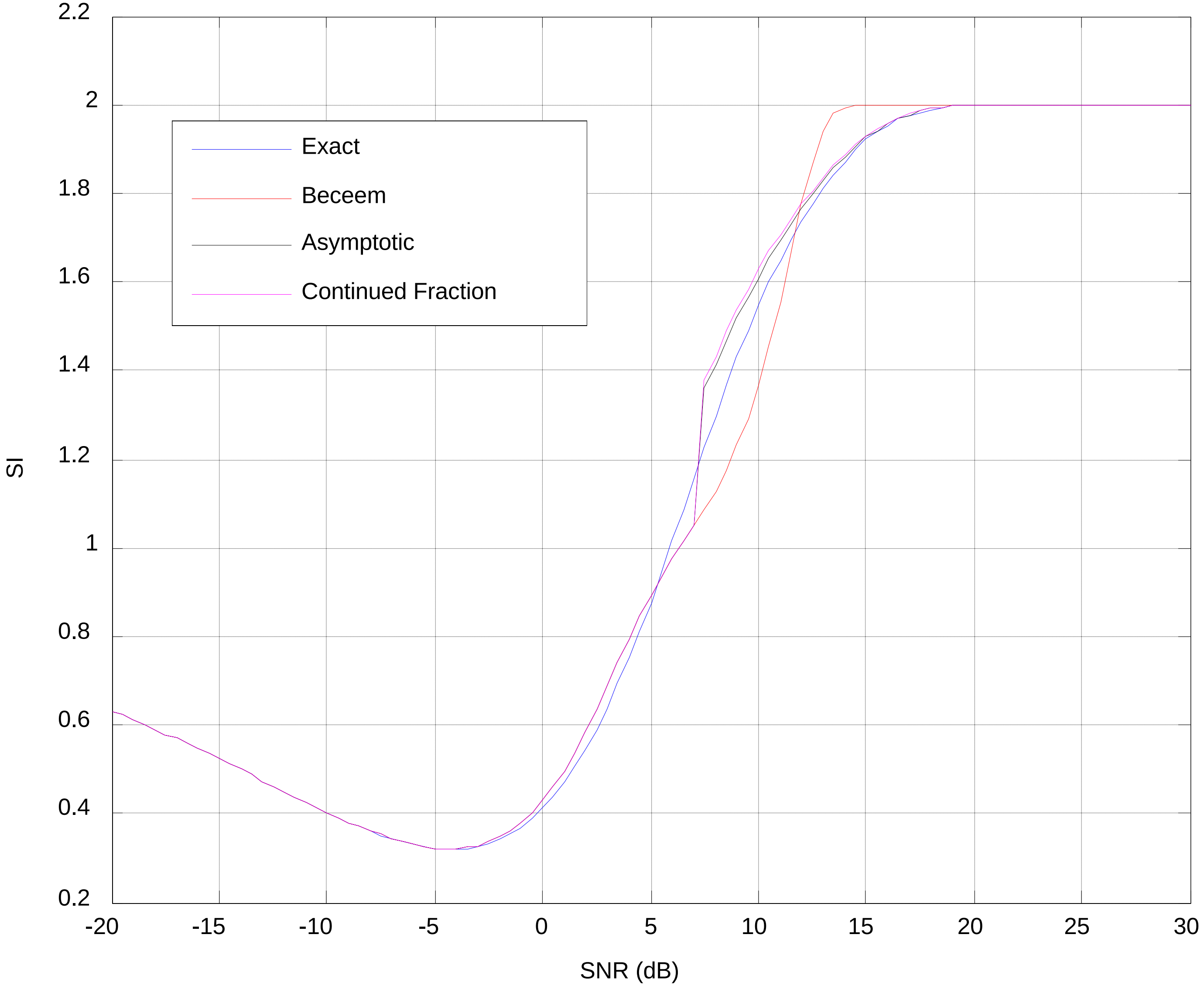
$$\Gamma(a,x) = \int_x^{+\infty} t^{a-1} \cdot e^{-t} \cdot dt$$

$$\Gamma(a) = \int_0^{+\infty} t^{a-1} \cdot e^{-t} \cdot dt$$

- Legendre continued Fraction

$$\Gamma(0.5, x) \approx e^{-x} \cdot \sqrt{x} \cdot \frac{2x+3}{(2x+1)\cdot(x+1.5)-1}$$

Continued Fraction comparison



Final Expression

$$J_A = \sqrt{VAR} \cdot \frac{\exp\left(-\frac{\eta^2}{2}\right)}{\sqrt{2\pi}} \cdot \left\{1 - \eta^2 \cdot \frac{\eta^2 + 3}{\left[\left(\eta^2 + 1\right) \cdot \left(\eta^2 + 3\right) - 2\right]}\right\}$$

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:

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

- With

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

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

where

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

$$J_B = \frac{2}{3} f_1(AVE) + \frac{1}{6} f_1\left(AVE + \sqrt{3VAR}\right) + \frac{1}{6} f_1\left(AVE - \sqrt{3VAR}\right)$$

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

$$\mathrm{sign}(x) = +1\,;\, x \geq 0 \quad \text{and} \quad -1\,;\, x < 0$$