

10GBASE-T Line Signaling

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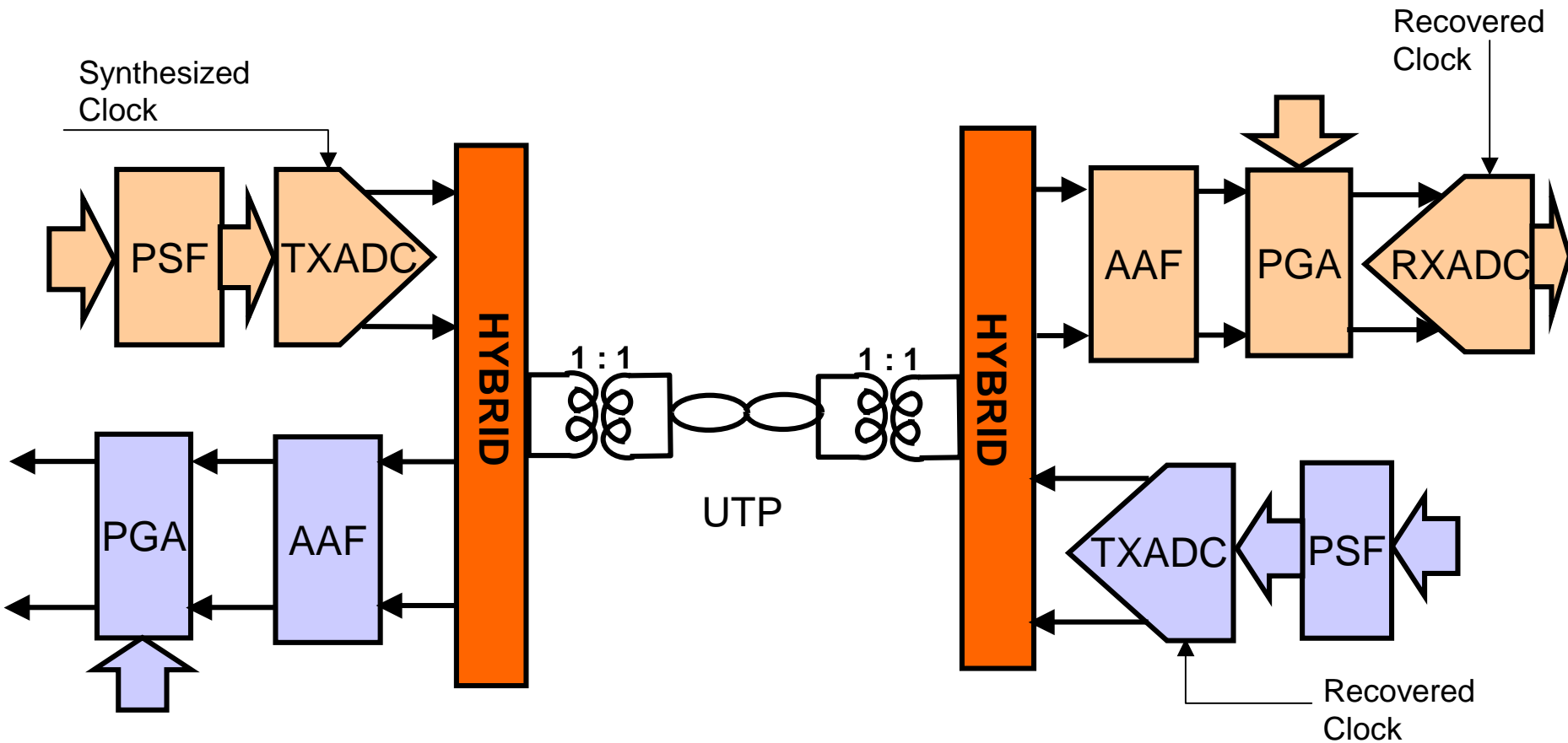
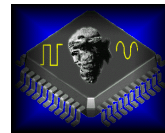
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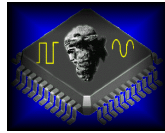
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Analog Front End (AFE) model for DSP Solution





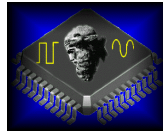
Assumptions for AFE Linearity Analysis

- 2 V_p peak-to-peak PAM-M launch signal
- Analog differential blocks have only odd non-linearity
- Analog blocks are characterized by:

$$Y = \beta X(1 + \alpha X^2)$$

- β block gain
- α 3rd order non-linearity coefficient

Worst-case Non-linearity Error (Normalized - 0m)



For l (cable length)=0 cascading seven $X(1+\alpha X^2)$ blocks and retaining only 1st three terms assuming:

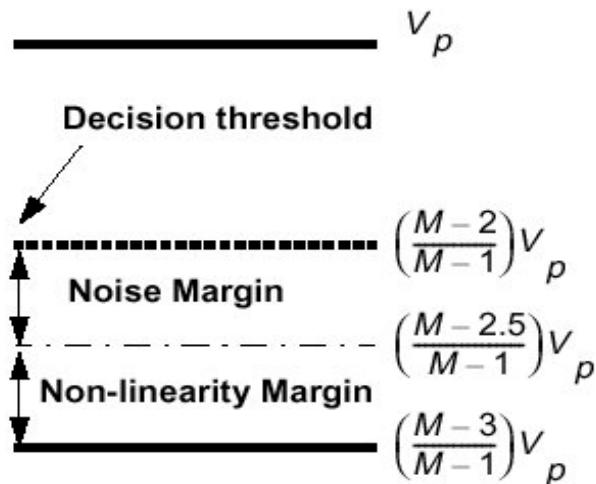
$$\beta_{1-6} = 1 \quad \beta_{7(PGA)} = \frac{1}{1 + 7\alpha V_p^2 + 63\alpha^2 V_p^4}$$

The slicer input becomes:

$$Y = \frac{X(1 + 7\alpha X^2 + 63\alpha^2 X^4)}{1 + 7\alpha V_p^2 + 63\alpha^2 V_p^4}$$

The maximum error happens when

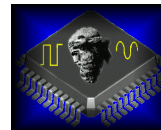
$$X = \pm \left(\frac{V_p}{\sqrt{3}} \right) \sqrt{1 + 9\alpha V_p^2}$$



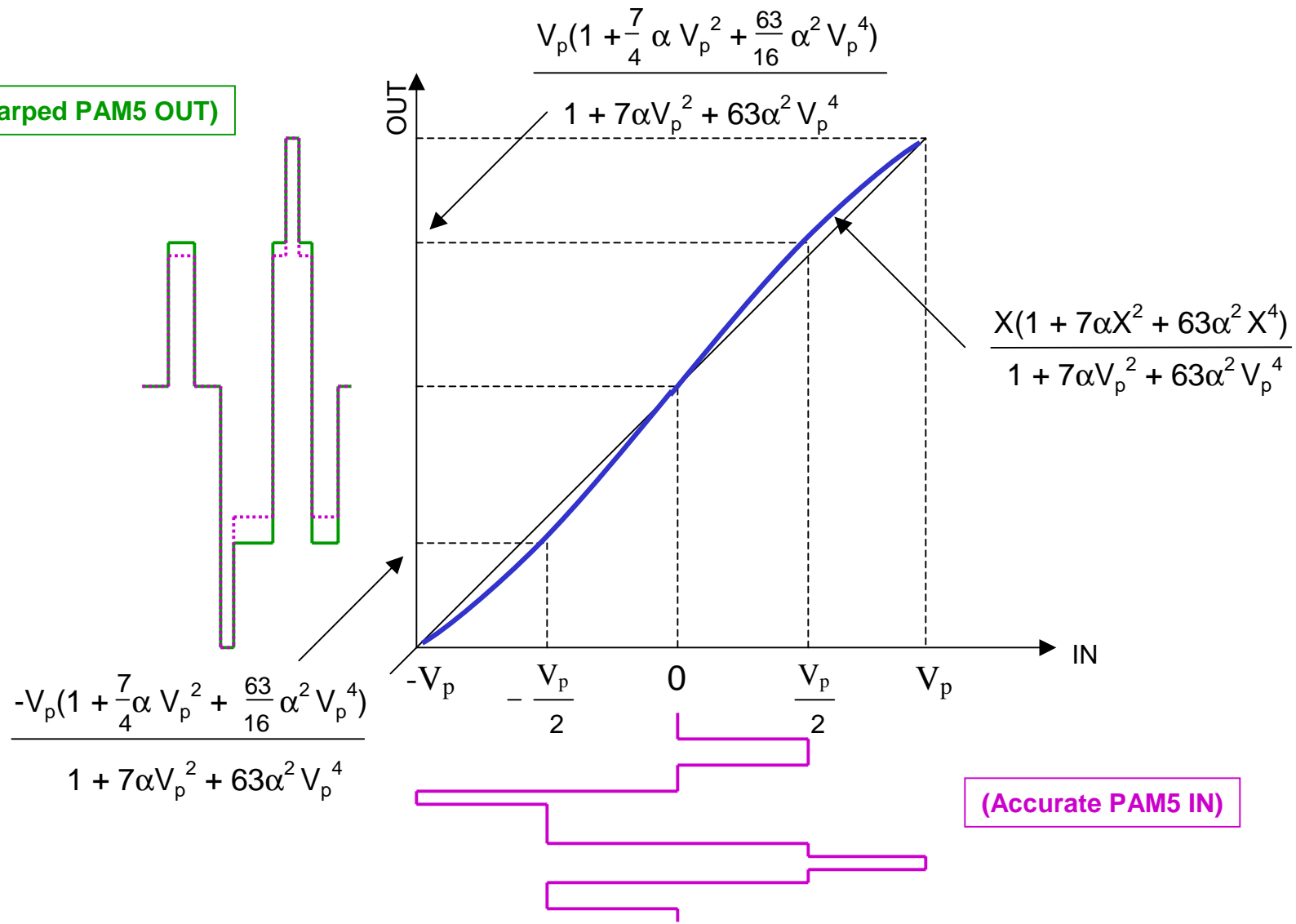
$$error \leq \frac{V_p}{2(M-1)}$$

$$|\alpha| \leq \frac{1}{5.39(M-2.30)V_p^2}$$

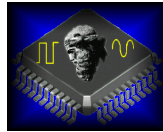
Combined AFE Non-linearity (7 blocks normalized)



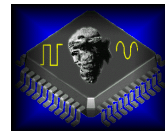
(Warped PAM5 OUT)



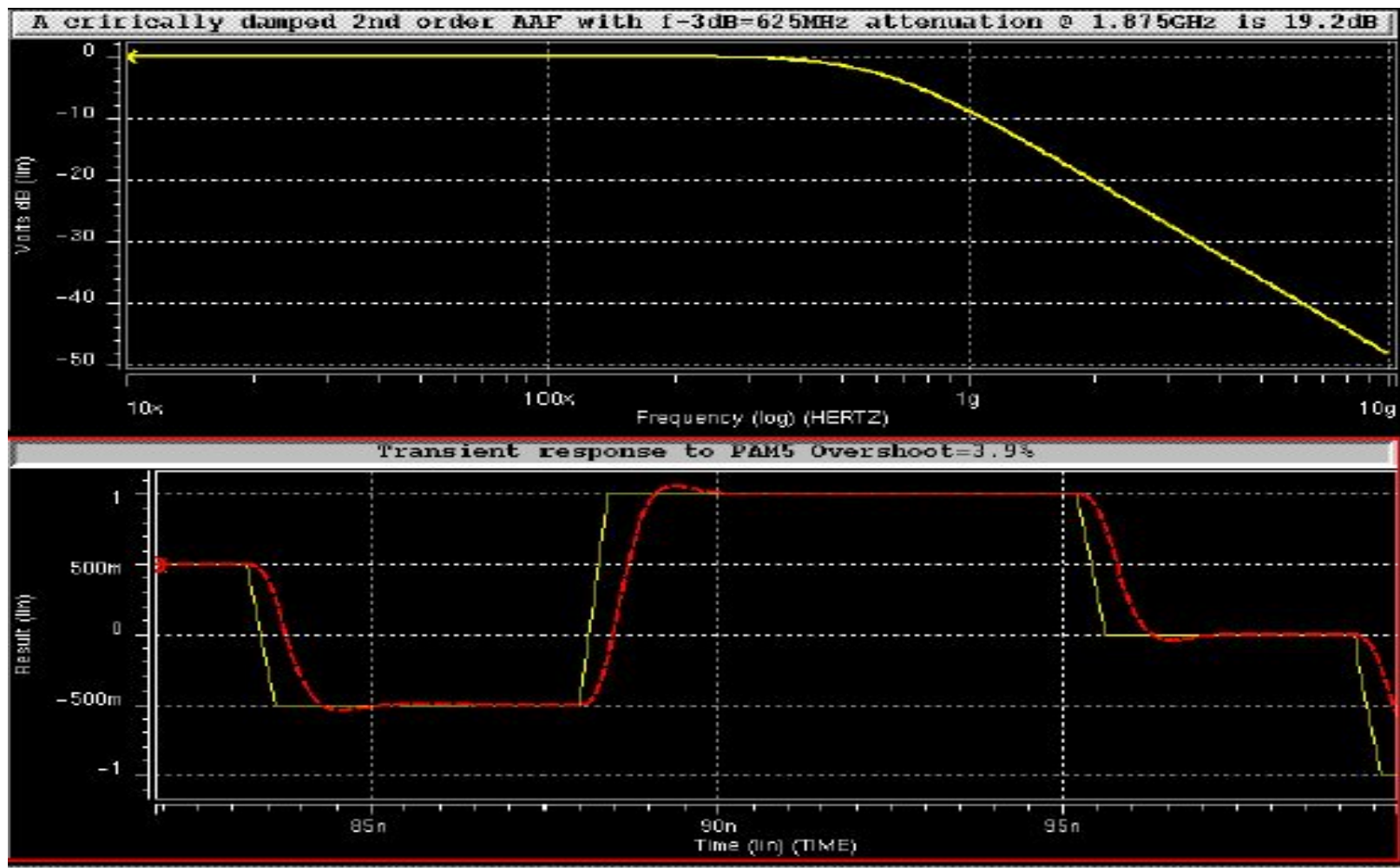
AFE Linearity Requirement (Normalized) vs. Line-Signal

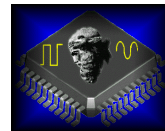


Line Code	Peak-to-Peak (V)	Launch Power (dBm)	α Formula (%)	α Simulation (%)
PAM-5 (Plato Labs)	2.000	7.00	6.90	6.00
PAM-10 (Solar Flare)	3.134	10.00	1.00	1.30
PAM-10 (MRVL/BRCM)	2.000	6.10	2.41	

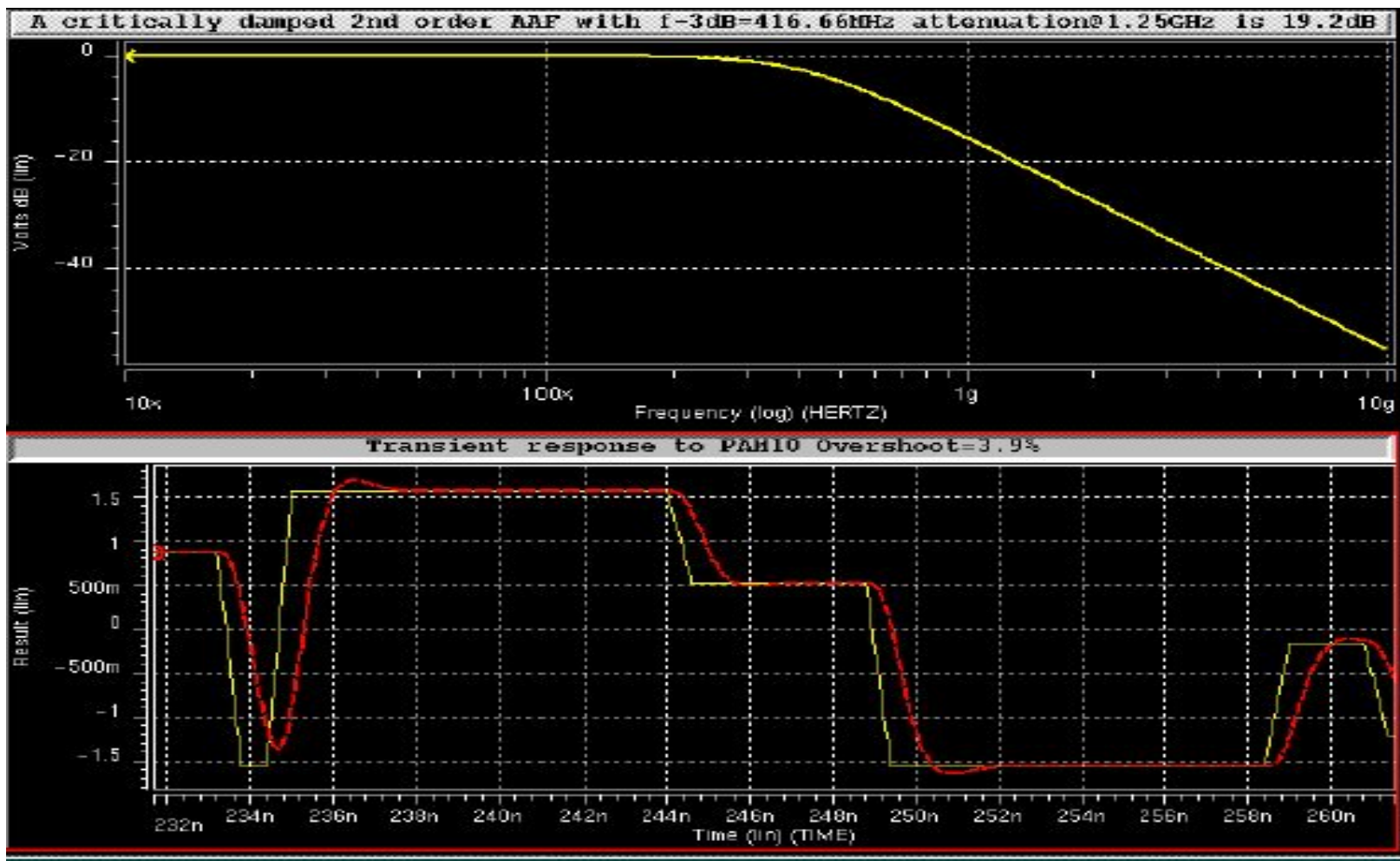


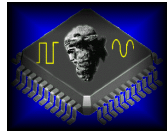
Frequency & transient (PAM5) responses of a critically damped 2nd order AAF



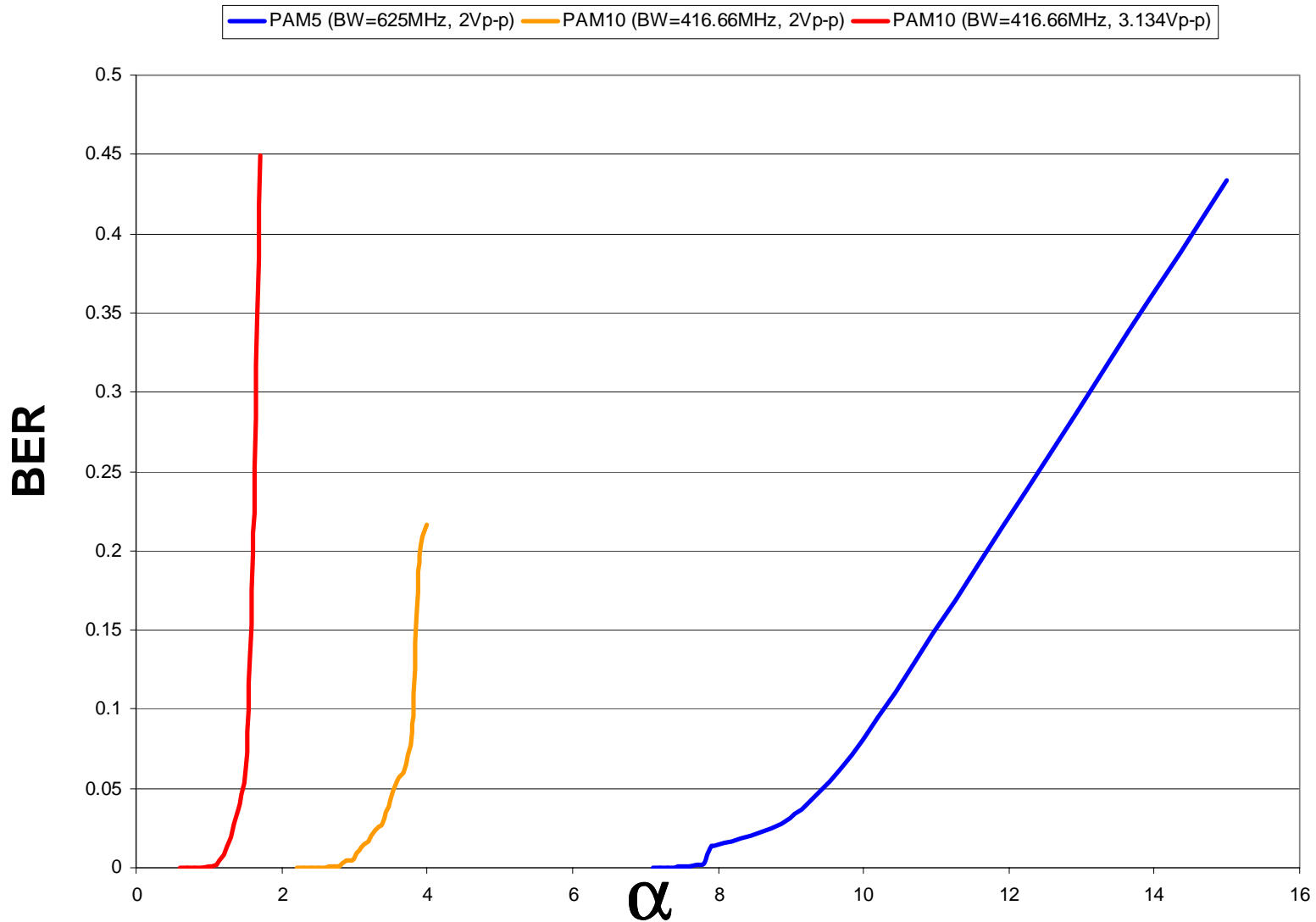


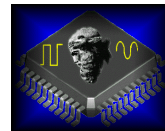
Frequency & transient (PAM10) responses of a critically damped 2nd order AAF





BER vs Non-linearity





BER vs Non-linearity

