

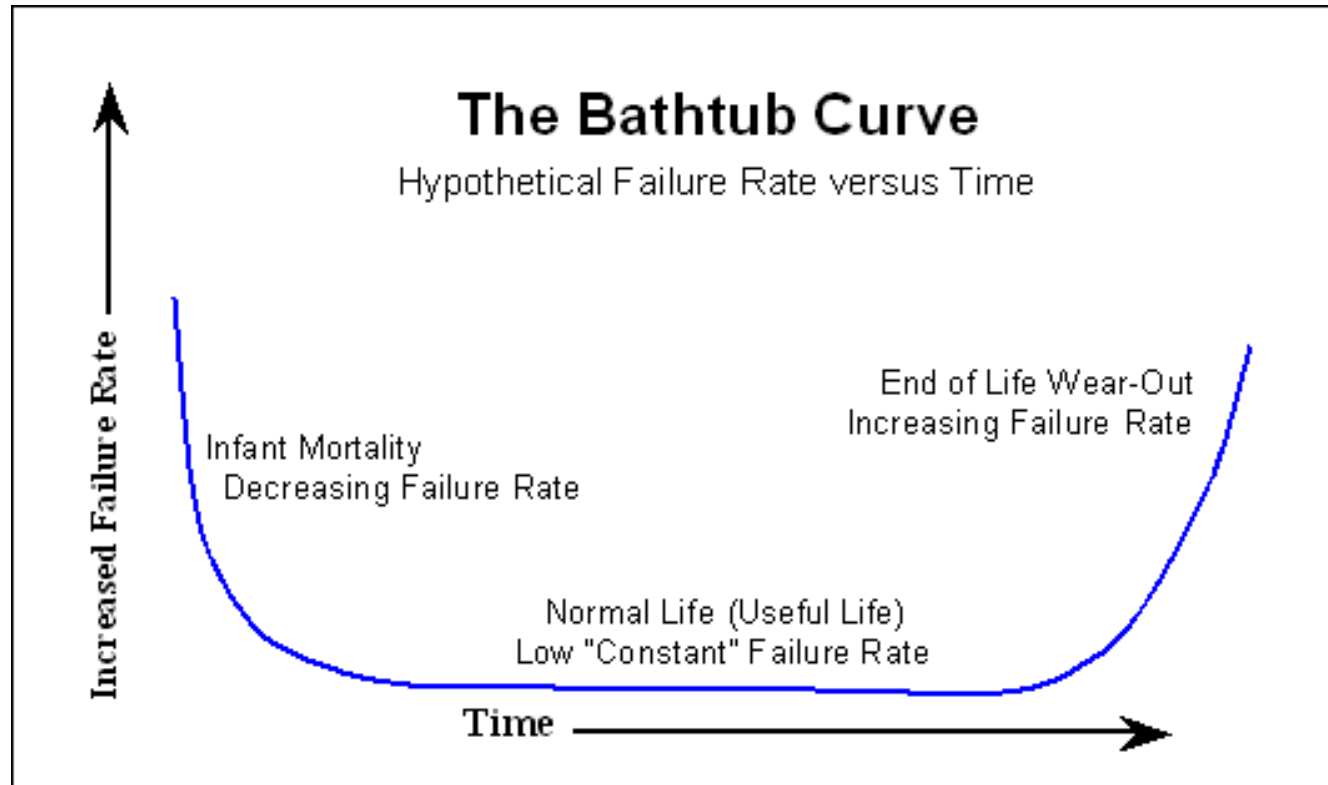
Bathtub Curve Generation

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What: A Measure of Reliability

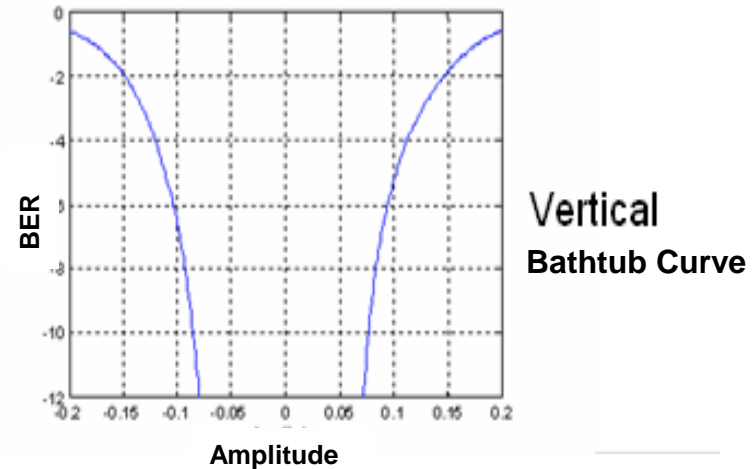
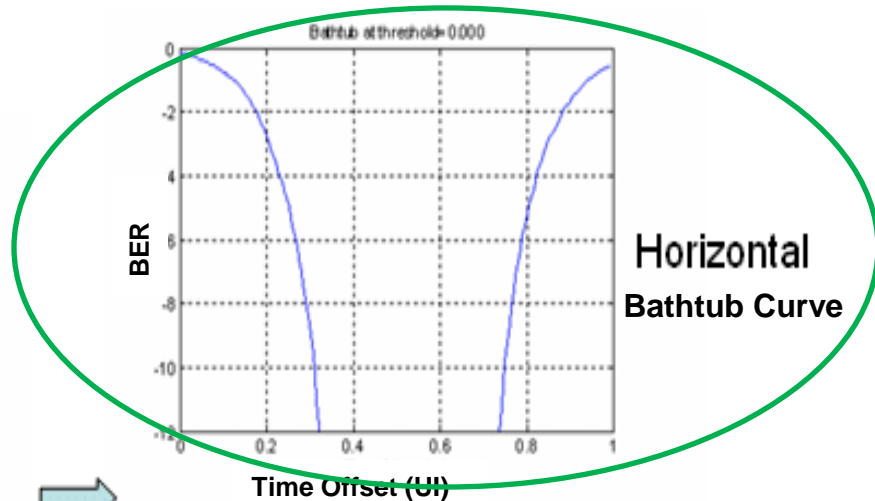
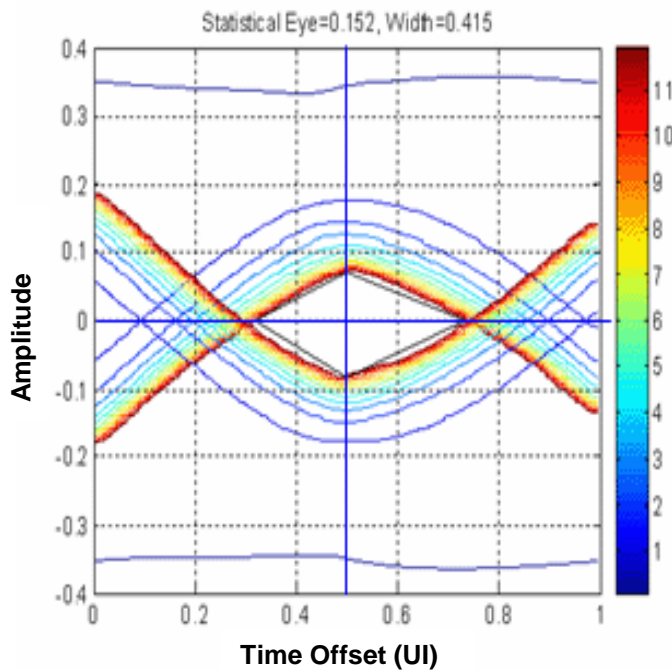
Describes the failure rate of products like cars, TVs, toasters and...



even applies to non-products like **signal integrity (SI)**.

Bathtub curve as a jitter tolerance indicator

- Bathtub Curve = BER(sample-time offset from ideal)

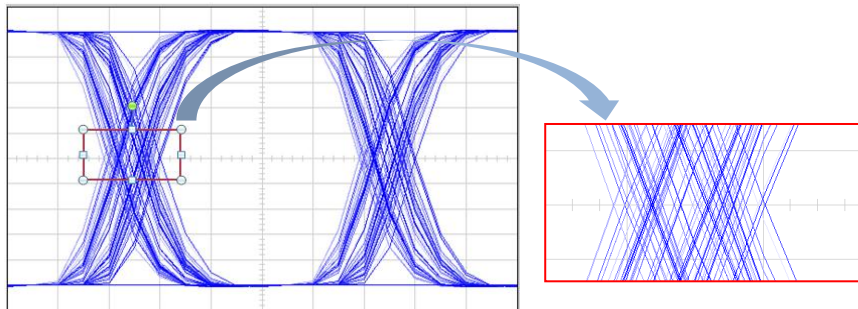


How: Two Ways to Generate Bathtub Curves

1. **Direct:** Count Errors to determine BER

if RX bit(n) != TX bit(n)
error_cnt = error_cnt + 1;
n++;

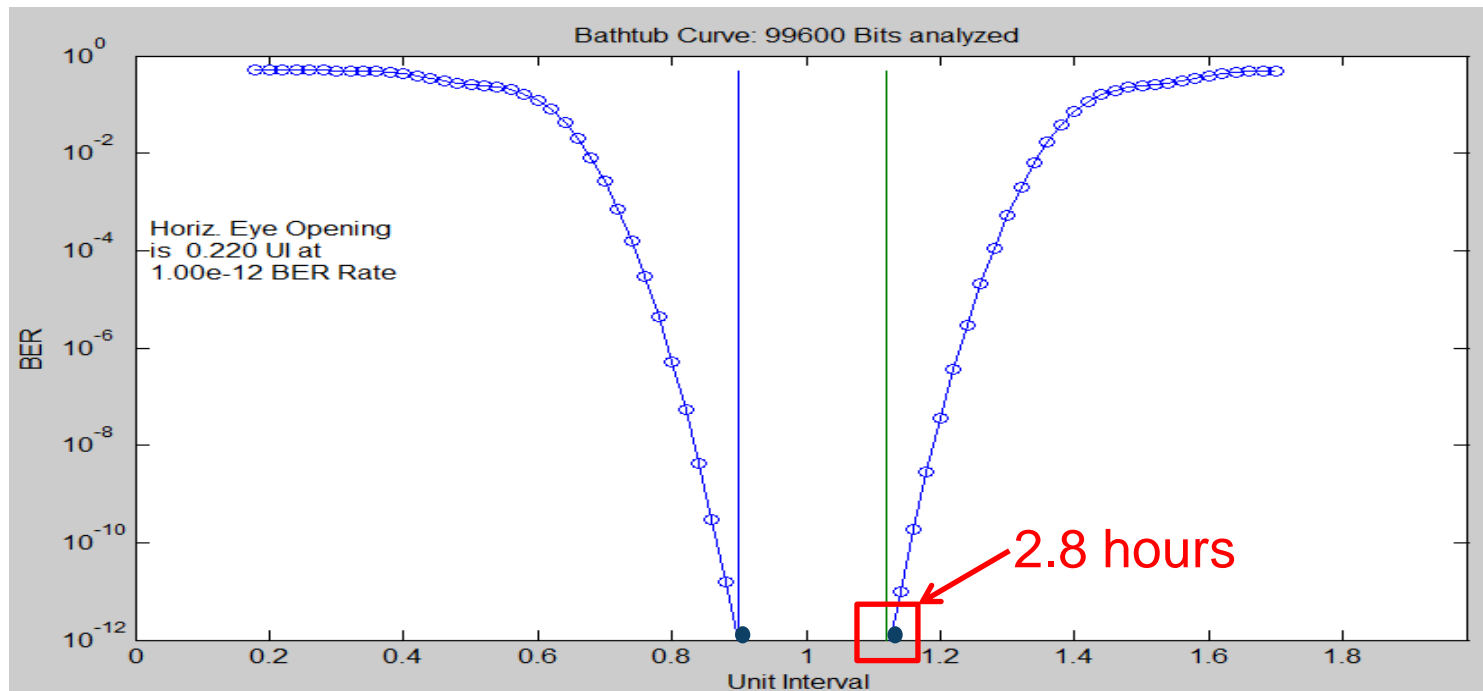
2. **Indirect:** Statistically estimate BER from zero-crossings



➤ Both methods have their place.

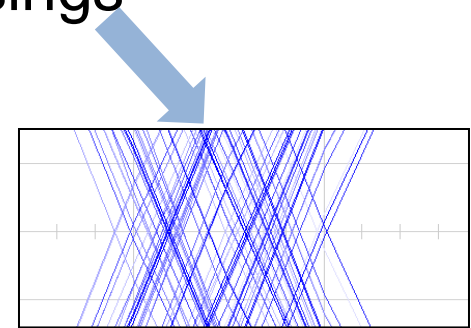
1. Direct Method: Counting Errors

- Example: 100 errors for $1e-12$ BER \rightarrow $100e12$ total bits
 - **Hardware:** Assume 10 Gb/s processing. $100e12/10e9 = 1e4$ sec
 - **Software:** Not feasible.



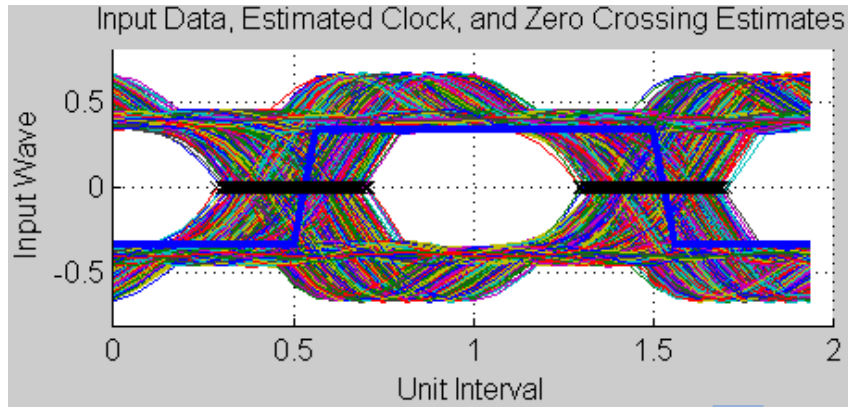
2. Indirect Method: Statistical BER Estimation

- Statistically estimate BER from zero-crossings
- An *all-at-once* measurement technique
 - Single simulation
 - No errors, no comparisons
- **When and Why:** Applicable when Dual-Dirac¹ modeling assumption holds AND:
 - Pre-silicon
 - BERT is unavailable
 - **Speed is paramount**

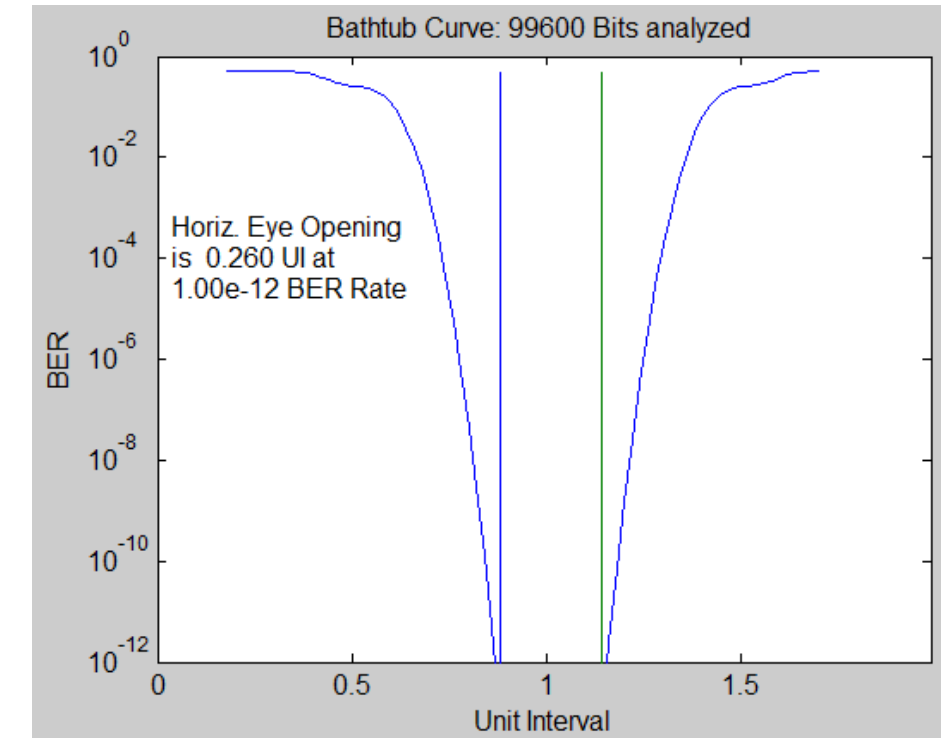
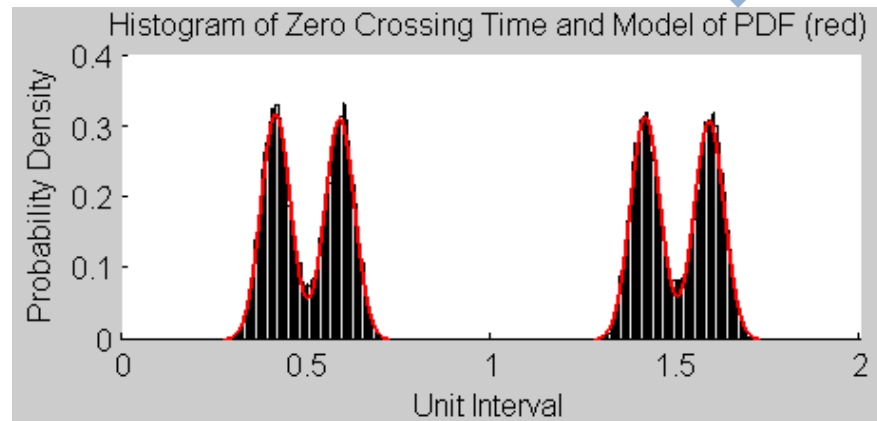


1. http://www.ece.ncsu.edu/asic/ece733/2009/docs/Jitter_Tektronics.pdf

How: It's a 3 step process



1. Align Eye & Log



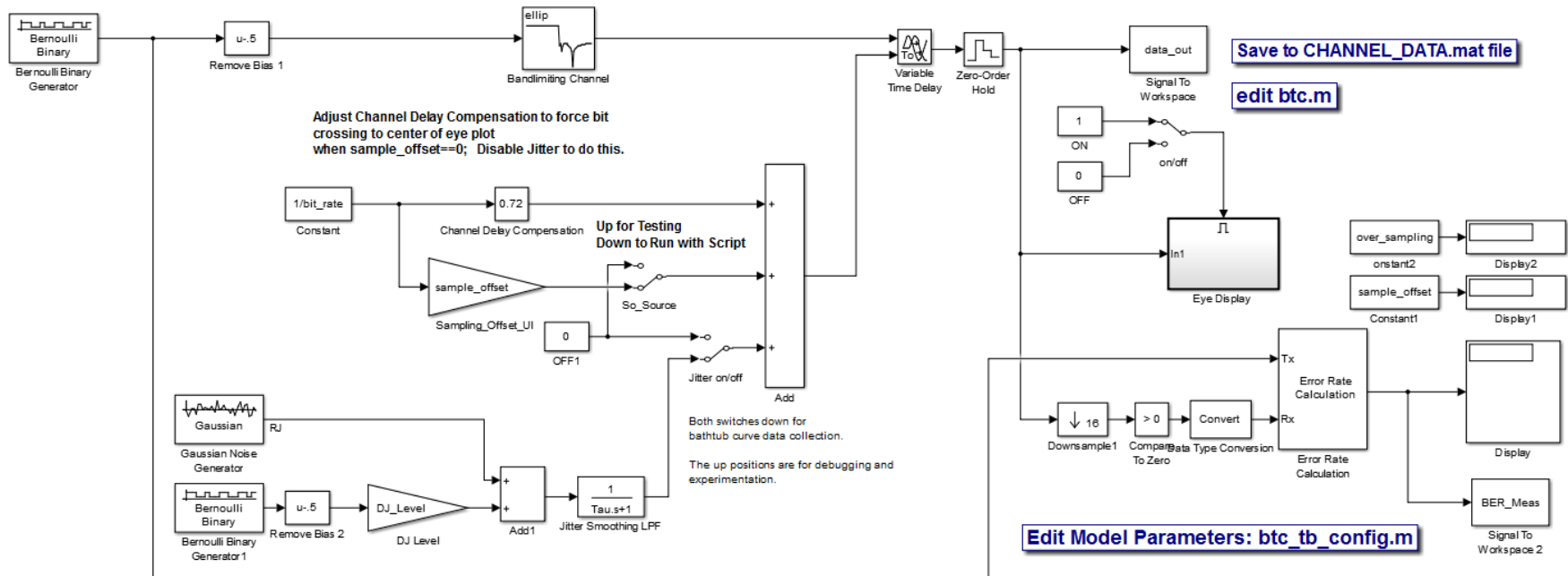
3. Integrate & Plot

2. Histogram ZC's & DD Fit

Our Flow Today

- Generate data with RJ, DJ, and ISI
- Coarsely Align Eye
- Log Channel Output → (Histogram, Fit, & Integrate using MATLAB)

Bathtub Curve Testbench



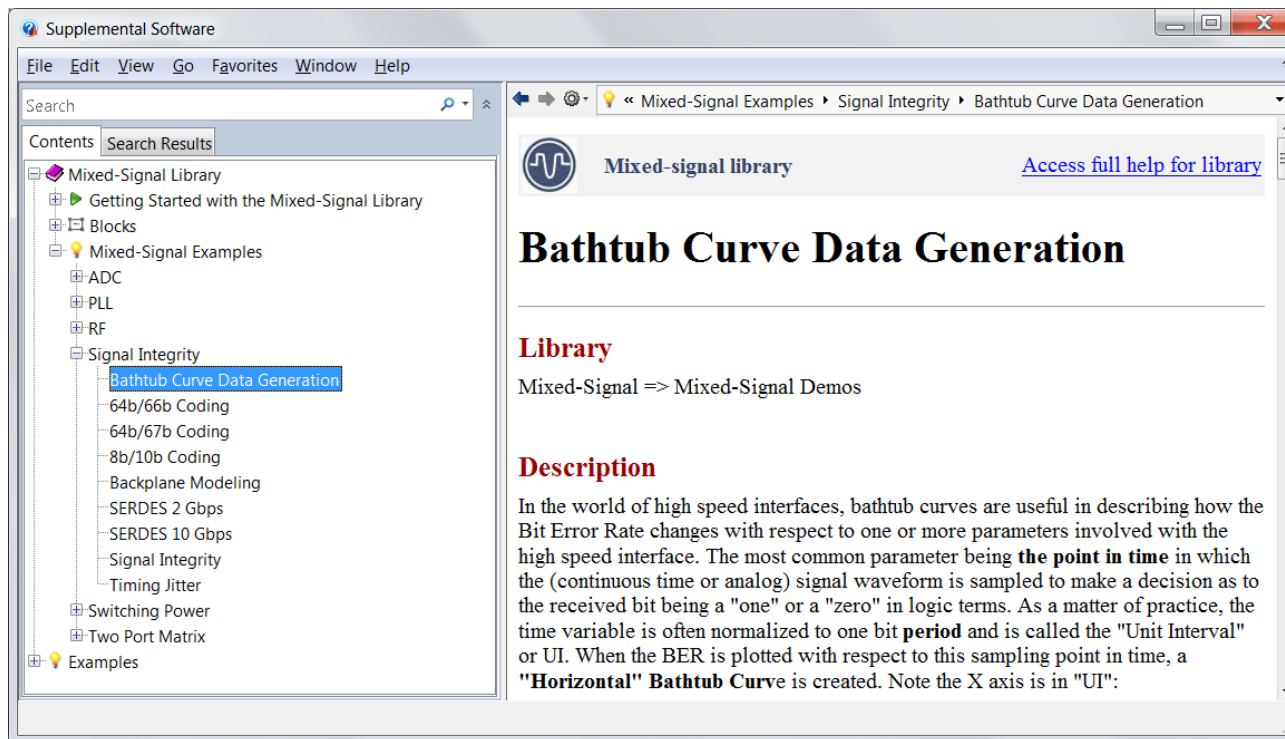
Getting Started

- For bathtub curve examples

<https://www.mathworks.com/programs/mixed-signal/index.html>

- Intel-only portal

www.mathworks.com/programs/user-portals/intel.html



The screenshot shows a web browser window titled "Supplemental Software". The address bar displays the path: « Mixed-Signal Examples » Signal Integrity » Bathtub Curve Data Generation. The left sidebar shows a tree view of the "Mixed-Signal Library" with "Bathtub Curve Data Generation" selected under "Signal Integrity". The main content area displays the title "Bathtub Curve Data Generation" and a "Library" section with the text "Mixed-Signal => Mixed-Signal Demos". Below this is a "Description" section.

Library
Mixed-Signal => Mixed-Signal Demos

Description
In the world of high speed interfaces, bathtub curves are useful in describing how the Bit Error Rate changes with respect to one or more parameters involved with the high speed interface. The most common parameter being **the point in time** in which the (continuous time or analog) signal waveform is sampled to make a decision as to the received bit being a "one" or a "zero" in logic terms. As a matter of practice, the time variable is often normalized to one bit **period** and is called the "Unit Interval" or UI. When the BER is plotted with respect to this sampling point in time, a "**Horizontal**" Bathtub Curve is created. Note the X axis is in "UI":