"Bathtub" Method To Find Emphasis Values

Overview

Optimal emphasis settings (pre, post and main) are responsible for providing link stability/data integrity by controlling the shape of the TX signal. Due to a multitude of connection characteristics between TX/RX port pairs, the signal may be significantly degraded/deformed by the time it reaches the RX port. Therefore, signal shape manipulation on the TX port is used to help ensure proper reception on the RX port.

Interactive Emphasis Settings Chart

To see how emphasis values affect the shape of the signal, click and download the How To Use Emphasis Values spreadsheet.

Once downloaded, open the spreadsheet and insert various emphasis values in the following fields (TXDIFFCTRL, TXPOSTCURSOR and TXPRECURSOR):

You will then see how the pre (TXPRECURSOR), post (TXPOSTCURSOR) and main (TXDIFFCTRL) tap values affect the shape of the TX signal:

Ideally, Link Training (LT) should be used in order to automatically determine the optimal emphasis settings between two ports. However, customers are frequently unable to fully support LT on their Device Under Test (DUT) by the time they start using Spirent test equipment. Therefore, the "Bathtub" method can be employed in order to manually determine emphasis values for link stability.

Bathtub Curve Abstract

The Bathtub Curve is widely used in reliability engineering. It describes a particular form of the hazard function which comprises three parts:

- The first part is a decreasing failure rate, known as early failures.
- The second part is a constant failure rate, known as random failures.
- The third part is an increasing failure rate, known as wear out failures.
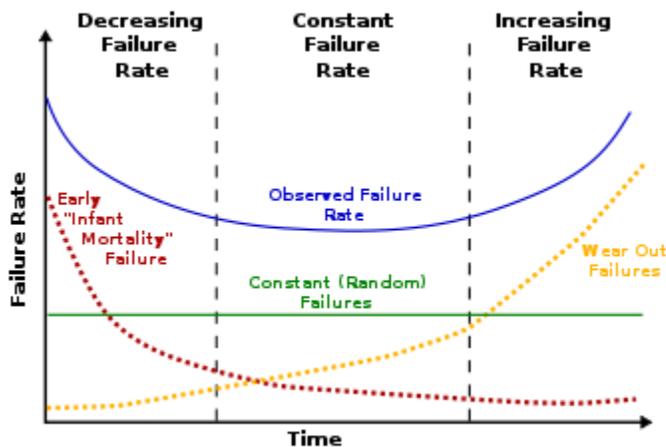
The name is derived from the cross-sectional shape of a bathtub: steep sides and a flat bottom.

The 'bathtub curve' hazard function (blue, upper solid line) is a combination of a decreasing hazard of early failure (red dotted line) and an increasing hazard of wear-out failure (yellow dotted line), plus some constant hazard of random failure (green, lower solid line).

The bathtub curve is generated by mapping the rate of early "infant mortality" failures when first introduced, the rate of random failures with constant failure rate during its "useful life", and finally the rate of "wear out" failures as the product exceeds its design lifetime.

In less technical terms, in the early life of a product adhering to the bathtub curve, the failure rate is high but rapidly decreasing as defective products are identified and discarded, and early sources of potential failure such as handling and installation error are surmounted. In the mid-life of a product—generally speaking for consumer products—the failure rate is low and constant. In the late life of the product, the failure rate increases, as age and wear take their toll on the product. Many electronic consumer product life cycles strongly exhibit the bathtub curve.[1]

While the bathtub curve is useful, not every product or system follows a bathtub curve hazard function, for example if units are retired or have decreased use during or before the onset of the wear-out period, they will show fewer failures per unit calendar time (not per unit use time) than the bathtub curve.

In reliability engineering, the cumulative distribution function corresponding to a bathtub curve may be analyzed using a Weibull chart.[1]

Bathtub Method Deficiency

One caveat to using the bathtub method is that it requires access to DUT error count information (e.g. Dropped Packet Counts, FCS Error Counts, FEC Error Counts, etc., etc.).

Algorithm

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1. Setup:
   1. Configure desired speed on Spirent and DUT ports.
   2. Disable AN/LT and FEC on both sides (i.e. the algorithm is more effective with the higher possibility of errors).
   3. Spirent Port Setup:
      1. Setup raw stream of fixed length packets with PRBS as content @ 100% load.
      2. Enter "Advanced" mode to manually configure TX emphasis values.
      3. Connect media between Spirent and DUT ports.

2. On STC GUI, immediately set pre, post and main tap values to 0:0:0.

3. Find Optimal Main Tap Value:
   1. Increment main tap value until link comes up.
   2. Once link comes up:
      1. Run traffic and monitor for **any** errors on both Spirent and DUT ports.
      2. Continue to increment main tap value until **no errors occur** for at least **5 seconds**.
      3. Once no errors are seen within a 5 second window, take note of the current main tap value and record it as **MAIN_TAP_MIN**.
         - **MAIN_TAP_MIN** is considered one side of the bathtub.
   3. Now set the main tap value to the max.
   4. Decrement main tap value until link comes up.
   5. Once link comes up:
      1. Run traffic and monitor for **any** errors on both Spirent and DUT ports.
      2. Continue to decrement main tap value until **no errors occur** for at least **5 seconds**.
      3. Once no errors are seen within a 5 second window, take note of the current main tap value and record it as **MAIN_TAP_MAX**.
         - **MAIN_TAP_MAX** is considered the other side of the bathtub.
   6. Once **MAIN_TAP_MIN** and **MAIN_TAP_MAX** have been determined:
      1. Calculate the average and round to the closest integer, this will be the **MAIN_TAP_OPTIMIZED** value.
      2. Set the main tap to **MAIN_TAP_OPTIMIZED**.
         - **MAIN_TAP_OPTIMIZED** is considered the center of the bathtub.

4. Find Optimal Pre Tap Value:
   1. Similarly, the **PRE_TAP_OPTIMIZED** value is determined by performing the same steps as was done above for the main tap value.

5. Find Optimal Post Tap Value:
   1. Similarly, the **POST_TAP_OPTIMIZED** value is determined by performing the same steps as was done above for the main tap value.