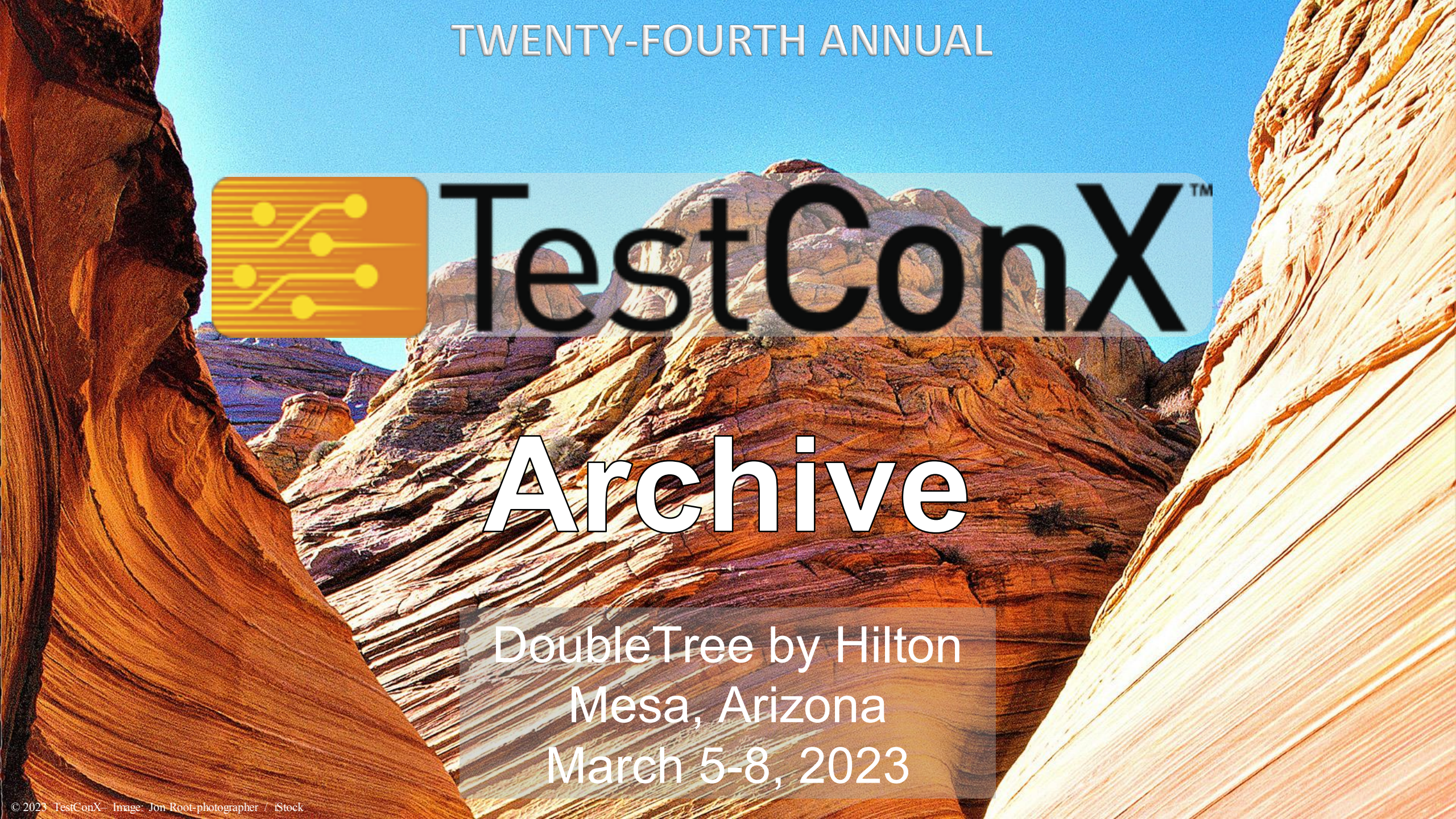

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The de-skewing technology for channel branching with fan-out buffers to implement a high parallelism probe card

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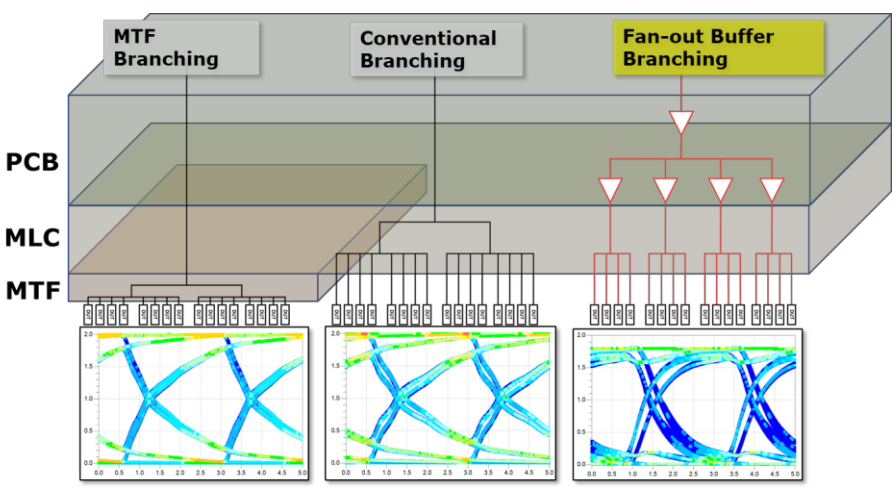
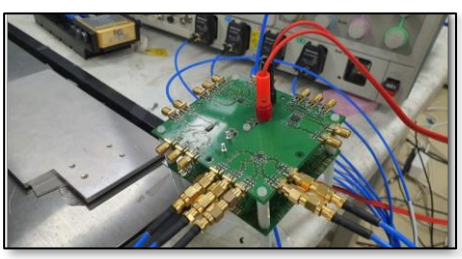
Introduction

The branching technology using fan-out buffers is a promising solution to achieve good SI performance for the DRAM probe card by substituting critical branches that cause impedance discontinuities. However, fan-out buffers on the market have too significant skews to be adopted for DRAM probe cards as they are. Therefore, we propose a novel de-skewing method to measure and correct skews due to buffers and channels which is applicable to arbitrary signals as well as repetitive clock signals.



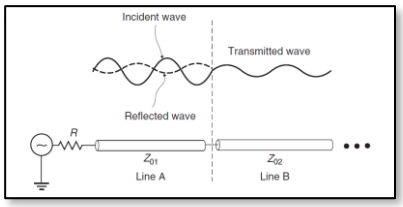


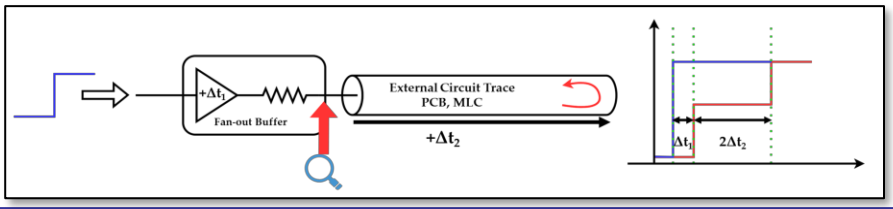
Sample	200MHz / 4Ch-Skews					
	1.6V	1.5V	1.4V	1.3V	1.2V	1.1V
A	108ps	74ps	74ps	72ps	-	-
B	48ps	54ps	46ps	34ps	-	-
C	41ps	39ps	49ps	49ps	-	-
D	-	-	-	-	-	22ps

De-skewing Methods Suitable for Use in Probe Cards

Unfortunately, most de-skewing techniques are designed for repetitive clocks, which are inappropriate for use with the arbitrary command signals transmitted through probe card channels.

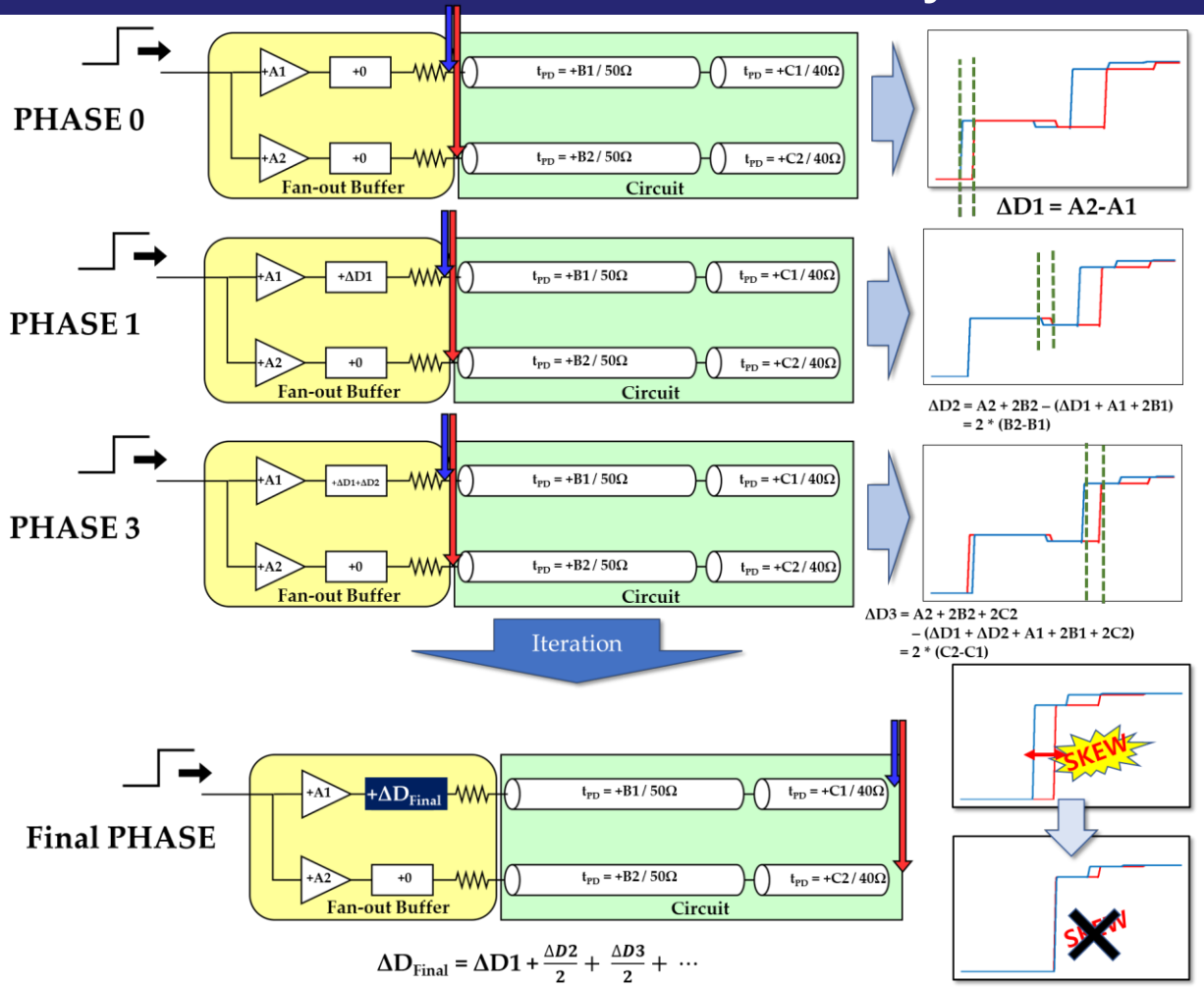
Applicability of Time Domain Reflectometry





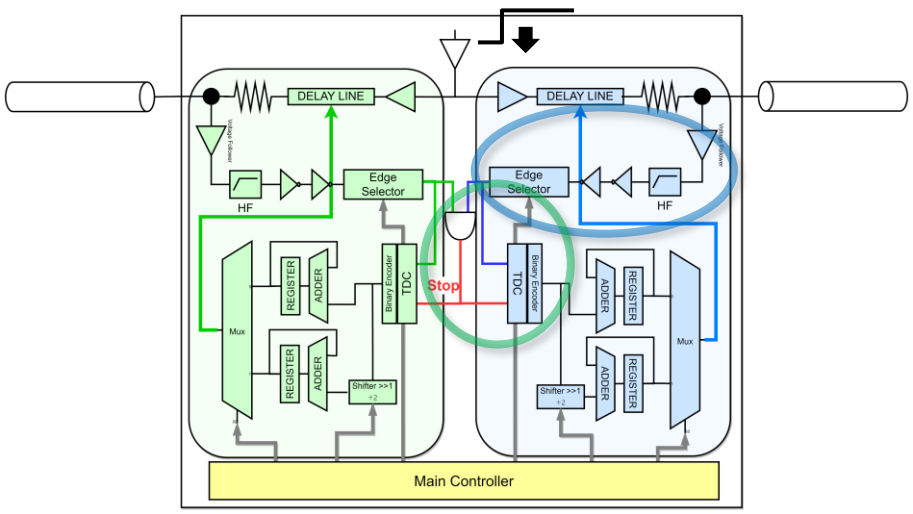
Time Domain Reflectometry (TDR) could be a valuable tool for evaluating the quality of probe card channels during the inspection stage. TDR determines the locations of impedance discontinuities by calculating the arrival time of the reflected signal. We propose a compact method to implement the TDR technique for the fan-out buffers to measure and correct buffer and channel skews.

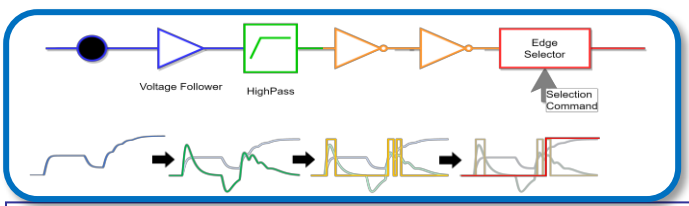
How to De-skew Simultaneously

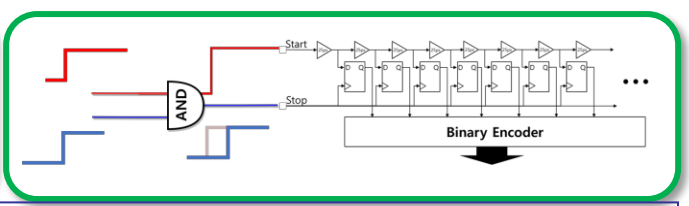


By driving a step signal and comparing it with the reflected signal at the output of the buffer, it is possible to distinguish between the skews caused by individual buffers and those caused by the channels. As shown in the above figure, the time difference between the first rising edges corresponds to the skew within the buffer, while the difference between other edges corresponds to the skew in the channels of the probe card. By analyzing these differences in a sophisticated manner, we can accurately calculate the total skew originating from the buffer and channels of the probe card.

How to Implement the De-Skewing Function







- We can convert the returned signal into a step signal shape using a high-pass filter and an edge selection logic with a D-FF.
- TDC generates binary numbers from the time difference referenced to the slowest signal.
- Time differences are accumulated in memory, and each delay line adjusts the delay of the signal in iterative sequences.
- After the final calculation, the total time difference referenced to the slowest channel is memorized and fixed.
- **Eventually, all channels are delayed based on the slowest channel, so signals from all channels arrive simultaneously at each destination**.

Summary

The proposed de-skewing technology suggests that it is possible to compensate for the total skews caused by buffers and channels simultaneously. By delaying each channel based on the slowest channel, signals can be made to arrive simultaneously at each termination. Additionally, the calculation process is simply iterative and can be adapted to accommodate an arbitrary number of branching points.

Future Work

We plan to design and test a prototype of a fan-out buffer equipped with de-skewing technology.