



# Temperature Variation

The Unappreciated Environmental Factor in the Stability of Multigigabit Automotive Ethernet

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Vehicles operate



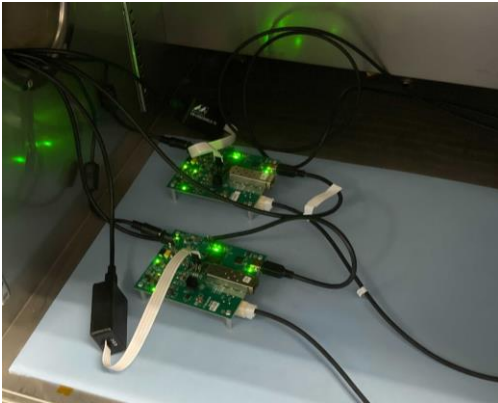
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in the extremes



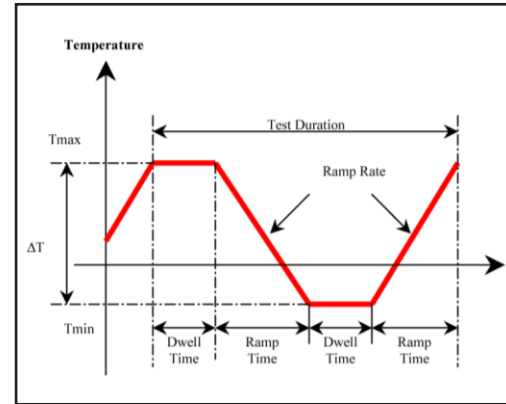
# Two types of temperature tests

## Static tests



“Error-free” links at any valid temperature

## Ramp tests



“Error-free” as temperature ramps across range

# Static testing process is well-defined

- PHY links without error at any valid temperature
- The underlying standard provides a limit on cable/board electrical characteristics
  - For all temperatures, the cable/board should not violate these requirements on insertion loss, return loss, jitter, etc.

**Ramp** testing is well-defined, too, but to get good results...hard

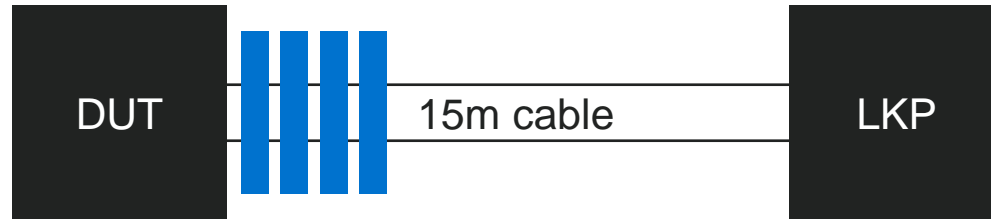


# What's so hard about passing a ramp test?



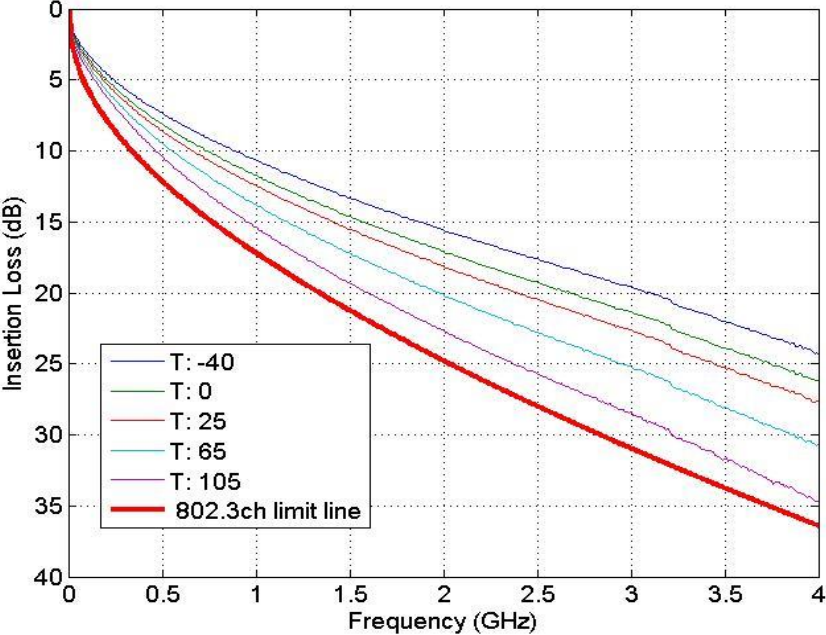
# First things first: measurement setup

- 15m shielded twisted pair with four inline connectors
- Temperature range: -40° to 105° Celsius



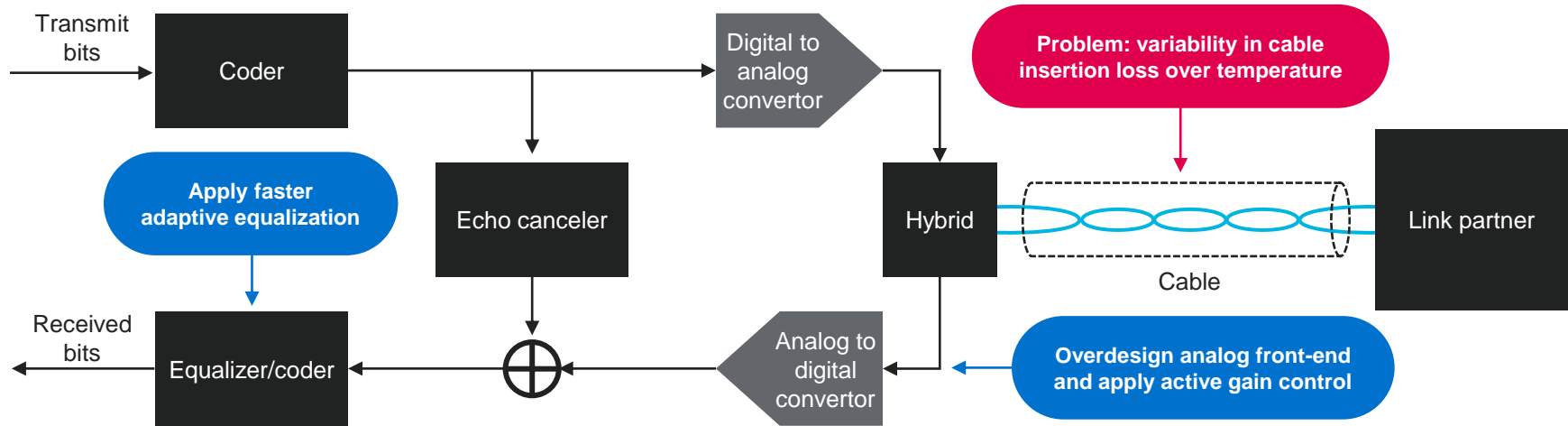
# Channel insertion loss increases with temperature

15m BASE-T1 cable



Source: Marvell

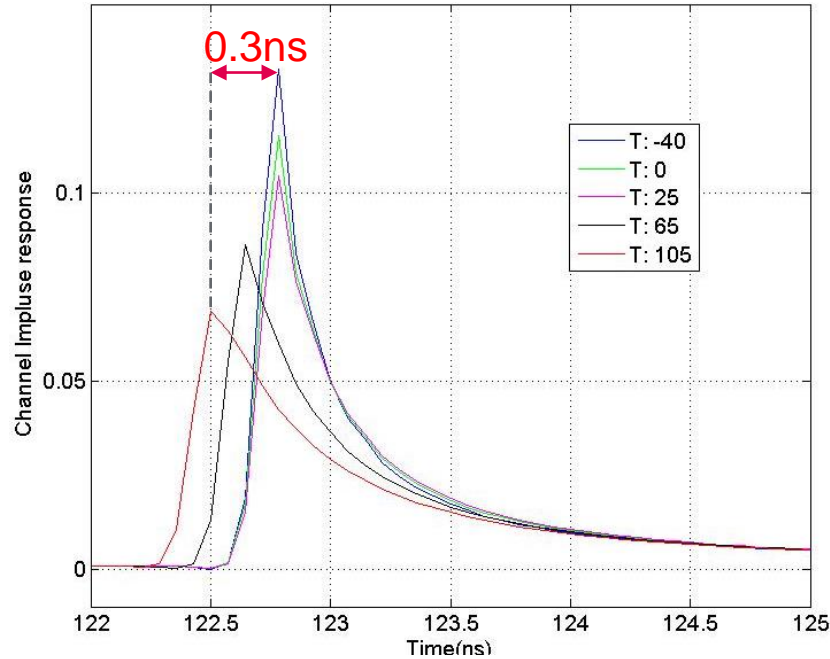
# How do we address insertion loss variability?



**Addressing insertion loss variability increases chip size, power and cost**



# Cable delay varies with temperature

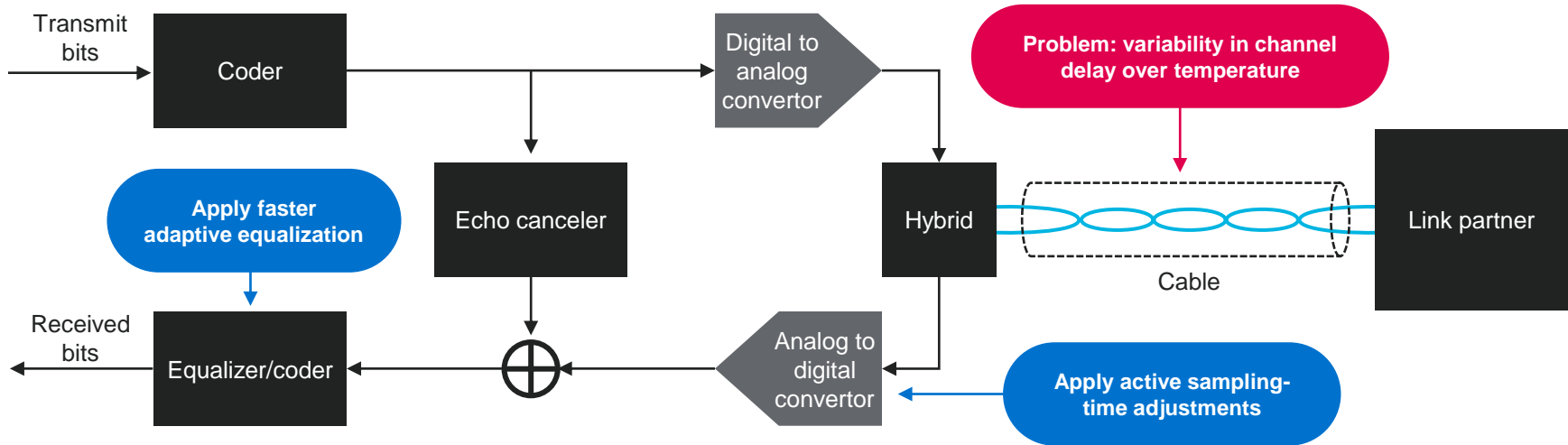


Delay variation  $\sim 1.7$  symbol duration of 10GBASE-T1

Source: Marvell

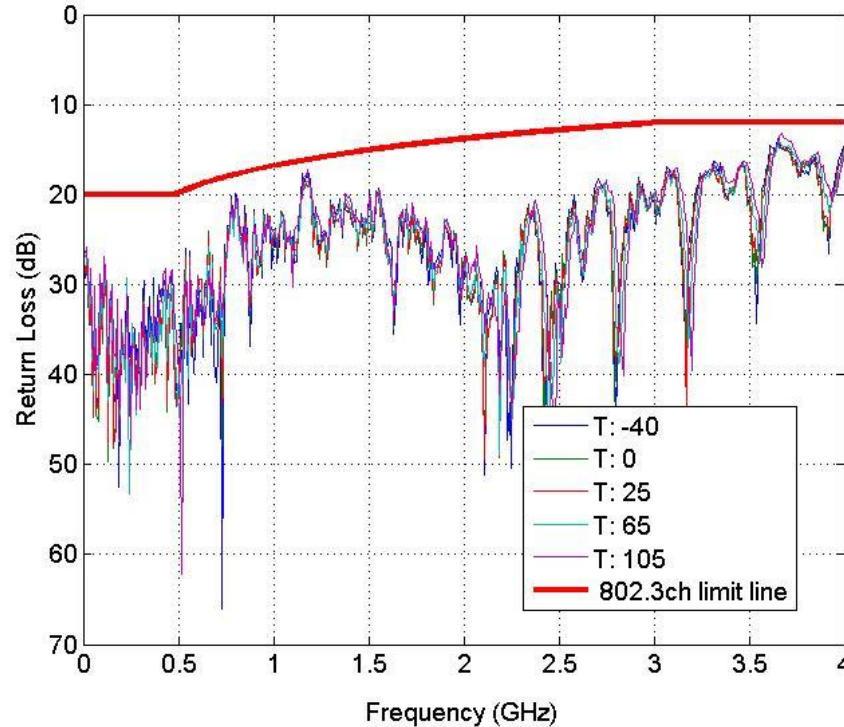
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# How do we address channel delay variability?



**Addressing delay variability increases chip size, power and cost**

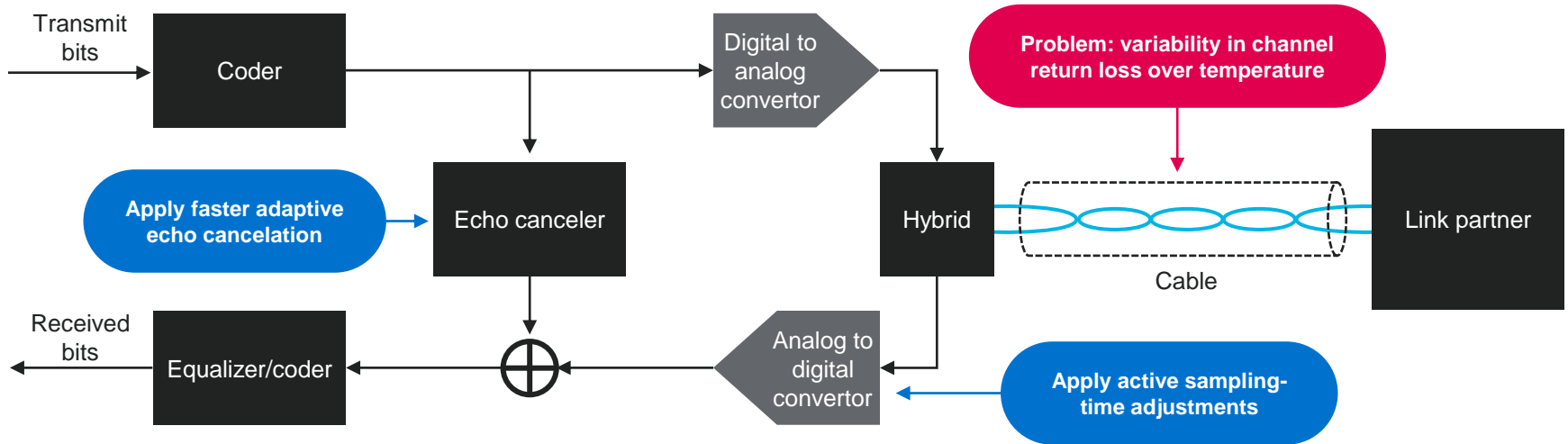
# Return loss over temperature is unpredictable



Source: Marvell

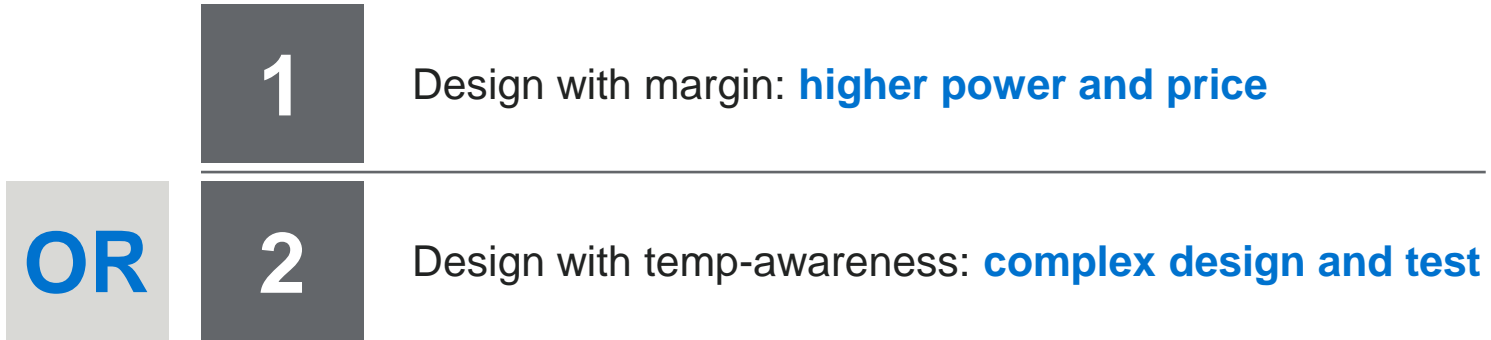
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# How do we address channel return loss variability?



**Addressing insertion loss variability increases chip size, power and cost**

# Summary: passing the temperature ramp test





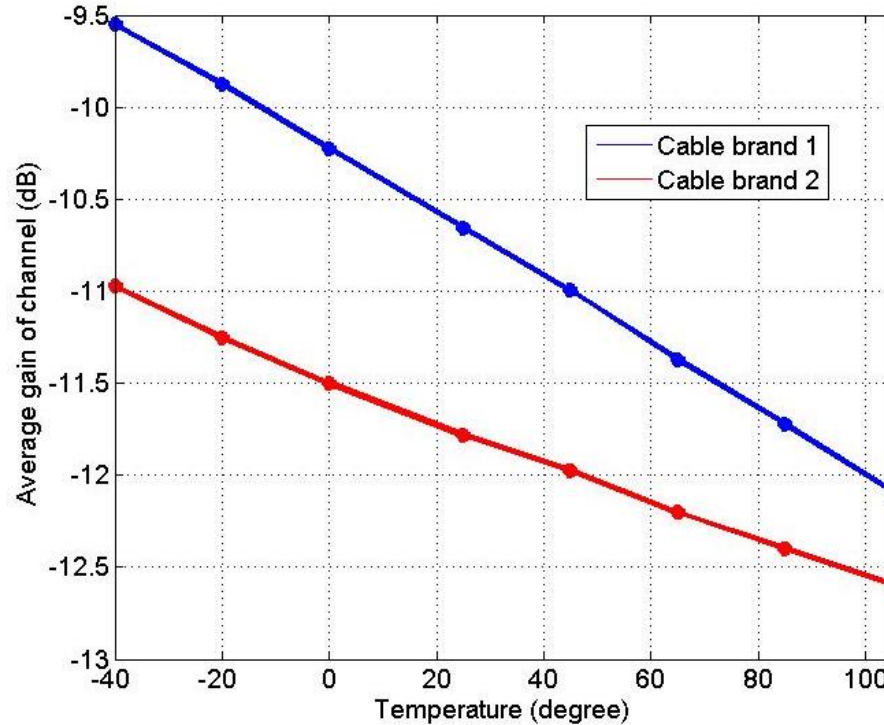
So, we can fix it, right?





**Not so fast...**

# Insertion loss over temp varies by cable brand



Source: Marvell

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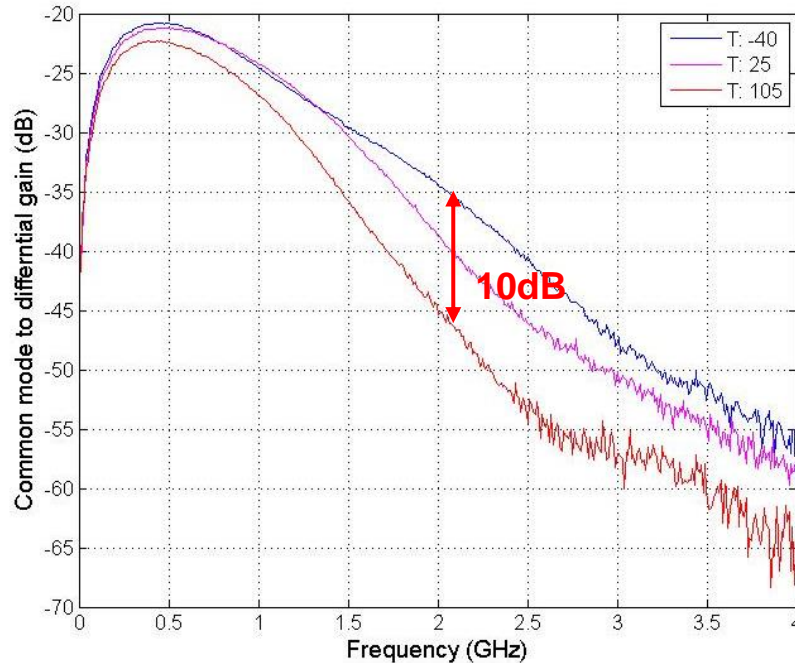


# Call to action

To create more economical, reliable Ethernet Solutions

**We need to define reasonable min and max boundaries for cable performance over temperature**

# Common mode to differential gain varies over temp



**Varying temp affects the behavior of device in ElectroMagnetic Interference test**

# Key takeaways

1

Insertion loss and related metrics exhibit high variability over temperature

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2

Degree of temperature-induced variability differs between cable brands

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3

Penalties are steep for overdesigning PHYs to accommodate max variability

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4

Min/max limits should be established for performance variability over temp

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Thank You



Essential technology, done right™

# Special thanks

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Danny Chan

Mark Davis