Exercise 2:

Define the time variance of a fiber optic channel's Impulse Response, and suggest a method for measuring it.

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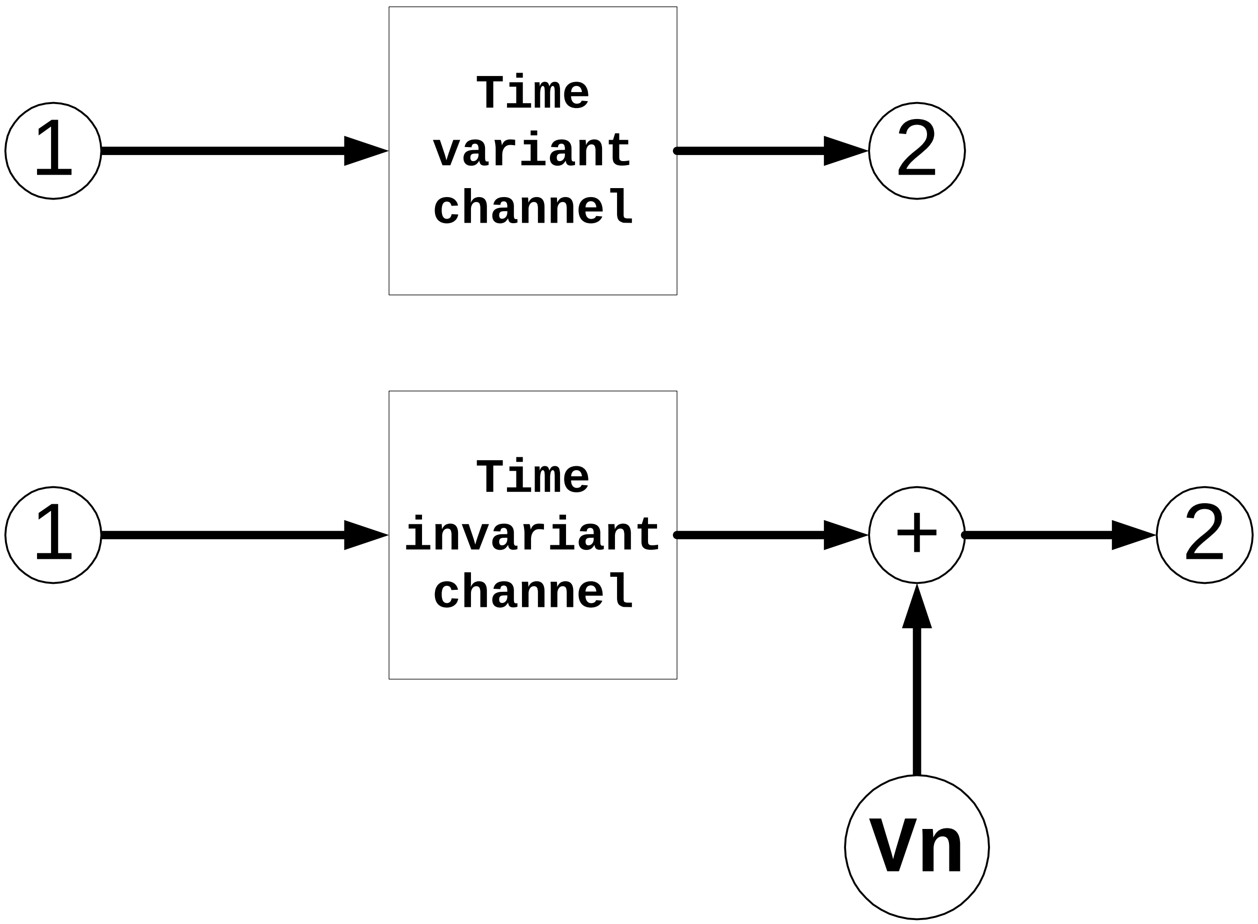
Definition: A time-variant channel is defined as a combination of a time-invariant channel and a noise source, Vn, as shown below.



Definition continued:

.. where Vn is assumed to have a noise profile (tbd). Vnp(t), or the peak-peak value of Vn, represents the peak-peak amount of variation in the channel and is assumed to have a first order time constant τ.

Therefore Vnp(t) = Vnp(1 - $e^{t/\tau}$).

At t=0, the channel does not have time to vary, and Vnp(0)= 0.

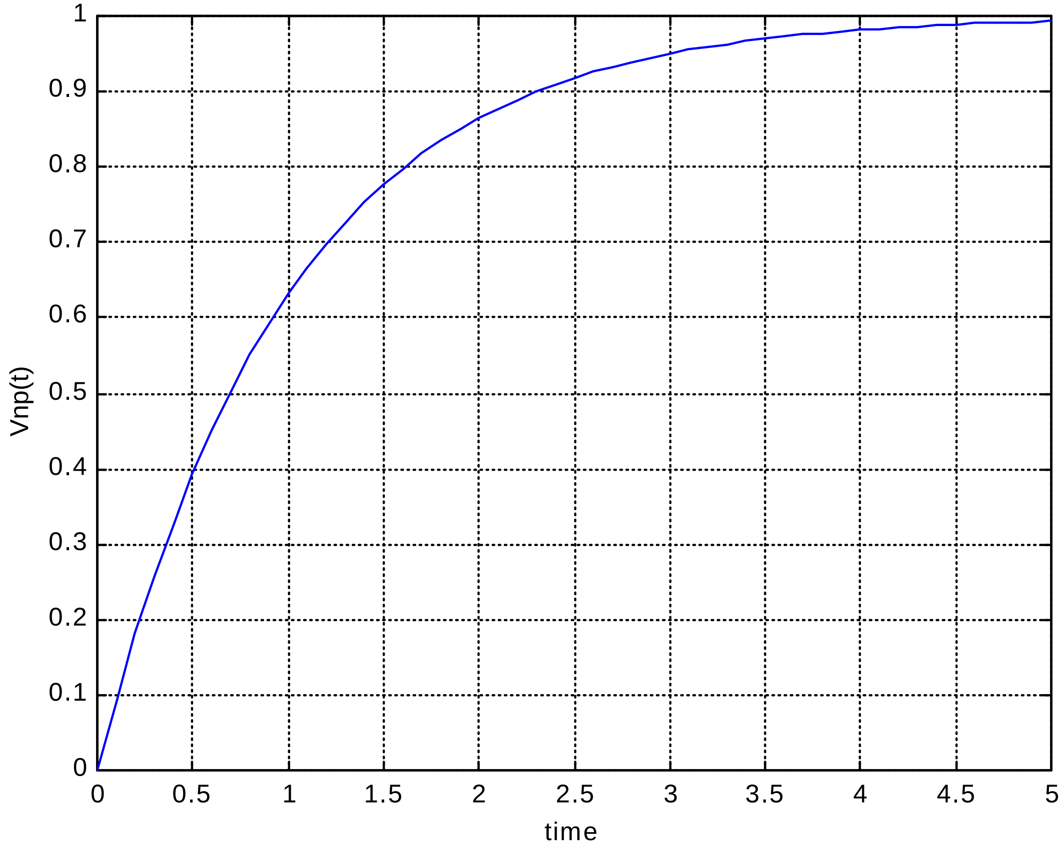
At t=τ, the peak-peak variation in the channel is:

Vnp(τ) = Vnp(1-1/e)

At t=infinity, the peak-peak variation in the channel is:

Vnp(infinity) = Vnp.

Vnp(t) versus t



Measurement Limitations

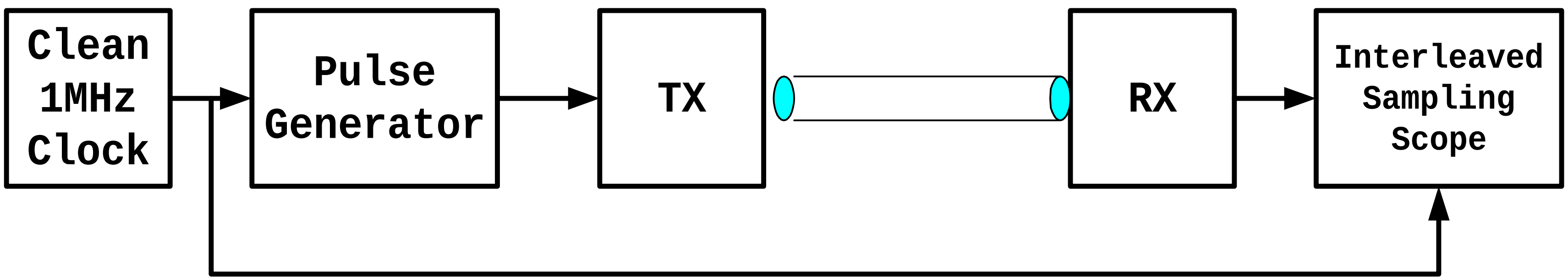
- Real time sampling speed of the Oscilloscpe does not support the resolution bandwidth for:
  - high resolution impulse response measurement at 10GHz
  - high resolution impulse response measurement over an extended period of time to account for variations in impulse response
- Interleaved Sampling Scopes do not provide information about “fast” variations

Part 1: To calculate the peak-peak variation in the channel cumulated over a “long” period of time, I.e, Vnp

- Send a narrow pulse (50-80ps) into the fiber channel.
- Measure the input to the channel and the output at the end of the channel using an Interleaved Sampling Scope at a 2ps resolution. (Interleaved sampling in KHz).
- Set the Interleaved Sampling Scope to persistence mode and measure the “thickness” of the impulse response after 10 hours.

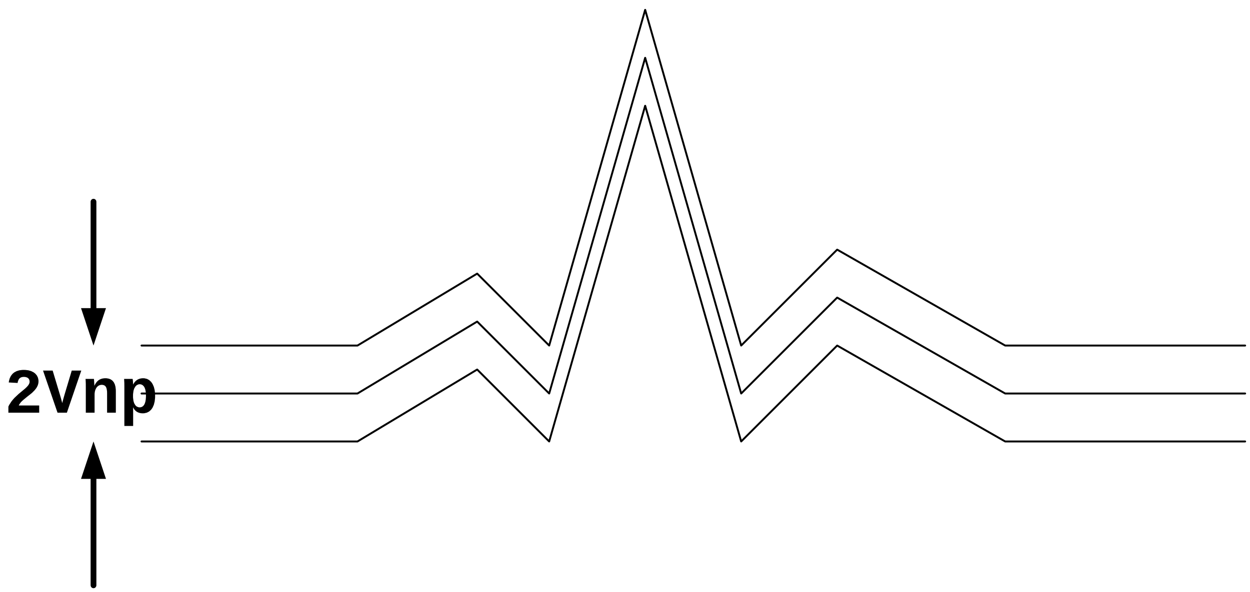
Part 1: To calculate the peak-peak variation in the channel cumulated over a “long” period of time, I.e, Vnp

Setup:



Part 1: To calculate the peak-peak variation in the channel cumulated over a “long” period of time, I.e, Vnp.

Persistence (after 10 hours) of the Impulse response using an Interleaved Sampling Scope:

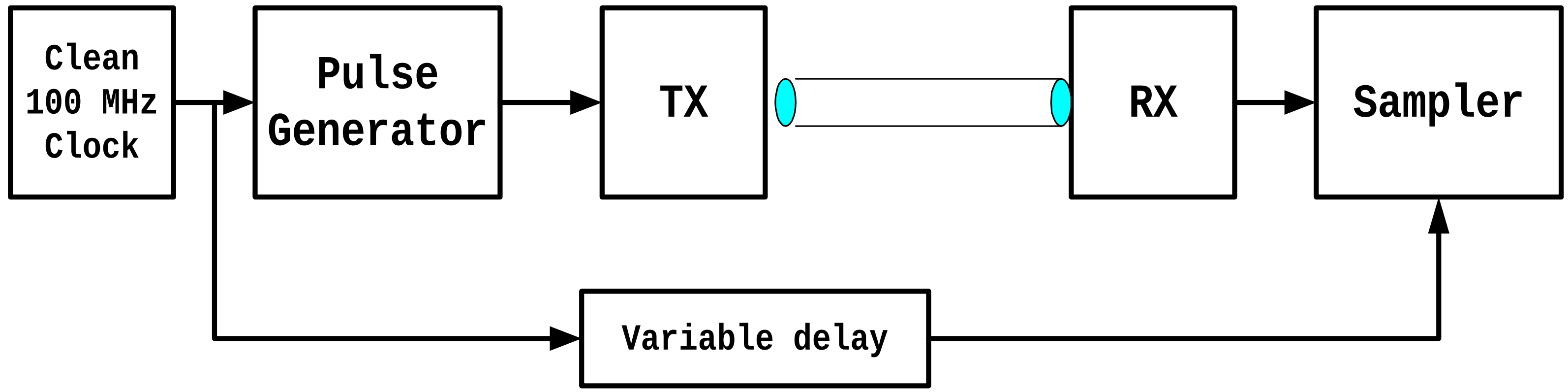


Part 2: To calculate the peak-peak variation in the channel cumulated over a period of time , Δt, I.e, $Vnp(\Delta t)$. (For example $\Delta t = 1us$)

- Send a narrow pulse (50-80ps) into the fiber channel.
- Measure the output at the end of the channel using a Sampler (The Sampler may be a Real-time scope with control over sampling clock/trigger).
- Collect one data sample for every pulse, at a given sampling point. Collect 100 such samples for 100 pulses (at 100MHz) to cover a time span of 1us. Compute Vnp(1us), as the peak-peak variation in the sampled value across 100 pulses, at this sampling point in the impulse response
- Change the "variable delay" by δt (2 ps) and repeat the experiment at the new sampling point. In this manner, trace Vnp(1us) along the entire impulse response.

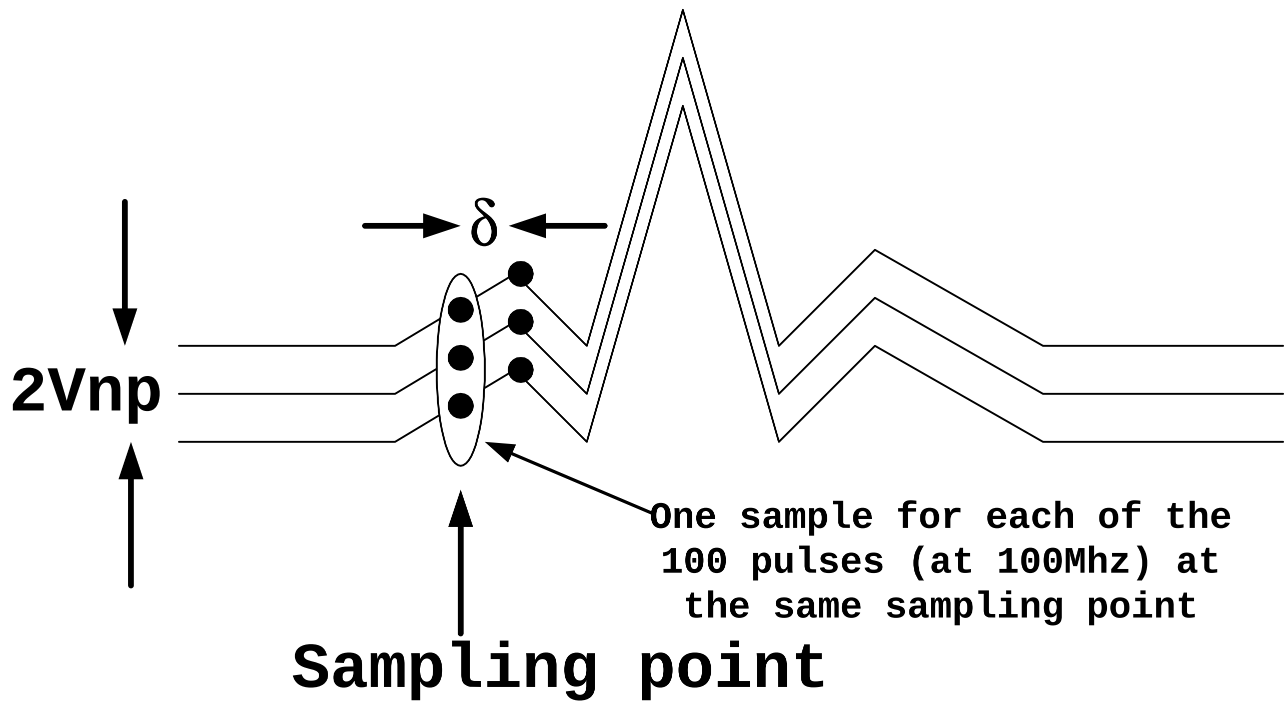
Part 2: To calculate the peak-peak variation in the channel cumulated over a period of time , Δt, I.e, Vnp(Δt). (For example Δt = 1us)

Setup:



Part 2: To calculate the peak-peak variation in the channel cumulated over a period of time , Δt, I.e, Vnp(Δt). (For example Δt = 1us)

Calculating variation of the Impulse response using a Sampler:



Points of caution

- Sampling aperture of the Oscilloscope
- Jitter of the clean clock
- Noise of the measurement set-up
- Phase noise and Amplitude noise is combined into a noise source (works wells for modeling and simulating the system).

Conclusions

- A time invariant channel has been defined for purposes of characterization, modeling, and simulation.
- Part1 of the experiment measures total variation in a channel. This places an upper bound on the variation and may make Part 2 un-necessary.
- Part 2 of the experiment enables characterization of the variation of the channel as a function of time.