IEEE802.3aq Channel model ad-hoc
Temperature Variation Impact on Channel Model

Petre Popescu - Quake Technologies

Contributors:

- Joerg R Kropp, Infineon
- Andre Van Schyndel, Bookham
- Jack Jewell, Picolight
- Paul Kolesar, Systimax
- John S Dr Abbott, Corning

1. Temperature variation

- Transmitter temperature, fiber temperature and receiver temperature can be assumed not correlated.
- Receiver temperature change has minimal impact on received signal, will affect receiver operation and not the received signal.
- Fiber temperature range 60^{o}C, centred at 30^{o}C. The expected speed of change is less than 20^{o}C/hour.
- Connector temperature change may result in small offset change (<1μ).
  - small attenuation change
  - polarisation change depending on the type of laser and launch (kropp_1_0704.pdf and sun_1_0704.pdf)
- Laser operating temperature range is 0^{o}C to 80^{o}C. The expected rate of change is maximum 10^{o}C/hour.

2. Temperature variation impact on fibre

- Fiber temperature range 60^{o}C, centred at 30^{o}C. The expected speed of change is less than 20^{o}C/hour.
- Fiber length change.
  - α_{silica}=3.4x10^{-7}/^{o}C (total expected change 2.04x10^{-5}), will change the modal delays (they scale with the length) by 10 ppm.
  - $\alpha_{plastic}$=10^{-4}/^{o}C (total expected change 6x10^{-3})
- Refractive index change over the working temperature range
  - the temperature coefficient of group index of refraction
    dn/dT=4 to 13*10^{-6}, depending on glass composition
  - total variation over the operating temperature range of 60^{o}C
    2.4*10^{-4} to 7.8*10^{-4}
  - while the total index may change with temperature, the waveguide is defined by the index difference and impulse response of the fiber will be stable.

3. Temperature variation impact on laser (1)

- Operating temperature range 0°C to 80°C.
- Intensity and extinction ratio are roughly constant, maintained through the feedback loops in the TOSA.
- Laser wavelength change, the amount of change will depend on the type of laser.

  - DFB lasers ~0.1nm/°C, total variation 8nm,
  - FP lasers ~0.25 - 0.5nm/°C, total variation 40nm,
  - VCSEL lasers ~0.08nm/°C, total variation 6.4nm,

- Polarization

  - the random nature of polarization state causes a modal noise process,
  - polarization change depending on the type of laser and launch (sun_1_0704.pdf),
  - DFB and FP lasers are designed to transmit linearly polarized light, the change in polarization is less than a few degrees over working temperature range
  - for high speed 1300nm VCSEL the variation of polarization condition is slow and causes no additional noise.

4. Temperature variation impact on laser (2)

- Relaxation oscillation and damping

  - for DFB and FP lasers, the damping and relaxation oscillation frequencies are reduced as the temperature increases,
  - the damping coefficient can typically decrease by a factor of 1.2 to 4, increasing the asymmetry of the rise and fall times, and will result in increased jitter,
  - high speed 1300nm VCSELs have a similar behaviour.

- RIN

  - for DFB lasers, RIN is typically -150dB/Hz and will decrease at high operating temperatures
  - for FP lasers, RIN is typically -130dB/Hz and the change over the temperature range is not well defined,
  - for high speed 1300nm VCSELs the RIN is reduced significantly at high operating temperatures,

5. Temperature variation impact on laser (3)

- **Mode-partition noise**

  - mode partition noise is an FM noise due to the power shifting between a laser multiple modes,
  - the mode-partition noise in FP lasers is higher at high temperature,
  - in a DFB laser, the sideband suppression will reduce the mode-partition noise by 40 dB.
  - high speed 1300nm VCSELs are single mode with a high sideband suppression.

- **Spot size**

  - for DFB and FP lasers the spot size changes by less than 1% over the working temperature range,
  - high speed 1300nm VCSELs will show some variation, the absolute size and the degree of variation depends strongly on the design.

6. Summary of temperature variation impact

Varying Factor	Impact	Comments
Receiver temperature change	small	
Fiber length change over the operating temperature range	small	
Fiber refractive index change over the operating temperature range	small	
Connector attenuation change over the operating temperature range	small	
Polarization change due to connector temperature variation	needs review	will affect noise
Laser wavelength change over the operating temperature range	small	
Laser polarization change over the operating temperature range	small	
Laser relaxation oscillation and damping variation over the operating temperature range	small	will affect jitter
RIN variation over the operating temperature range	small	
Laser mode-partition noise	needs review	will affect noise
Laser spot size change over the operating temperature range	small	design dependent

Note 1: Temperature variation impact on time varying channel is small.

Note 2: Laser polarization change and mode-partition noise change over the operating temperature range and impact on noise need more analysis.