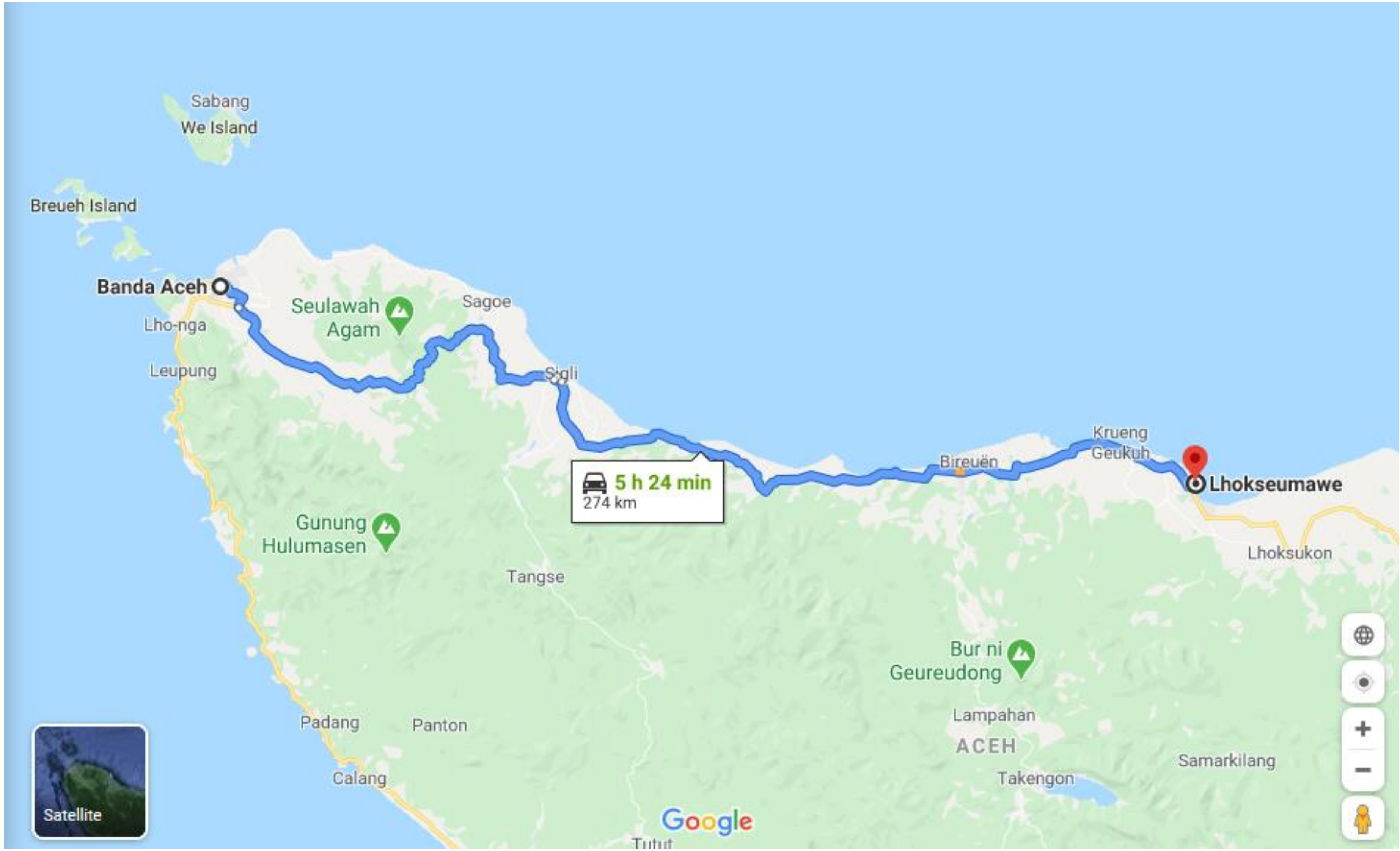
TUGAS BESAR

SKO

Design Procedure

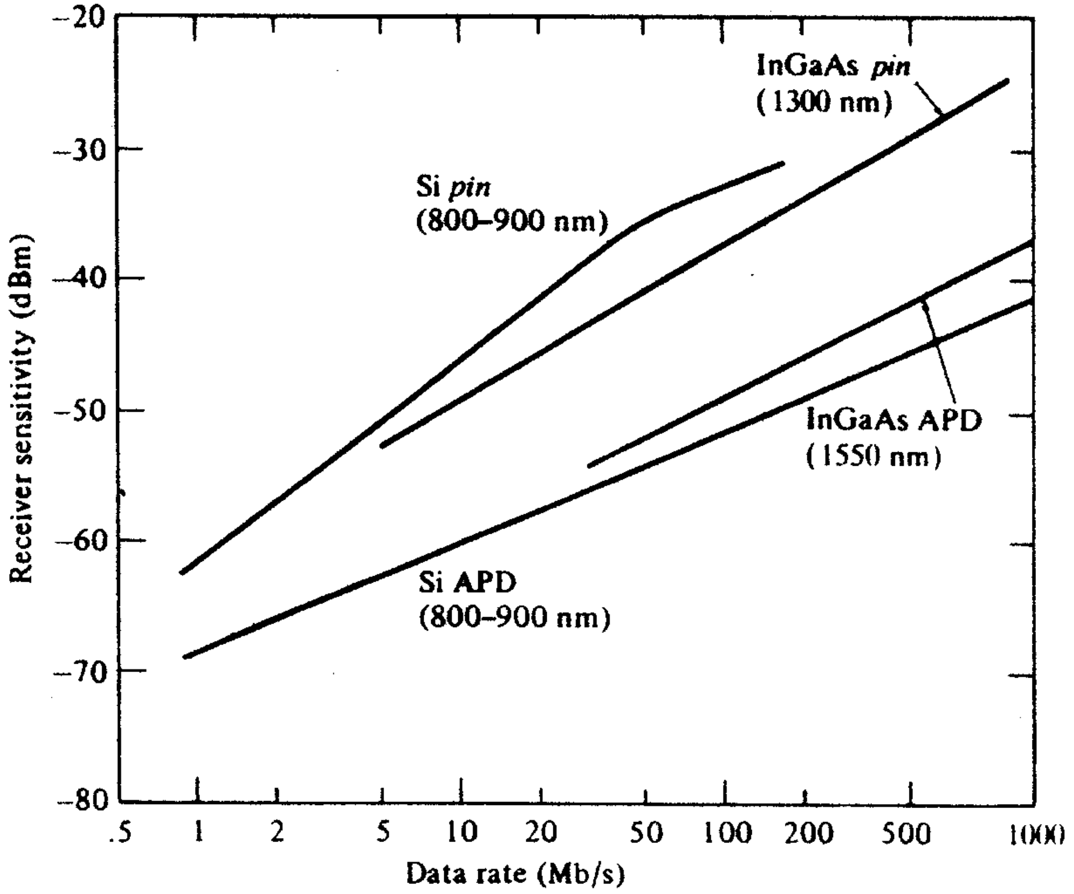
1. Map Route



Design Procedure

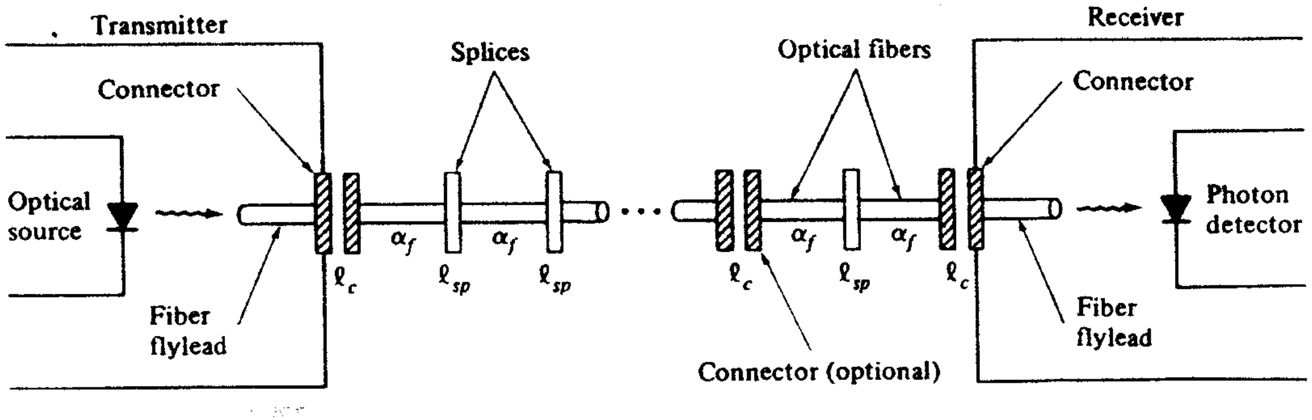
2. Specification of Link System

   a. Output power = 10mW = 10dBm
   b. Loss Connector = 0.2 dB
   c. Loss Joint = 0.01 dB
   d. Loss Fiber = 0.2 dB/km
   e. Margin System = 6 dB
   f. Receiver Sensitivity = -40dBm
   g. Drum fiber = 4km



Design Procedure

3. Link Calculation



Power Received :

$$P_R = P_S - A_T$$

$$A_T = 2\,\alpha_c + n\,\alpha_{sp} + \alpha_f L + M_S$$

P_S : Optical power from light source at fiber edge [dBm]

P_R : Detector power received [dBm]

A_T : total loss [dB]

α_c : connector loss [dB/pc]

α_{sp} : loss splice [dB/each]

α_f : fiber loss [dB/Km]

L : link length [Km]

M_S : margin system [dB]

Link power budget met if:

P_R>= Receiver Sensitivity

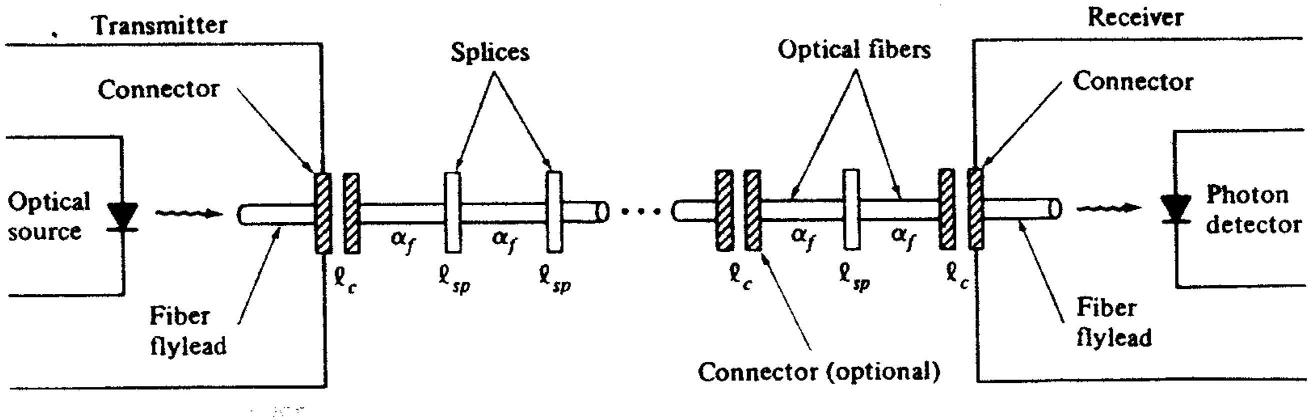
Design Procedure

4. Link Calculation

Power Received :

$$P_R = P_S - A_T$$

$$A_T = 2\,\alpha_c + n\,\alpha_{sp} + \alpha_f L + M_S$$

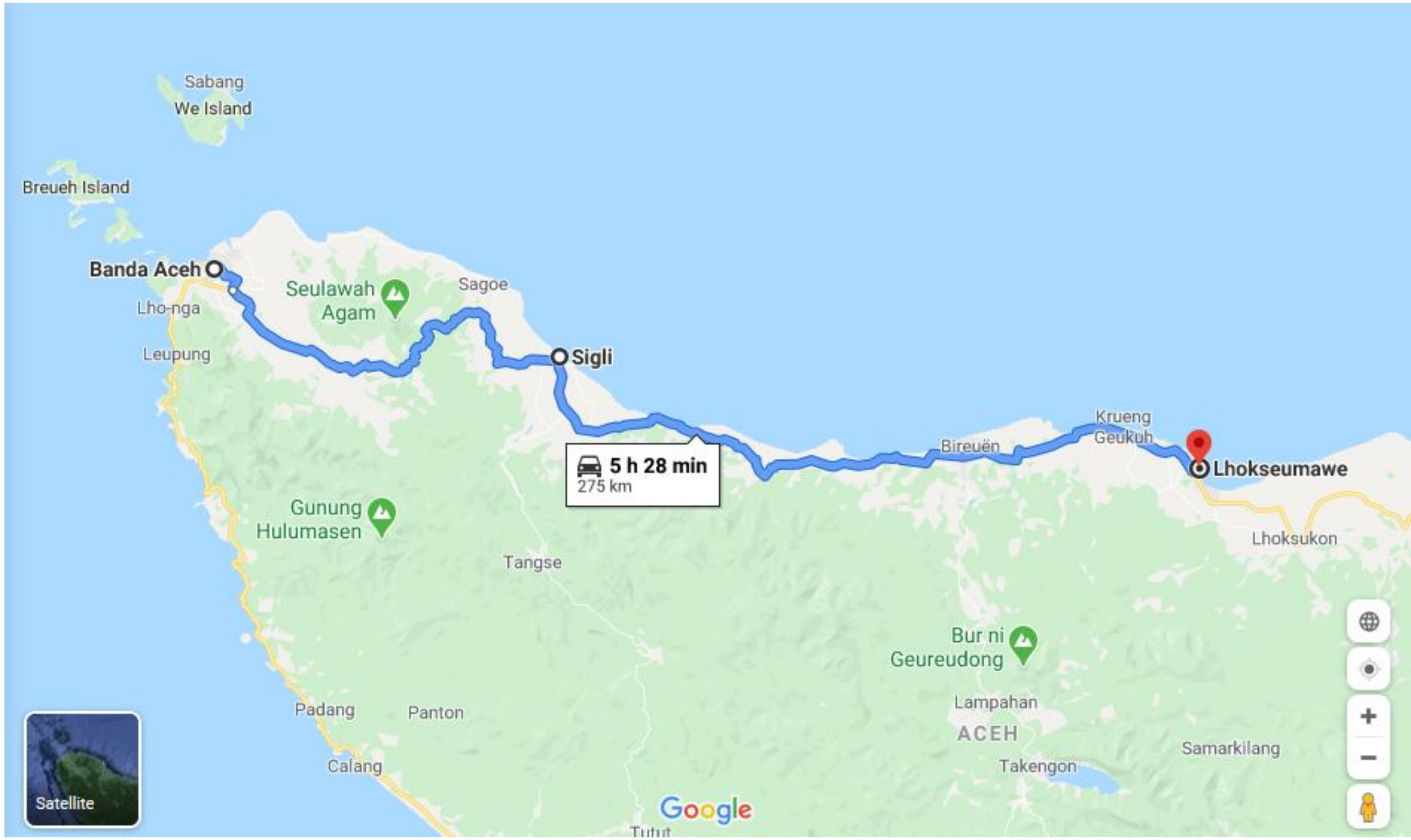


For Aceh – Lhokseumawe = 274 km

If direct -> $P_R = P_S - A_T$ = 10 – [(2*0.2)+(68*0.01)+(274*0.2)+6)] = -51.88 dBm --→ P_R < Receiver Sensitivity (-40dBm)

Link needs redesign

Design Procedure



New Link:

Banda Aceh - Sigli &
Sigli - Lhokseumawe

Design Procedure

New Link:

Banda Aceh - Sigli = 111km
Sigli - Lhokseumawe = 164km

Banda Aceh - Sigli = 111km

If direct -> $P_R = P_S - A_T$ = 10 – [(2*0.2)+(27*0.01)+(111*0.2)+6)] = -18.87 dBm --→ **P_R > Receiver Sensitivity (-40dBm)**

Banda Aceh - Sigli = 164km

If direct -> $P_R = P_S - A_T$ = 10 – [(2*0.2)+(40*0.01)+(164*0.2)+6)] = -29.6 dBm --→ **P_R > Receiver Sensitivity (-40dBm)**

Rise Time Budget

A rise time budget analysis is a convenient method for determining the dispersion (σ) limitation of an optical fiber link.

Total Rise time :

$$t_{sys} = \sqrt{\sum_{i=1}^{N} t_i^2}$$

t_i : rise time from each contributor :

t_{tx} : transmitter rise time

t_{GDV} : group velocity dispersion rise time

t_{mod} : modal dispersion rise time

t_{wg} : waveguide dispersion rise time

t_{rx} : optic detector rise time

Rise Time Budget

The response of the receiver front end can be modelled by a first order lowpass filter having a step response:

$$g(t) = [1 - e^{-2\pi B_{rx} t}]\, u(t)$$

B_{rx} : 3dB electrical bandwidth of the receiver

u(t) : unit step function which is 1 for $t \geq 0$

and 0 for $t < 0$

Rise time of receiver usually defined interval between g(t) = 0.1 and g(t) = 0.9, known as 10% - 90 % rise time.

Similarly, $t_{rx} = 350/B_{rx}$ ns

B_{rx} : in MHz

Assuming both transmitter and receiver as first order low pass filters

Rise Time Budget

Group Velocity Dispersion

$$t_{GVD} = |D| L \sigma_{\lambda}$$

Where,

D is the dispersion parameter (ns/km/nm) given by eq. (3.57)

σ_{λ} is the half power spectral width of the source (nm)

L is the distance in km

Rise Time Budget

Modal Dispersion Rise Time

Bandwidth $B_M(L)$ due to modal dispersion of a link length L is empirically given by,

$$B_M(L) = B_o / L^q$$

B_0 is the BW per km (MHz-km product) and q ~0.5-1 is the modal equilibrium factor

$$t_{\text{mod}} = 0.44 / B_M = 440 L^q / B_0 \text{ (ns)}$$

Rise Time Budget

Total Rise-Time

$$t_{sys} = [t_{tx}{}^2 + t_{\mathrm{mod}}{}^2 + t_{GVD}{}^2 + t_{rx}{}^2]^{1/2}$$

$$= \left[t_{tx}{}^2 + \left(\frac{440 L^q}{B_0} \right)^2 + D^2 \sigma_\lambda{}^2 L^2 + \left(\frac{350}{B_{rx}} \right)^2 \right]^{1/2}$$

$t_{tx}[ns]$: transmitter rise time $t_{rx}[ns]$: receiver rise time $t_{\mathrm{mod}}[n]$: modal dispersion

$B_{rx}[MHz]$: 3dB Electrical BW $L[km]$: Length of the fiber $B_0[MHz]$: BW of the 1 km of the fiber;

$q \approx 0.7$ t_{GVD}[ns]: rise-time due to group velocity dispersion

$D[ns/(km.nm)]$: Dispersion σ_λ[nm]: Spectral width of the source

Rise Time Budget

Generally the total transition time degradation of a digital link should not exceed:

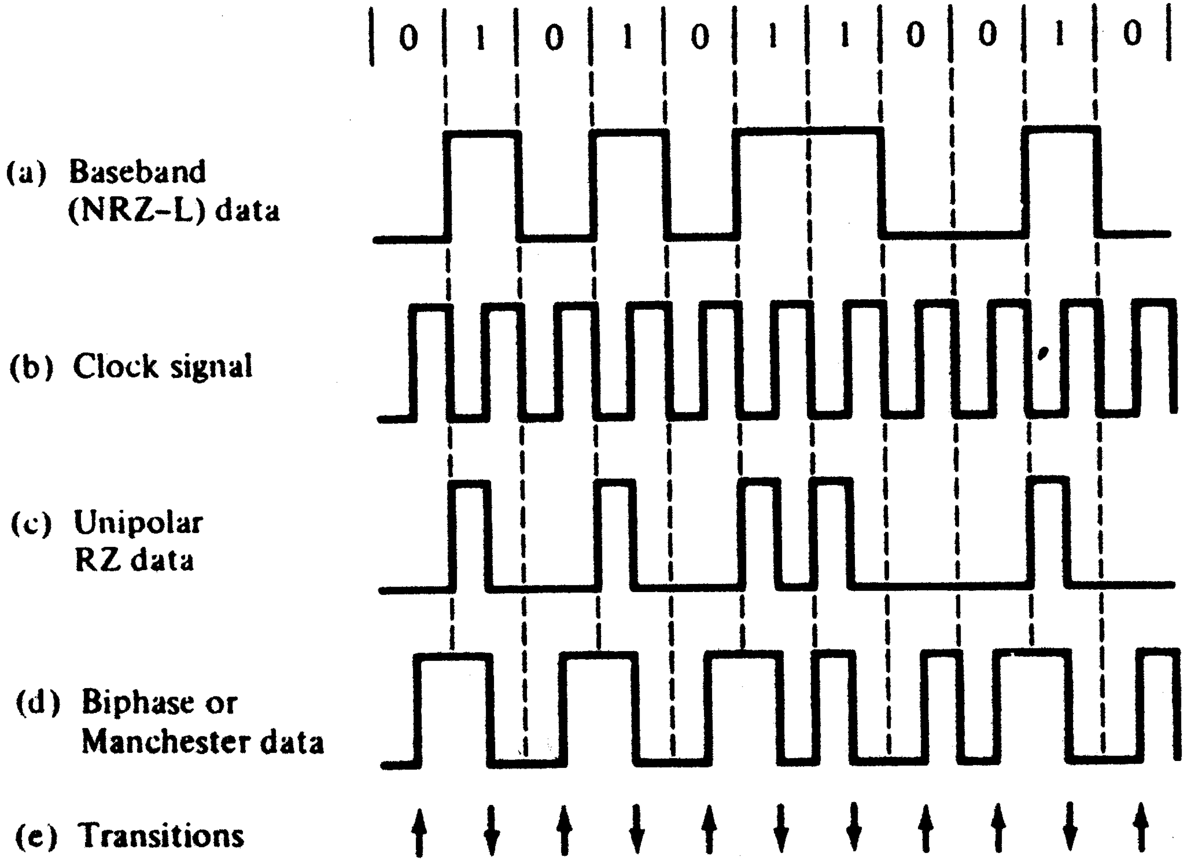
- NRZ ➔ ≤ 70 % bit period

- RZ ➔ ≤ 35 % bit period

Rise time budget met if :

Rise time system < degradation transition time

Line Code



0 1 0 1 0 1 1 0 0 1 0
(a) Baseband (NRZ-L) data
(b) Clock signal
(c) Unipolar RZ data
(d) Biphase or Manchester data
(e) Transitions

Line Code

Optical link with bit rate data 60 Mb/s :

Length 60 Km

Fiber has 800 MHz-km bandwidth distance product, Material Dispersion 0.07ns ns/nm-Km, q=1

Light source : 1.3 μm, rise time 2 ns, σ_λ = 3 nm, Detector : rise time 1 ns

Check if the rise time budget meet for NRZ and RZ requirement?

$$t_{sys} = [t_{tx}{}^2 + t_{\mathrm{mod}}{}^2 + t_{GVD}{}^2 + t_{rx}{}^2]^{1/2}$$

$$t_{sys} = \left[2^2 + \left(\frac{440*60^1}{800}\right)^2 + 0.07^2 * 3^2 * 60^2 + 1^2\right]^{1/2}$$

$= (4+1089+158.76+1)^{1/2}$

$= 35.39$ ns

$T_b = 1/60Mbps = 16.6$ ns

For $0.7T_b = 0.7*16.6 = 11.62$ ns $< t_{sys}$ (rise time doesn't meet NRZ requirement)

For $0.35Tb = 0.35*16.6 = 5.81$ ns $< t_{sys}$ (rise time doesn't meet RZ requirement)

If L = 15km

$$t_{sys} = [t_{tx}{}^2 + t_{\text{mod}}{}^2 + t_{GVD}{}^2 + t_{rx}{}^2]^{1/2}$$

$$t_{sys} = \left[2^2 + \left(\frac{440 * 15^1}{800}\right)^2 + 0.07^2 * 3^2 * 15^2 + 1^2\right]^{1/2}$$

$= (4+68.06+9.92+1)^{1/2}$

$= 9.1$ ns

$T_b = 1/60Mbps$ = 16.6ns

For $0.7T_b$ = 0.7*16.6= 11.62 ns > t_{sys} (rise time meet NRZ requirement)

For $0.35T_b$ = 0.3*16.6= 5.81 ns < t_{sys} (rise time doesn't meet RZ requirement)

Line Code

Optical link with bit rate data 60 Mb/s :

Fiber has 800 MHz-km bandwidth distance product, Material Dispersion 0.07 ns/nm-Km, q=1

Light source : 1.3 μm, rise time 2 ns, σ_λ = 3 nm

Detector : rise time 1 ns

Find maximum L that meet NRZ and RZ requirement?

$T_b = 1/60Mbps$ = 16.6ns

For $0.7T_b =$ 0.7*16.6= 11.62 ns for NRZ

For $0.3T_b =$ 0.35*16.6= 5.81 ns for RZ

Line Code

For NRZ

$t_{sys} = 11.62$ ns

$$t_{sys} = 11.62 = \left[2^2 + \left(\frac{440 * L^1}{800}\right)^2 + 0.07^2 * 3^2 * L^2 + 1^2\right]^{1/2}$$

135.02 = 4+(0.3025*L^2)+0.0441*L^2+1

130.02 = 0.3466*L^2

375.129 = L^2

L = 19.37 km

For RZ

$t_{sys} = 5.81$ ns

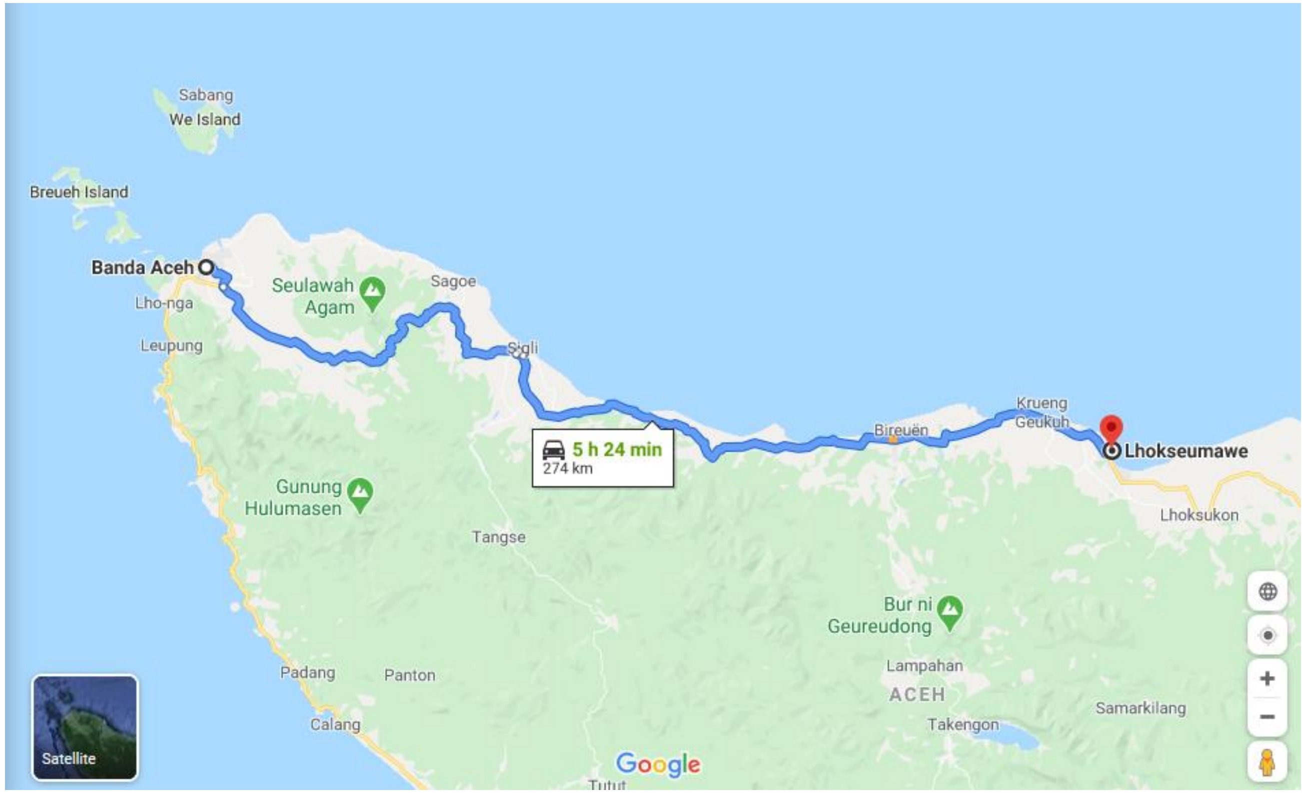
$$t_{sys} = 5.81 = \left[2^2 + \left(\frac{440 * L^1}{800}\right)^2 + 0.07^2 * 3^2 * L^2 + 1^2\right]^{1/2}$$

33.75 = 4+(0.3025*L^2)+0.0441*L^2+1

28.75 = 0.3466*L^2

82.95 = L^2

L = 9.1 km



If we back to our design.
Banda Aceh – Lhokseumawe = 274km

For NRZ line code:
274/19 = 15 segment link

For RZ line code:
274/9 = 31 segment link