UNIVERSITAS BRAWIJAYA

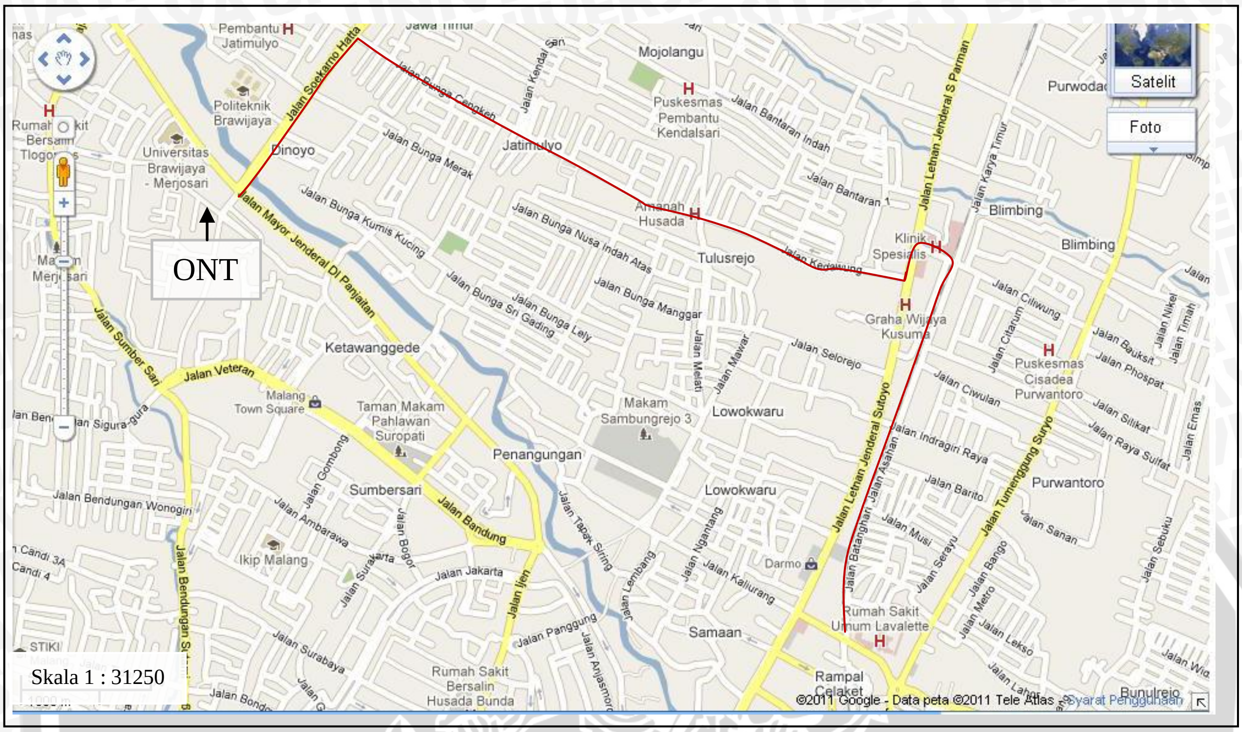
LAMPIRAN Perencanaan Jaringan Serat Optik Untuk Mendukung Distance Learning di Universitas Brawijaya

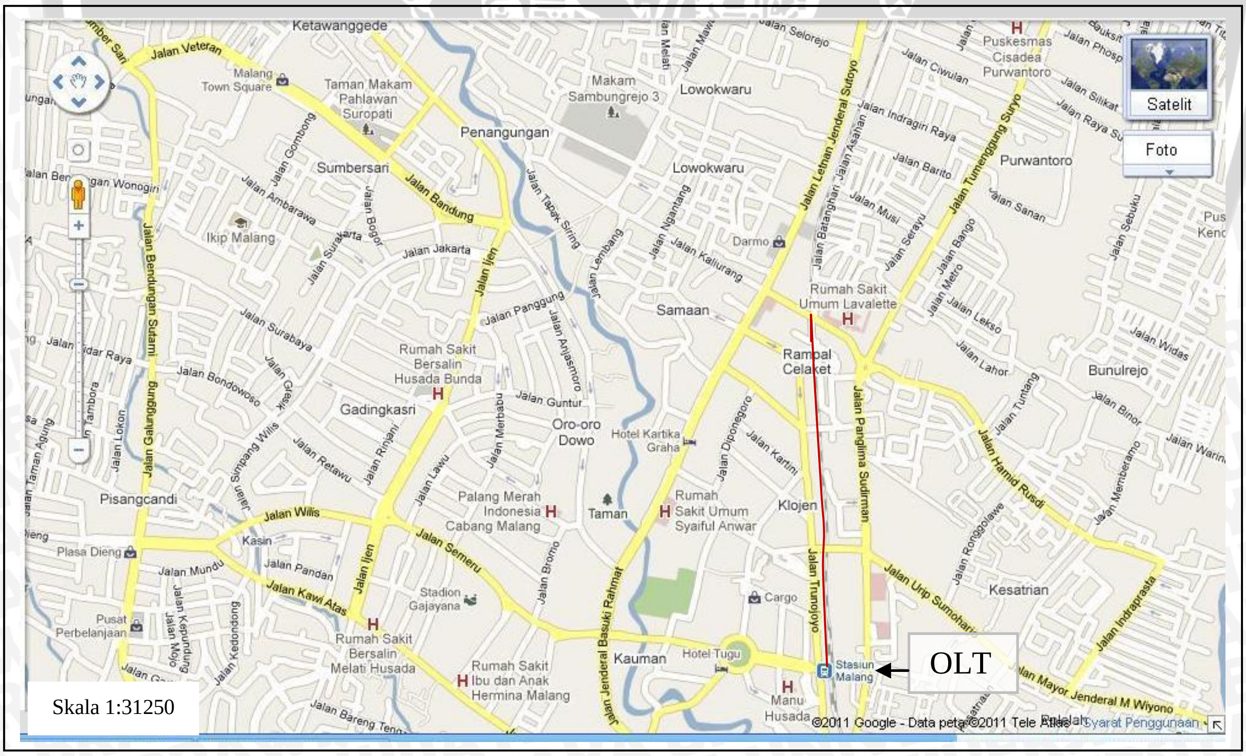
DEVIE FIBTARICA (0710633010)

LAMPIRAN
08 FEBRUARI 2011

LAMPIRAN I

PETA JALUR KABEL FIBER OPTIK



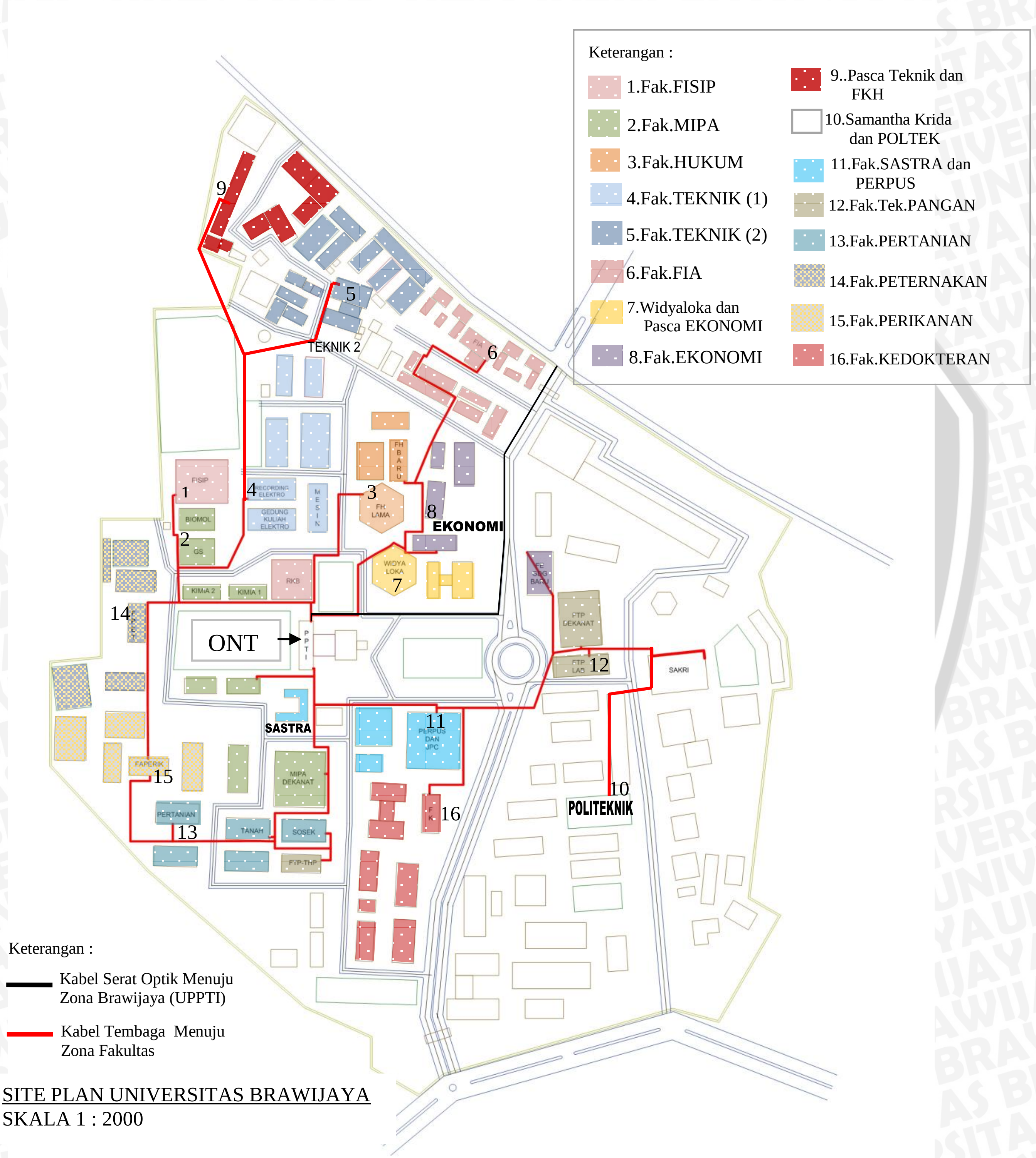


Jaringan Serat Optik dari STO Malang Kota Stasiun Kota Baru ke Zona Universitas Brawijaya

(Sumber : Perencanaan, 2011)

LAMPIRAN II

PETA JALUR KABEL *FIBER* OPTIK DI ZONA UNIVERSITAS BRAWIJAYA



SITE PLAN UNIVERSITAS BRAWIJAYA
SKALA 1 : 2000

LAMPIRAN III

SPESIFIKASI PERALATAN *OPTICAL LINE TERMINAL* (OLT)

Motorola AXS2200

GPON Optical Line Terminal

NO	TECHNICAL SUMMARY	SPESIFICATION
1	Management Features	• ITU-T G.984.4 OMCI • SNMP v2, TELNET, SNTP for AXSvision • CLI, remote CLI with TELNET and FTP
2	Environmental	• Operating Temperature: 0C to 50C (32F to 122F) • Storage Temperature: -40C to 70C (-40F to 158F) • Operating Humidity: 5% to 85%, non-condensing • Altitude: 60 m (197 ft) below sea level to 4,000 m (13,123 ft) above sea level
3	Protocols	• ITU-T G.984.1, G.984.2, G.984.3, G.984.4 • GPON Encapsulation Method (GEM) • IEEE Std 802.1D™ (bridging) • IEEE 802.1Q VLAN, transparent LAN service (TLS) •IEEE 802.1ad tagging, IEEE 802.3ad link aggregation

		• Ethernet QoS •IGMP multicasting control, snooping, Ethernet multicasting •SIP-enabled VoIP: RFC2617 (authentication), RFC2806bis (Tel URI), RFC2833 (RTP Payload for DTMF Digits), and RFC3261 (SIP) • GR-303, TR-08 Mode 1, T1CAS
4	Physical Description*	• Height: 22.75" (57.79 cm) • Width: 21.4" (54.36 cm) • Depth: 12.0" (30.48 cm) without cabling; less than 18" (45.7 cm) with cabling • Weight: 60 lbs (27 kg) empty; 120 lbs (54 kg) fully loaded • Cooling: front intake through air filter; rear exhaust through fan assembly
5	Shelf/Switch Capacity	• 22 slots (2 system controllers, 2 switch cards,18 applications units) • 200 Gbps non-blocking, redundant switch fabric • 1 Tbps backplane with 40 Gbps slot capacity • Common: 200 Gbps switch/WAN with 10GbE and six GbE ports, system controller • Application: IP voice gateway (56x DS1 and 42x E1), 4-port 2.488Gbps/1.244Gbps GPON, 1x GbE / 1x GbE WAN
6	ONT Support	• SFU: ONT1000GT/GT-JI (2x POTS, GbE, MoCA, +18 dBmV RF Video) • Desktop: ONT1100GE (4x GbE) • SFU2: ONT1400GT-RP (2xPOTS, 2x GbE, MoCA, +18 dBmV RF video, RF return) • SOHO: ONT1500GT (8x POTS, 2x GbE, MoCA, SyncE, +18 dBmV RF video)
7	Power & Electrical	• Power: -48 VDC, 30 A (maximum) • Power Consumption: 1500 W (maximum)

LAMPIRAN IV

SPESIFIKASI *TRANSCEIVER OPTICAL LINE TERMINAL*

Sumitomo Electric Industries, Ltd.

Part No.: SLT4410 SLT4460 Series

Document No.: HUW9824016-01E

Date of issue: June 19, 2002

1. General

SLT4410 Series and SLT4460 Series are 1.55μm InGaAsP/InP MQW-DFB laser diode modules designed for fiber optic communication systems. These modules are ideally suitable for long reach and intermediate reach of 622Mb/s and 2.5Gb/s transmission applications.

A laser diode is mounted into a coaxial package integrated with an InGaAs monitor PD and a single mode fiber pigtail. Especially SLT4460 Series have a single stage isolator integrated inside.

2. Package dimension and pin assignment (See attached appendix.)

3. Absolute maximum ratings

Parameter	Symbol	Ratings	Unit
Storage temperature	Tstg	-40~+85	°C
Operating case temperature	Top	-40~+85	°C
Peak optical output power	Pf	10	mW
Forward current (LD)	IfL	150	mA
Reverse voltage (LD)	VrL	2	V
Reverse voltage (PD)	VrP	15	V
Reverse current (PD)	IrP	2	mA
Soldering temperature (<10s)	Stemp	260	°C

Electrical and optical characteristics (Pf=2mW, Tc=+25°C, unless otherwise noted.)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Threshold current	Ith	CW	—	10	20	mA
		CW, Tc=-40~+85°C	—	—	50	
Optical output power	Pf	CW, If=Ith+20mA	1.0	2	2.5	mW
		CW, If=Ith+20mA, Tc=-40~+85°C	0.6	—	4.0	
Operating voltage	Vf	CW, Tc=-40~+85°C	—	—	1.7	V
Slope efficiency	Se	CW	0.05	—	0.125	mW/mA
		CW, Tc=-40~+85°C	0.03	—	0.2	
Peak wavelength	λp	CW	1540	—	1565	nm
		CW, Tc=-40~+85°C	1530	—	1575	
Side-mode suppression ratio	SSR	CW, Tc=-40~+85°C	30	—	—	dB
Spectral width	Δλ	CW, RMS, Tc=-40~+85°C	—	—	1	nm
Tracking error	ΔPf	Im hold(@Pf=2mW(+25°C)), CW Tc=-40~+85°C	-1.0	—	1.0	dB
Rise time	tr	Ib=Ith, 20-80%, Tc=-40~+85°C	—	0.05	0.10	ns
Fall time	tf	Ib=Ith, 80-20%, Tc=-40~+85°C	—	0.10	0.15	ns
Extinction ratio	Er	10log(2mW/Pf(Ith)), Tc=-40~+85°C	10	—	—	dB
Monitor current	Im	CW, VrP=5V, Tc=-40~+85°C	50	—	1500	μA
Monitor dark current	Id	VrP=5V	—	1	10	nA
Monitor capacitance	C	VrP=5V, f=1MHz	—	—	10	pF

Fiber pigtail specification

Parameter	Min.	Typ.	Max.	Unit
Type	Single Mode			—
Mode field diameter@1310nm	8.5	9.5	10.5	μm
Cladding diameter	122	125	128	μm
Outer jacket diameter	0.8	0.9	1.0	mm
Bending radius	30	—	—	mm

Optical isolator specification (λ=1550nm, unless otherwise noted.(for SLT4460 Series))

Parameter	Condition	Min.	Typ.	Max.	Unit
Type		Single stage			—
Optical isolation	Tc=+25°C	30	—	—	dB
	Tc=-40~+85°C	20	—	—	

LAMPIRAN V

SPESIFIKASI PERALATAN *OPTICAL NETWORK TERMINAL* (ONT)

No	Technical Summary	Spesification
1	Brand	MOTOROLA ONT1000GT2
2	Physical Description*	• Height: 11.5’’ (29.21 cm) • Width: 10.4’’ (10.4 cm) • Depth: 3.0’’ (7.62 cm) • Weight: 5 lbs.(2.26 km) • Mounting: Wall *Not including fiber management*
3	Power Supply	• ONT Power: 20 Watts (maximum) • ONT Input Voltage: +12 VDC • UPS Input Voltage: 100 to 240 VAC, 50/60 Hz. • Battery Backup Time: 8 hours idle backup
4	Interface Configuration Telephony Interface:	• 2 POTS: 4 IDC terminals (Tip and Ring) per line • 2 RJ-11 gel-filled test point connections • 5 REN (maximum) per line • 10 REN (maximum) across all lines
5	Data Interface:	• MoCA port with F-type connector • Ethernet 10/100/1000Base-T port • RJ-45 gel-filled connector
6	Power Interface:	• 7 position 5mm header with remove-able IDC connector
7	Video Interface:	• 75-ohm F-type connector +18dBmV
8	Optical Interface:	• SC or OptiFit® connector
9	Environmental	• Operating Temperature: -40°C to +60°C ambient (+46°C with 750 W/m2 solar loading)

		• Storage Temperature: -40°C to +65°C • Operating Humidity: 0 to 100% RH
Network Interface		
1	Gigabit Passive Optical Network (GPON) interface	• 2.5 Gb/s downstream • 1.2 Gb/s upstream
2	Operating Wavelengths:	• 1490 nm voice/data receive • 1550 nm video receive • 1310 nm voice/data transmit
3	Protocols	• ITU-T G.984.1, G.984.2, G.984.3, G.984.4, as amended

LAMPIRAN VI

SPESIFIKASI *TRANSCEIVER OPTICAL NETWORK UNIT*

General

** Data Rate 2,488 Gbps, NRZ*

** Duty Cycle 50%*

** Fiber Coupled Power -8 ~ -15dBm (Typ. -11dBm) for SMF*

** Sensitivity ~ -28dBm (Typ. -34dBm)*

** Connector Interface SC Duplex Connector*

Transmitter side

Parameter		Symbol	min.	Typ.	Max.	Unit	Note
Supply Voltage		Vcc_{tx}-Vee_{tx}	3.14	3.30	3.47	V	
Supply Current		Idtx		70	150	mA	1, 2
				70	190	mA	1, 3
Input Voltage TD, TDb	High	Vih	Vcc_{tx}-1.17		Vcc_{tx}-0.73	V	4
	Low	Vil	Vcc_{tx}-1.95		Vcc_{tx}-1.45		
Input Current TD, TDb	High	Iih	-10		150	µA	4
	Low	Iil	-10		10		
Signal Input Rise / Fall Time					0.5	nsec.	5

Note 1. Input bias current is not included. 50% duty cycle data. 2,488 Gbps, NRZ

Receiver side

Parameter		Symbol	min.	Typ.	Max.	Unit	Note
Supply Voltage		Vcc_{rx}-Vee_{rx}	3.14	3.30	3.47	V	
Supply Current		Idrx		75	125	mA	1, 2
				75	145	mA	1, 3
Data Output Voltage	High	Voh	Vcc_{rx}-1.10		Vcc_{rx}-0.86	V	4
	Low	Vol	Vcc_{rx}-1.86		Vcc_{rx}-1.62		
Data Rise / Fall Time of Output Signal		Trd / Tfd			0.5	nsec	5
SD Assert Time		Sa			100	µsec	6,9
SD Deassert Time		Sd			350	µsec	6,9
SD Output Voltage	High	SDV_{OH}	Vee_{rx}+2.20		-	V	7
	Low	SDV_{OL}	-		Vee_{rx}+0.50		8

Transmitter side

Parameter	Symbol	min.	Typ.	Max.	Unit	Note
Average Output Power to SMF	Pos	-15.0	-11.0	-8.0	dBm	1
Extinction Ratio	Er	8.2			dB	1
Center Wavelength	λc	1274		1356	nm	
Spectral Width (RMS)	Δλ			2.5	nm	
Eye Mask for Optical Output	Refer to Figure 4					

Note 1. Measured at 622.08Mbps PRBS2^23-1, 50% duty cycle data,NRZ

Receiver side

Parameter	Symbol	min.	Typ.	Max.	Unit	Note
Center Wavelength	-	1261		1580	nm	
Minimum Sensitivity	Pmin		-34.0	-28.0	nm	1,2
Overload	Pmax	-8.0			nm	1,2
Flag Assert Level	Pa	-48	-36	-28	dBm	2
Flag deassert Level	Pd	-49	-39	-28	dBm	

Note 1. BER=10^{-10}

2. Measured at the bit rate of 622.08Mbps, PRBS 223-1, NRZ, 50% Duty cycle data.

LAMPIRAN VII

SPESIFIKASI PERALATAN *WDM COUPLER*

Figure. 980/1550, 1310/1550nm WDM Coupler

980/1550,1310/1550 *WDM Coupler (**WDM-C**) is manufactured using advanced fused biconic tapering technique. The 1310/1550nm WDM coupler is the baisc component to make up dual window WDM devices. The 980/1550nm WDM coupler is used for EDFA, whose pump wavelength is 980nm. Our fused WDM devices have met the Bellcore GR-1209-CORE*

requirements.

Features of our WDM-C:

- *High isolation*
- *Low insertion loss*
- *Low polarization sensitivity*

Applications for our WDM-C:

- *Fiber amplifier*
- *Telecommunication*
- *CATV fiber optic links*

No	PARAMETER	NILAI
1	*Operating Wavelength* (nm)	1310, 1490, 1550
2	*Insertion Loss* (dB)	≤ 0,4
3	*Return Loss* (dB)	≥ 50
4	*Power Handling* (mw)	300
5	*Operating Temperature* (‘C)	0 – 70
6	*Storage Temperature* (‘C)	(-40)- (85)
7	*Dimension* (L x W x H) mm	80 x 50 x 6

LAMPIRAN VIII

SPESIFIKASI PERALATAN *OPTICAL DISTRIBUTION NETWORK*

Enhanced Single-Mode Optical Fiber (ESMF)

Improved performance across the entire 1260 nm to 1625 nm wavelength spectrum

<table>
<tr><th colspan="4">Optical Specifications</th></tr>
<tr><th colspan="4">Attenuation</th></tr>
<tr><td colspan="2">Attenuation at 1310 nm</td><td colspan="2">0.33 – 0.35 dB/km</td></tr>
<tr><td colspan="2">Attenuation at 1383 nm*</td><td colspan="2">0.32 – 0.35 dB/km</td></tr>
<tr><td colspan="2">Attenuation at 1460 nm</td><td colspan="2">0.25 dB/km</td></tr>
<tr><td colspan="2">Attenuation at 1550 nm</td><td colspan="2">0.19 – 0.21 dB/km</td></tr>
<tr><td colspan="2">Attenuation at 1625 nm</td><td colspan="2">0.20 – 0.23 dB/km</td></tr>
<tr><td colspan="4">* Including H2-aging according to IEC 60793-2-50, type B.1.3</td></tr>
<tr><td colspan="4">Other values available on request</td></tr>
<tr><th colspan="4">Attenuation vs. Wavelength</th></tr>
<tr><td colspan="4">Maximum attenuation change over the window from reference</td></tr>
<tr><th>Wavelength range (nm)</th><th>Reference λ (nm)</th><th colspan="2">(dB/km)</th></tr>
<tr><td>1285 – 1330</td><td>1310</td><td colspan="2">≤ 0.03</td></tr>
<tr><td>1525 - 1575</td><td>1550</td><td colspan="2">≤ 0.02</td></tr>
<tr><td>1460 - 1625</td><td>1550</td><td colspan="2">≤ 0.04</td></tr>
<tr><th colspan="4">Point discontinuities</th></tr>
<tr><td colspan="4">No point discontinuity greater than 0.05 dB at 1310 nm and 1550 nm.</td></tr>
<tr><th colspan="4">Attenuation with Bending</th></tr>
<tr><th>Number of Turns</th><th>Mandrel Radius (mm)</th><th>Wavelength (nm)</th><th>Induced Attenuation (dB)</th></tr>
<tr><td>100</td><td>25</td><td>1310</td><td>≤ 0.05</td></tr>
</table>

100	25	1550	≤ 0.05
100	30	1625	≤ 0.05
Cutoff Wavelength			
Cable Cutoff wavelength (λccf)		≤ 1260 nm	
Mode Field Diameter			
Wavelength (nm)		**MFD (µm)**	
1310		9.0 + 0.4	
1550		10.1 + 0.5	
Chromatic Dispersion			
Wavelength (nm)		**Chromatic Dispersion (ps/[nm.km])**	
1285 – 1330		≤ |3|	
1550		≤ 18.0	
1625		≤ 22.0	
Zero Dispersion Wavelength (λ0):		1300 - 1322 nm	
Slope (S0) at λ0:		≤ 0.090 ps/(nm2.km)	
Polarization Mode Dispersion (PMD)			
PMD Link Design Value** (ps$\sqrt{km}$)		≤ 0.06	
Max. Individual Fiber (ps$\sqrt{km}$)		≤ 0.1	
*** According to IEC 60794 –3, Ed 3 (Q=0.01%)*			
Geometrical Specifications			
Glass Geometry			
Cladding Diameter		125.0 ≤ 0.7 µm	
Core/Cladding Concentricity Error		≤ 0.5 µm	
Cladding Non-Circularity		≤ 0.7 %	
Fiber Curl (Radius)		≤ 4 m	
Coating Geometry			
Coating Diameter		242 ≤ 7 µm	
Coating/Cladding Concentricity Error		≤ 12 µm	
Coating Non-Circularity		≤ 5 %	
Length		Standard lengths up to 50.4 km	
Mechanical Specifications			
Proof Test			
The entire length is subjected to a tensile proof stress ≤ 0.7 GPa (100 kpsi); 1% strain equivalent			
Tensile Strength			

Dynamic tensile strength (0.5 meter gauge length):		
Aged*** and unaged:		median ≤ 3.8 GPa (550 kpsi)
**** Aging at 85°C, 85% RH, 30 days*		
Dynamic and Static Fatigue		
Dynamic fatigue, unaged and aged***		nd ≤ 20
Static fatigue, aged***		ns ≤ 23
Coating Performance		
Coating strip force unaged and aged****:		
- Average strip force:		1 N to 3 N
- Peak strip force:		1.2 N to 8.9 N
**** *Aging: • 0°C and 45°C* • 30 days at 85°C and 85% RH • 14 days water immersion at 23°C • Wasp spray exposure (Telcordia)		
Environmental Specifications		
Attenuation		
Environmental Test	**Test Conditions**	**Induced Attenuation at 1310, 1550 nm (dB/km)**
Temperature cycling	- 60°C to 85°C	≤ 0.05
Temperature-Humidity cycling	- 10°C to 85°C, 4-98% RH	≤ 0.05
Water Immersion	14 days; 23°C	≤ 0.05
Dry Heat	30 days; 85°C	≤ 0.05
Damp Heat	30 days; 85°C; 85% RH	≤ 0.05
Typical Values		
Miscellaneous		
Nominal Zero Dispersion Slope		0.085 ps/(nm2.km)
Effective group index @ 1310 nm		1.467
Effective group index @ 1550 nm		1.468
Effective group index @ 1625 nm		1.468
Rayleigh Backscatter Coefficient for 1 ns pulse width:		
@ 1310 nm		- 79.4 dB
@ 1550 nm		- 81.7 dB
@ 1625 nm		- 82.5 dB
Median Dynamic Tensile Strength		5.3 GPa (750 kpsi)
(Aged at 85°C, 85% RH, 30 days; 0,5 m gauge length)		

LAMPIRAN IX

Analisis *Mathlab* Untuk Performansi Jaringan *Fiber To The Zone*.

Kurva Hubungan *Rise Time* dengan *Bit Rate*

Hubungan *bandwidth* dan *rise time* dalam sistem untuk format pengkodean *Return To Zero* dapat dilihat pada persamaan berikut :

$$B_{Rx} = \frac{0{,}35}{T_{Rx}}$$

Dengan :

T_{Rx} = *Rise time* penerima (ns)

B_{Rx} = *bandwidth* penerima *front-end* (MHz)

Berikut perhitungan untuk kecepatan transmisi maksimum yang dapat ditransmisikan dalam sistem untuk format pengkodean *Non Return to Zero.*

$$B_{Rx} = \frac{0{,}7}{T_{Rx}}$$

Dengan :

t_{sys} = *Rise time* total sistem (ns)

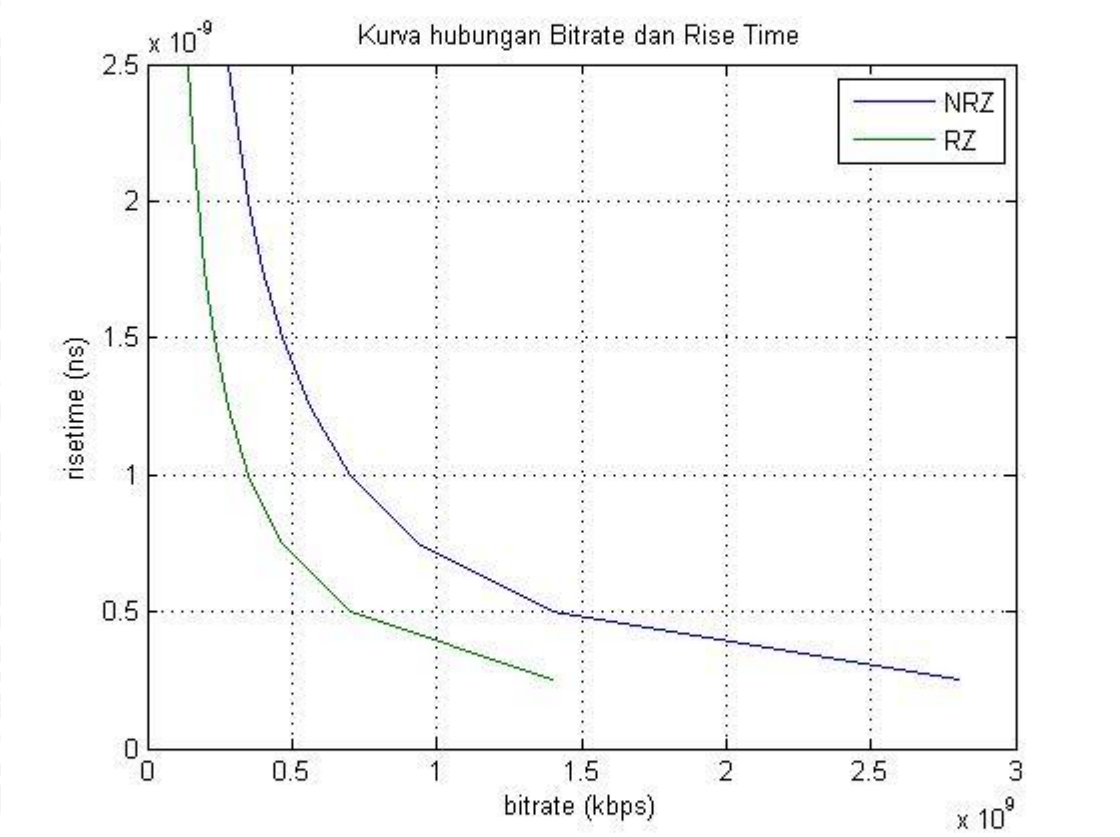
B_{Rx} = *bandwidth* penerima *front-end* (MHz)

Laju bit informasi maksimum diperoleh dari persamaan (Hoss, 1990:160) :

$$B_{R_{sys}} = \frac{0{,}7}{t_{sys}}$$

Listing Program :

```
rt=[0.25:0.25:2.5]*10^-9;
br1=0.7./rt;
br2=0.35./rt;
plot(br1,rt,br2,rt)
title('Kurva hubungan Bitrate dan Rise Time')
xlabel('bitrate')
ylabel('risetime')
legend('NRZ','RZ')
grid
```



Analisis :

Terlihat pada kurva diatas, dimana hubungan antara *bit rate* dengan *rise time* atau waktu jangkit saling berkaitan. Tidak hanya itu jenis *coding* juga mempengaruhi keduanya. Dengan coding NRZ *bit rate* yang dihasilkan lebih besar dibandingkan dengan nilai *risetime* yang sama dengan menggunakan *coding* RZ . *Rise Time* disini merupakan penjumlahan *rise time* dari sumber optik, detektor optik, dan *rise time* sistem.

Kurva Hubungan *Link Loss Budget* dengan Jarak

Secara matematis rumus redaman total pada PON adalah sebagai berikut :

Link Loss Budget (a total) = (α x L) + (B x Nb) + (C x Nc) + L*coupler* + S

Dengan :

α = Rugi serat optik (dB/km)

L = Panjang serat optik (km)

B = Rugi penyambungan/*splicing* (dB/titik sambung)

Nb = Jumlah titik penyambungan

C = Rugi konektor (dB/pasang)

Nc = Jumlah pasang konektor yang digunakan

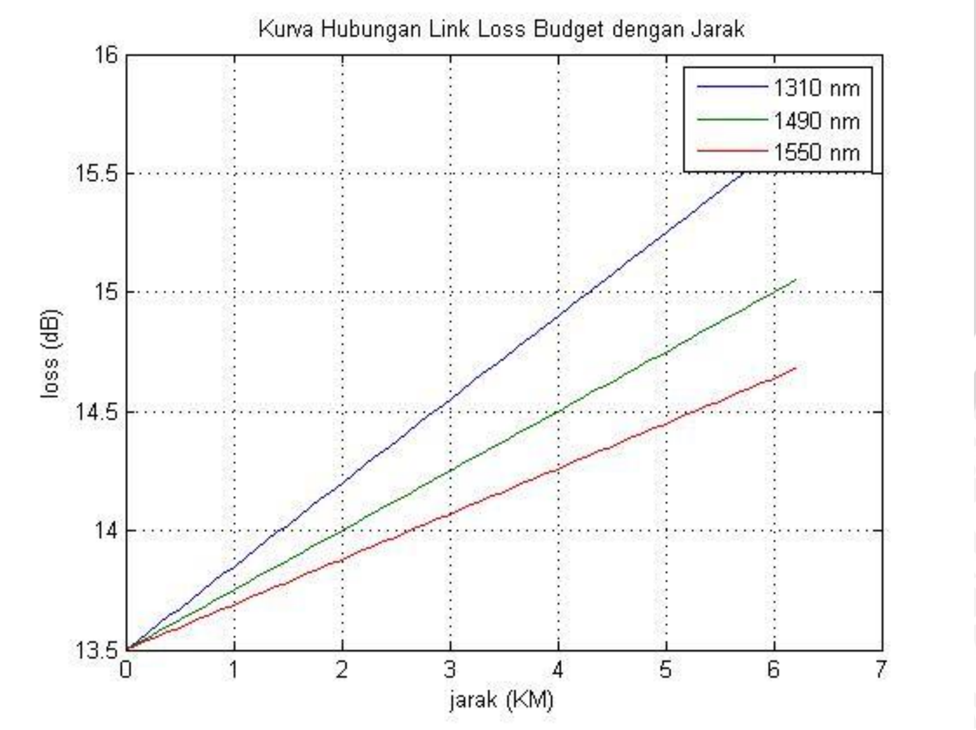
L*coupler* = Rugi WDM *Coupler* (dB)

S = Rugi *splitter* (dB)

Listing Program :

```
l=[0:0.1:6.21038];
b=0.2;
nb=2;
c=0.1;
nc=3;
nw=2;
s=12,041;
w=0.4;
loss=(0.35*l)+(b*nb)+(c*nc)+s+(nw*w);
losss=(0.25*l)+(b*nb)+(c*nc)+s+(nw*w);
lossss=(0.19*l)+(b*nb)+(c*nc)+s+(nw*w);
plot(l,loss,l,losss,l,lossss);
title('Kurva Hubungan Link Loss Budget dengan Jarak')
xlabel('jarak (KM)')
ylabel('loss (dB)')
legend('1310 nm','1490 nm','1550 nm')
grid
```

Kurva Karakteristik :



Analisis :

Dari kurva diatas dapat diketahui bahwa semakin besar jarak saluran *optical distribution network* maka *link loss budget* juga akan semakin tinggi. Hal ini menunjukkan bahwa jarak adalah faktor yang dapat mempengaruhi besar kecilnya *link loss budget* atau redaman total jaringan. Selain itu dapat diketahui dari kurva diatas bahwa semakin kecil panjang gelombang yang digunakan, berarti semakin kecil *rise time* maka redaman total pada jaringan juga akan semakin kecil.

Kurva Hubungan *Delay* Transmisi dengan Jarak

Delay propagasi pada serat optik sebesar 5.10^{-6} s/km. Dengan menggunakan persamaan (3.6), maka nilai *delay* transmisi dengan jarak OLT-ONT sebesar 6,21038 km adalah sebagai berikut :

$$TD = TD_1 + TD_2 + TD_3$$

$$TD = \left((5.10^{-6} x 10^{-1}) + \frac{53 \; x \; 8}{2488.10^6}\right) + \left((5.10^{-6} x 10^{-2}) + \frac{53 \; x \; 8}{2488.10^6}\right)$$

$$+ \left((5.10^{-6} x 6{,}21038) + \frac{53 \; x \; 8}{2488.10^6}\right)$$

Dengan :

TD = *Transmission Delay*

TD_1 = *Delay* antara *server* layanan suara dengan ATM *switch*

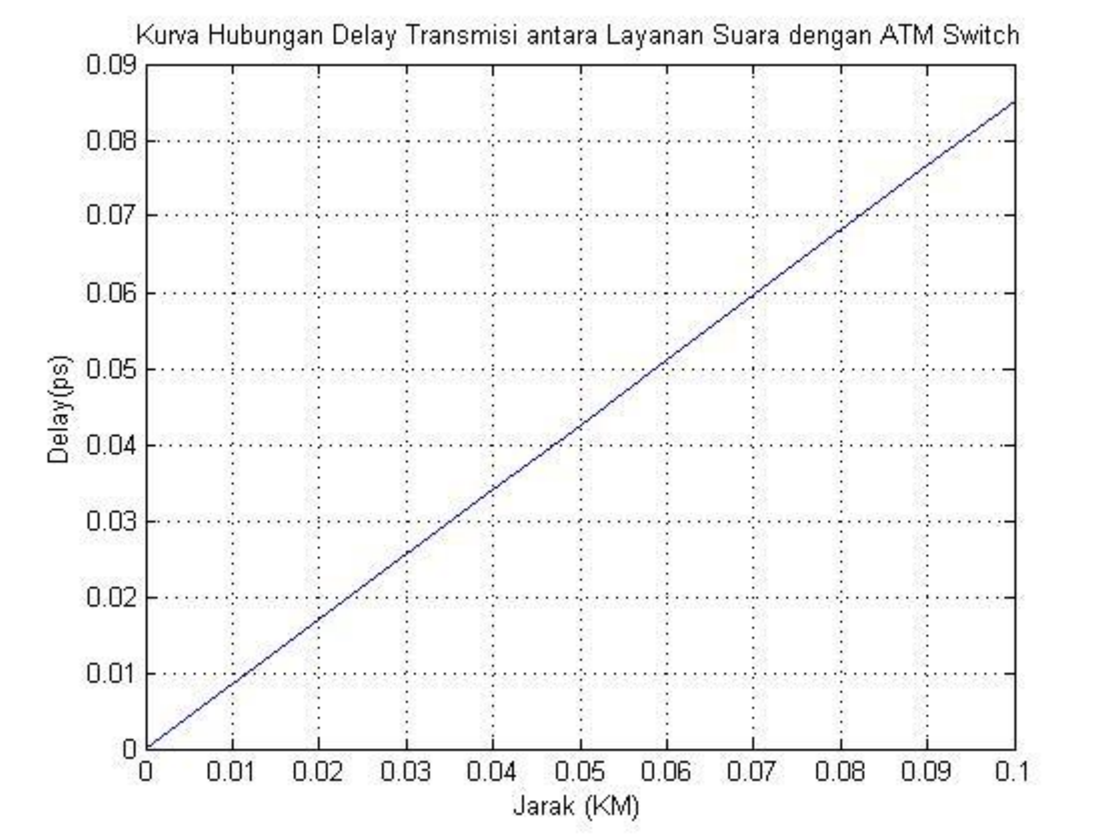
TD_2 = *Delay* transmisi antara ATM *switch* dengan OLT

TD_3 = *Delay* transmisi antara OLT dan ONT

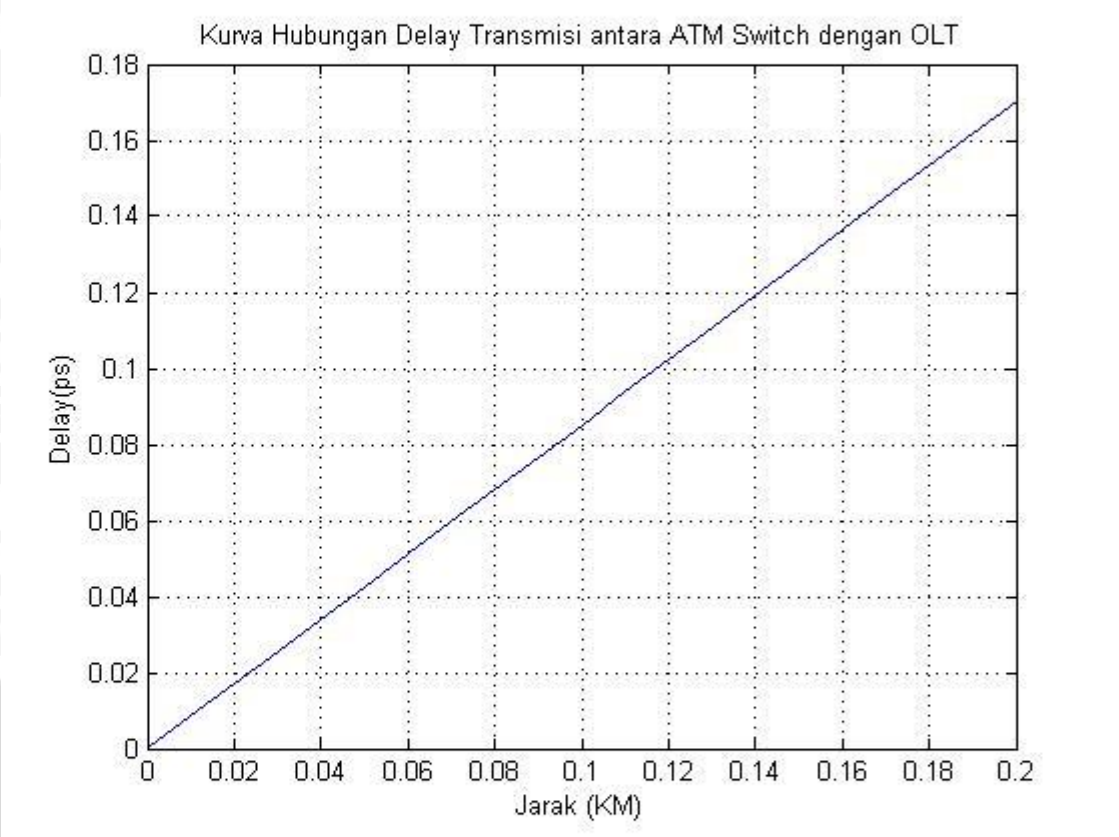
```
Listing Program :

l=[0:0.01:0.1];
a=5*(10^6);
c=424;
d=2488*(10^6);
delay3=(a*l*(c/d))
plot(l,delay3);
title('Kurva Hubungan Delay Transmisi antara Layanan Suara dengan
ATM Switch')
```

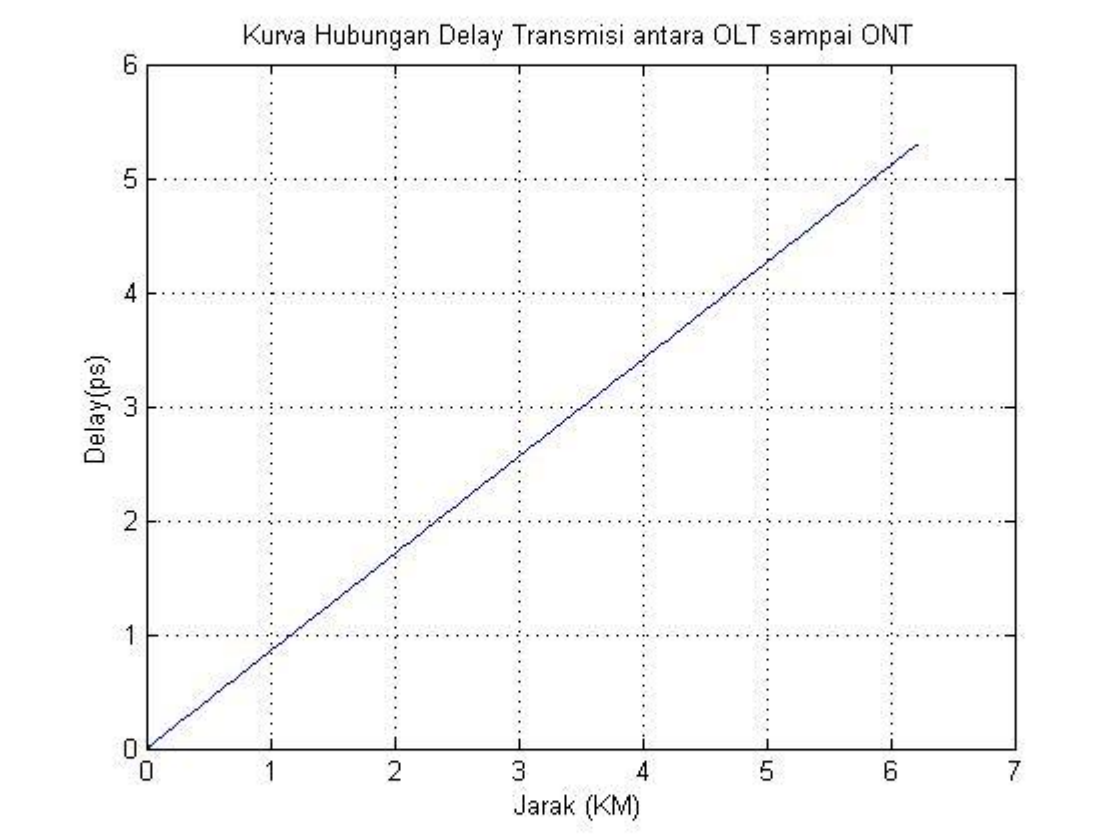
```
xlabel('Jarak (KM)')
ylabel('Delay(ps)')
grid
```




```
l=[0:0.01:0.2];
a=5*(10^6);
c=424;
d=2488*(10^6);
delay3=(a*l*(c/d))
plot(l,delay3);
title('Kurva Hubungan Delay Transmisi antara ATM Switch dengan OLT')
xlabel('Jarak (KM)')
ylabel('Delay(ps)')
grid
```




```
l=[0:0.01:6.21038];
a=5*(10^6);
c=424;
d=2488*(10^6);
delay3=(a*l*(c/d))
plot(l,delay3);
title('Kurva Hubungan Delay Transmisi antara OLT sampai ONT')
xlabel('Jarak (KM)')
ylabel('Delay(ps)')
grid
```



Analisis *Mathlab* :

Dari 3 buah kurva di atas dapat disimpulkan bahwa jarak sangat mempengaruhi *delay* transmisi dari sebuah jaringan serat optik. Pada kurva pertama, dengan jarak sebesar 0.1 antara layanan suara dengan ATM *Switch* terlihat bahwa semakin besar jarak maka *delay* akan semakin besar. Begitu pula dengan kurva kedua dan ketiga dimana jarak dari ATM *switch* menuju OLT dan OLT menuju ONT semakin besar, maka *delay* transmisinya juga akan semakin besar.