



# WDM PON

Wavelength Division Multiplexing Passive Optical Network Technology

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(B.T. Kim)	가

WDM-PON 가  
 가  
 WDM 가  
 FTTH 가  
 가  
 WDM/TDM, WDM/SCM, WDM/CDM 가  
 가  
 가  
 가  
 WDM-PON WDM  
 가

## I.

가 Gbps  
 Mbps , xDSL  
 30Mbps 가  
 0.4~1Mbps  
 Mbps 가 가  
 10Mbps~10Gbps  
 가  
 가  
 2000 가  
 250Gbps 2005 250Tbps 1,000 가  
 가  
 (Contents Delivery Net- WDM 가  
 work: CDN), 50~80% 가 가  
 WDM(Wavelength Division Multi- PON(Passive  
 plexing) 가 TPON  
 , LAN 10Mbps 100Mbps (Telephony PON) , FSAN(Full Ser-  
 155Mbps B-PON  
 (Broadband PON), 622Mbps APON(ATM PON),

GPON(Gigabit PON), EFM(Ethernet in the First Mile) 1Gbps EPON(Ethernet PON) FTTH(Fiber To The Home) FTTB(Fiber To The Building) PON solutions

[1].

PON (Central Office: CO)

OLT(Optical Line Termination),

ONU

(Optical Network Unit) ONT(Optical Network Termination), tree topology

OLT ONU/ONT

cascade

PON

OLT

ONU ONT

optical split-

ter

PON

OLT ONU/ONT

가

[2].

TDM(Time

Division Multiplexing)

PON

가

, 가

가

가

가

WDM-

PON

II

가

(Optical Multiplexer: OMUX)

(Optical DeMultiplexer: ODMUX)

WDM 가

III

WDM-PON , WDM/SCM(Sub-Carrier

Multiplexing) PON , WDM/CDM(Code Divi-

sion Multiplexing)

가

WDM

## II. WDM 가

WDM 가

WDM 가

가 가

가

가

### 1. WDM-PON

WDM 가

DFB-LD

(Distributed Feedback- Laser Diode)

가

가

가

가

가

DFB-LD

가

가

가

DFB-LD inventory

, DFB-LD

가

가

. DFB-LD

가

but-

terfly

가

가

가

TO can

FP-

LD(Fabry-Perot Laser Diode)

가

가

WDM

가

, EDFA(Erbium

Doped Fiber Amplifier), LED(Light Emitting Diode) SLED(Superluminescent Light Emitting Diode)  
 (Broadband Light Source: BLS) WDM spectrum sliced

WDM 가  
 SOA(Semiconductor Optical Amplifier) RSOA(Reflective SOA) 가  
 가 가 가

PLC(Planar Lightwave Circuit) 가  
 WDM

3가

가. Injection - Locking  
 Injection-locking master slaver  
 master  
 slaver

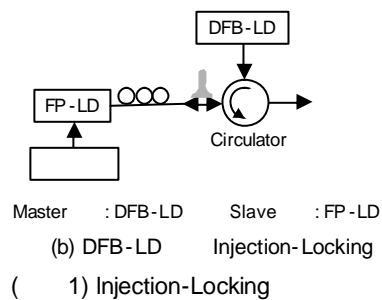
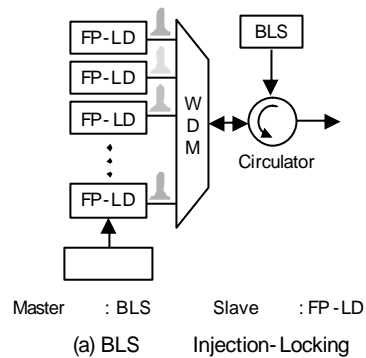
[3]. 가 가 가

[4]. ( 1) injection-locking  
 ( 1) injection-

locking master slaver  
 . ( 1(a)) BLS WDM  
 slicing FP-LD injection-  
 locking . FP-LD

injection  
 locking 가  
 injection-locking circulator  
 Mode Suppression Ratio) SMSR(Side

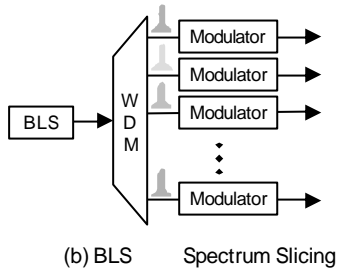
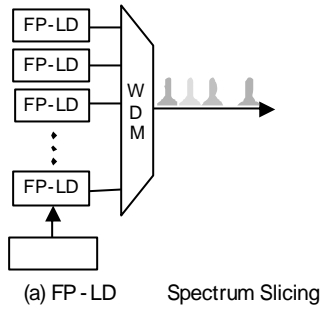
( 1(b))  
 DFB-LD master  
 LD FP-LD  
 injection DFB-LD  
 injection-locking FP-LD RSOA



. Spectrum Slicing

WDM slicing

BLS



( 2) Spectrum Slicing

가

[5]. ( 2) spectrum slicing . Spectrum slicing

( 2(a))

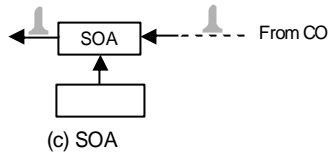
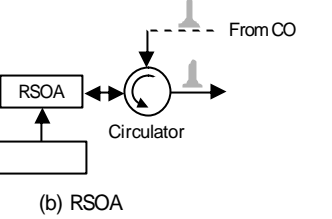
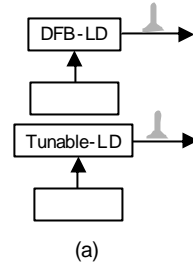
가 FP-LD WDM . FP-LD 가 WDM

BLS WDM WDM

가 . 가 가 가

( 3)

( 3(a)) DFB-LD tunable LD( 가 가



( 3)

가

CO . ( 3(b)), ( 3(c)) (loopback) RSOA( SOA) , CO RSOA( SOA)

가 . 3가 가

2. WDM - PON

PIN - PD(Photodiode) APD(Avalanche PD) 2가 , , APD 가 가 , PIN-PD 가 가 .

3. WDM - PON ( )

가 . arrayed waveguide , output slab waveguide

가 , . AWG type

가 . ( 4) AWG (Arrayed Waveguide Grating) type, thin film type diffraction grating( ) type

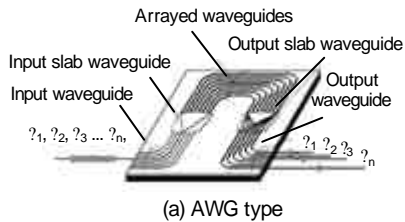
가 . crosstalk가 가 . athermal type AWG가 , 가 가

AWG type 가 , slab waveguide ( 4(a)) . AWG

Thin film type , thin film cascade

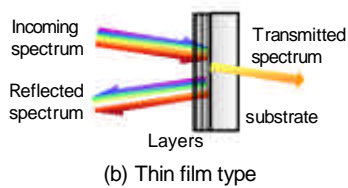
input slab waveguide arrayed waveguide

가 가 가 , thin film

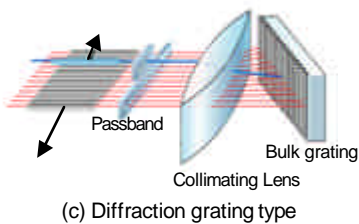


Diffraction grating type

. ( 4)



grating type . Diffraction 가 , 가 type 가 ,



UDWDM(Ultra Dense WDM)

1,000 GHz DWDM CWDM(Coarse WDM) 30 100 가

( 4) /

가  
 WDM-PON  
 UDWDM  
 1,022  
 10GHz  
 UDWDM  
 [6], K2 Op-  
 tronics UDWDM  
 external cavity  
 (<0.02nm/°C)  
 12.5GHz / Essex 8  
 3.125GHz  
 [7]. London 1.8THz  
 가 가 opti-  
 cal comb generator 1~25GHz  
 UDWDM  
 875 12.5GHz  
 UDWDM 가 UDWDM  
 [8], 2003

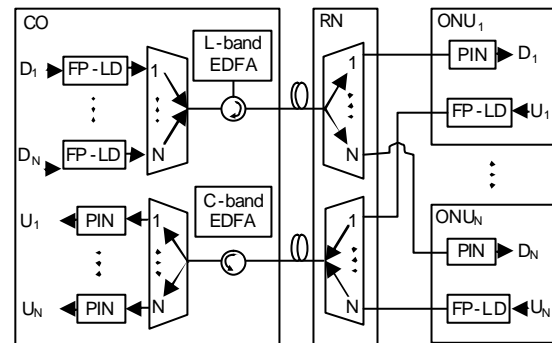
III. 가

가 OLT, RN  
 (Remote Node) ONT . OLT  
 MSO(Multi System Operator)  
 CO ,  
 가 ,  
 가 , RN 가  
 ( , )  
 ,  
 . ONT 가  
 가  
 WDM 가 WDM-PON , WDM/

SCM-PON WDM/CDM

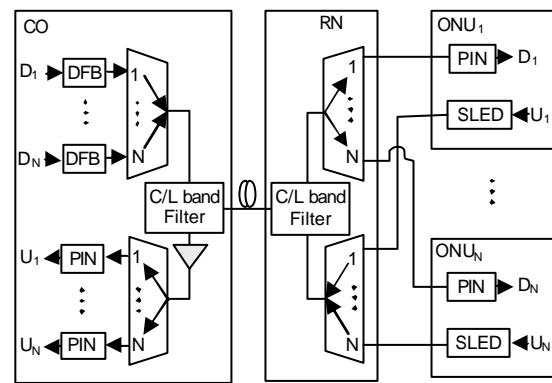
1. WDM-PON

가 WDM-PON  
 (ONT) 가 CO  
 가 CO  
 (OLT)  
 inventory  
 WDM-PON II 3가  
 가  
 Injection-locking WDM-  
 PON ( 5) [4].  
 EDFA BLS master



( 5) Injection-Locking

WDM-PON



( 6) Spectrum Slicing

WDM-PON

( 5) FP-LD injection-locking master  
CO RN

CO injection-locking DFB-LD  
가

( 6) spectrum slicing [5]. CO  
DFB-LD , 가

SLED SOA LED  
CO  
EDFA spectrum slicing 가 가

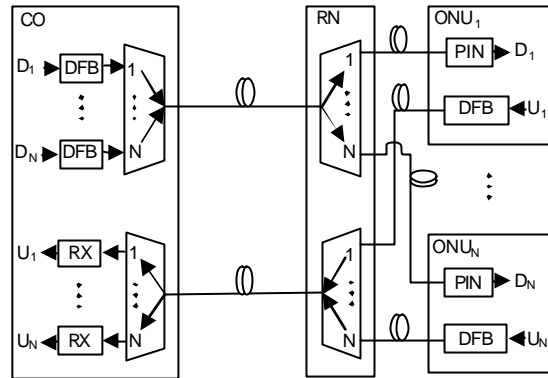
, C/L band 가  
( 7)

가 DFB-LD 가

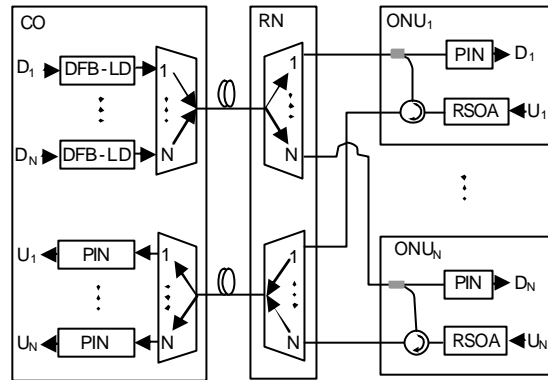
WDM-PON ( 8)  
[9]. ( 8)

가 RSOA optical coupler/circulator  
DFB-LD 가  
CO DFB-LD  
가 ONT 2x2

가 optical circulator RSOA  
RSOA  
star , ring  
. Ring /



( 7) WDM-PON



( 8) Loopback WDM-PON

OADM  
(Optical Add/Drop Multiplexer)

## 2. WDM-PON

WDM-PON

WDM

WDM

가 가

WDM

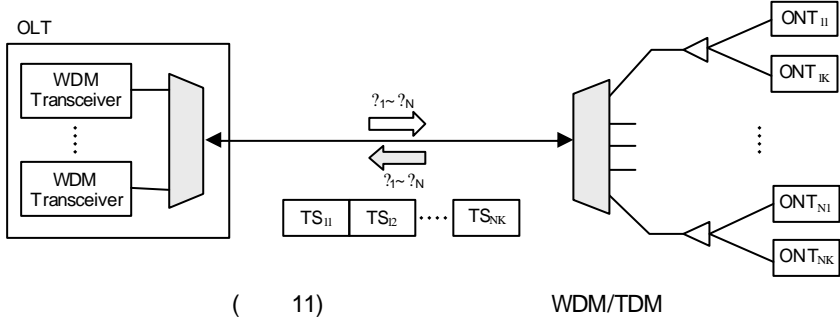
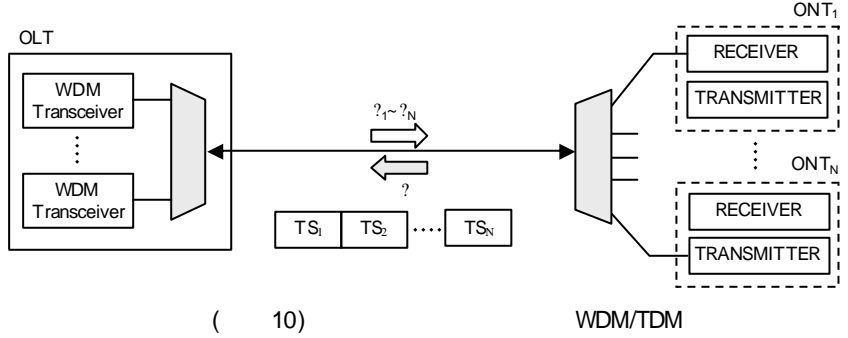
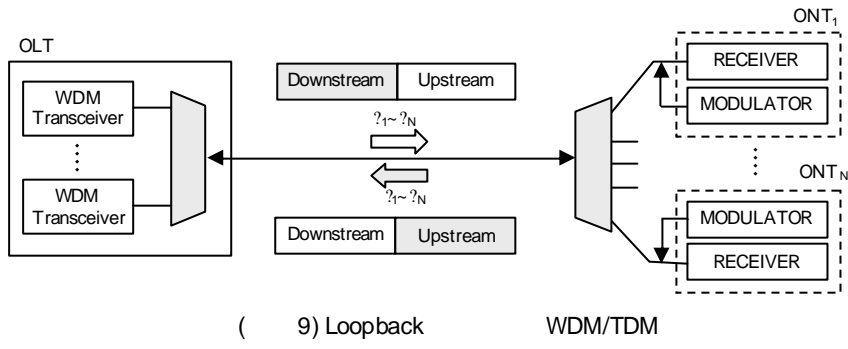
가

가

가

가

가 . PON  
 가 가  
 , 가 RTT(Round Trip Time)  
 TDM, SCM, CDM 가  
 가  
 가. WDM/TDM  
 WDM/TDM  
 APON, EPON,  
 GPON , WDM 가 OLT  
 ONU/ONT  
 ( 9) WDM- 가

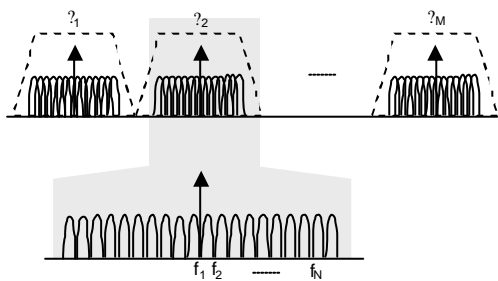




ONU/ONT  
 ONU/ONT  
 가 ONU ONT inven- 가 inventory 가  
 tory 가 inventory 가 가  
 10) ).  
 ( 11)

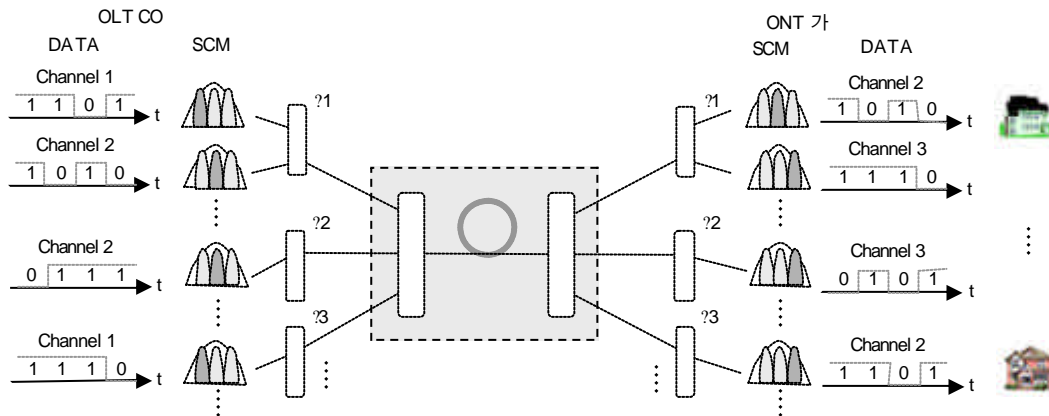
가  
 가 WDM/SCM  
 WDM/SCM ( 12) WDM

가  
 가 가  
 가 가  
 ( 13)  
 OLT  
 가 SCM WDM  
 , 가 ONT



( 12) WDM/SCM

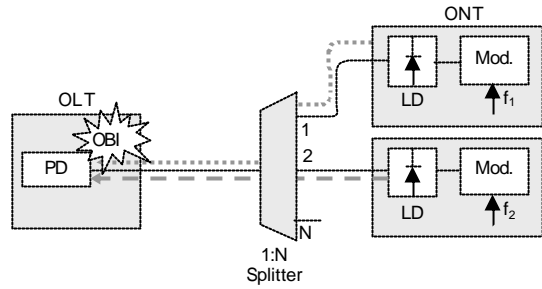
SCM  
 WDM/SCM  
 (1)  
 - :  $M(?) \times N(SCM)$   
 - 가 가  
 (2) Point-to-point  
 - OLT SCM ch.: ONT SCM ch.=1 : 1  
 -



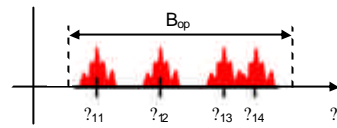
( 13) WDM/SCM

- (3) in-band & overlay 가
- (4) Protocol & bit rate transparency 가
- ranging, burst mode 가

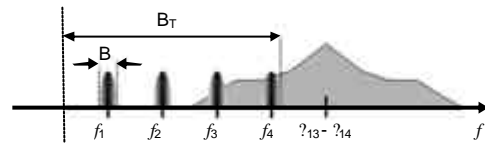
가  
WDM/SCM  
< 1 > [10],[11].



( 14)



(a)



(b) Photocurrent

( 15) OBI

가 WDM/SCM ( 14)  
ONT가

OLT  
(Optical Beat Interference: OBI)  
가

( 15)

f13 f14 WDM/SCM

( 15) OBI

가 WDM/SCM OBI

ETRI WPON SCM

100Mbps

OBI

< 1 > WDM/SCM

	Centerpoint	Sprint	NTT
Number of ?	64	-	32
? spacing	100GHz	-	100GHz
Bandwidth/?	20G	10G	6.2G
Number of SC	128	4	310
Modulation	16QAM	PSK	16QAM
bps/channel	155Mbps	2.5Gbps	20Mbps
Tx distance	80km	160km	20km
	Reed Solomon	-	Reed Solomon
	-	2.6~18GHz	2~3.9GHz
? range	-	-	1537 ~ 1562nm
	2001	2001	2003

. WDM/CDM

WDM/CDM WDM

가 . WDM

가 가 ,

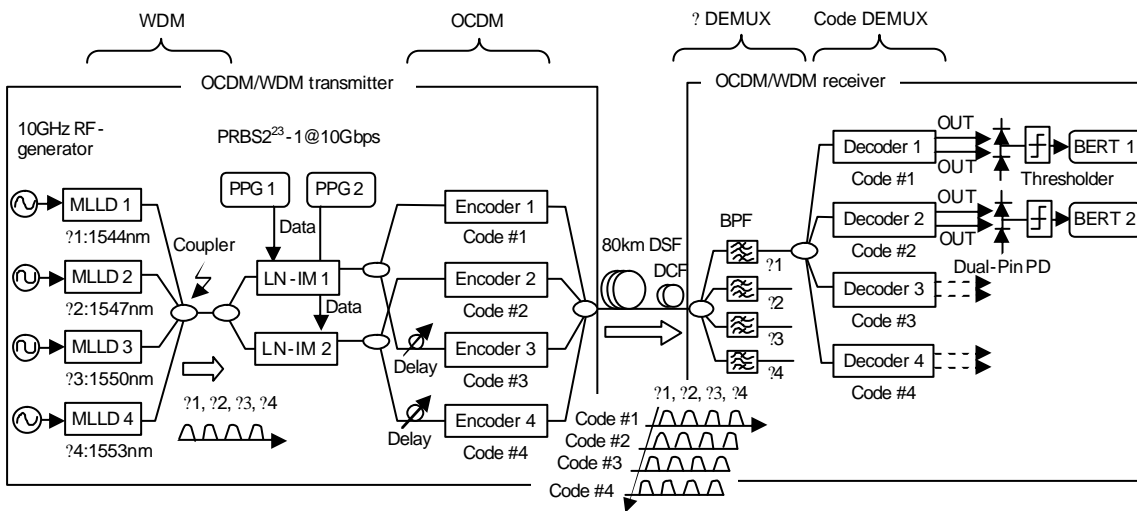
가

CDMA(Code Division Multi-  
plexing Access)

가

가

가 1980 가 CDMA 가 WDM 가 CDM 가  
 , OKI  
 , APN  
 , DARPA(Defense Advanced Research Projects Agency)  
 가 CDMA [12], 가 FTTH 가 PON , WDM-PON 가  
 , ETRI CDMA 가 가 가  
 ( 16) CRL WDM/CDM WDM-PON 가 Hybrid [13].  
 Diode: MLLD) PLC 가  
 , (Lithium Niobate-Intensity Modulator: LN-IM) 가  
 encoder 가 가  
 , decoder 가 가 WDM



( 16) CRL WDM/CDM Hybrid

WDM

가

가

가

WDM-PON 가

가

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