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Research and Implementation of Key Technologies in FTTH Networks Combining

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Abstract

Starting from the research of RFoG optical network technology and combining with the development of PON network, this paper puts forward a kind of integrated optical network structure, which can multiply the access bandwidth; furthermore, it analyzes the key technologies such as optical devices and integrated terminal equipment, and provides a technical scheme for upgrading the network.

Keywords: *RFoG; FTTH; access network; EPON; GPON; 10GPON*

1. Introduction

According to the "broadband China" strategy released by the China state council, by 2020, the broadband network will fully cover in urban and rural areas, the household penetration rate of fixed broadband will reach 70%, and some households in developed cities can reach 1 gigabit per second (Gbps).At present, the telecommunication network adopts EPON or GPON technology to connect to the optical fiber for household entry, and the total bandwidth of the

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access network is 1.25 Gbps or 2.5 Gbps. The radio and television adopts DOCSIS 3.0 technology, and combines RFoG fiber into the household, with a total bandwidth of 860 Mbps.Whether EPON or GPON or RFoG, the optical network is accessed by light: 1:32 or 1:64, that is, 32 users or 64 users share the total bandwidth.Therefore, there is still a gap between the goal of 1Gbps access for family users. On this basia, this paper builds a dual-network convergence network to improve the total access bandwidth,and gradually reaches the 1Gbps household requirement.EPON or GPON networks is well known,DOCSIS+RFoG network application is not yet popular in China ,but is widely used in North America. The following is a brief introduction to DOCSIS+RFoG networks.

2. DOCSIS+RFoG Networking Technology

DOCSIS technology is a classic two-way network technology of radio and television. Currently, DOCSIS3.0 technology is widely used, the total access bandwidth is 960Mbps.The downlink uses 256QAM modulation, 16 channel bundling to achieve 800Mbps bandwidth transmission; the uplink uses 64QAM modulation, 4 channel bundling to achieve 160Mbps bandwidth transmission.

RFoG technology [1], also known as radio frequency technology on fiber, is a fiber-to-the-home technology based on DOCSIS system, which pushes the optical workstation access network topology of traditional HFC bidirectional networks to fiber to the home.The key technology of RFoG network is that the uplink optical emission circuit works in burst mode, and the uplink channel of CMTS system adopts the characteristics of TDMA transmission to realize the time division multiplexing transmission of the uplink optical signals.This mode of operation is similar to PON network, which can form a point-to-multipoint network structure, typical of 32 RFoG nodes corresponding to one optical head.

As shown in Figure 1, the DOCSIS+RFoG network topology is constructed.The wave length was 1550nm downward and 1610nm upward, and the transmission of a single-fiber dual-wave common fiber was carried through WDM wavelength division multiplexing at the head end.The CMTS system adopts the DOCSIS3.0 standard to realize the broadband access of 960Mbps.

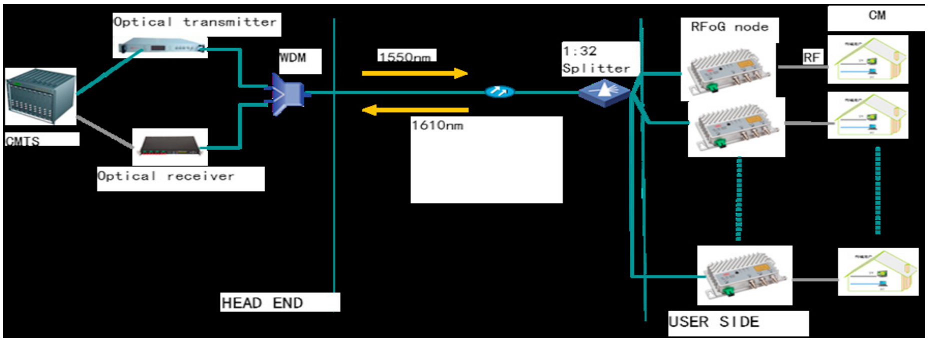

Fig1.DOCSIS+RFoG Network Topology

3. Single-Fiber Four-Wave FTTH Fusion Network and Its Implementation

After the FTTH fiber access network is deployed, how to make full use of fiber resources to provide users with higher speed bandwidth has always been the unremitting pursuit of technicians.Based on the similarity of point-to-multipoint network topology between RFoG technology and PON technology, a single-fiber four-wave FTTH fusion network is proposed to multiply the access rate bandwidth.As shown in Figure 2, a single-fiber four-wave FTTH fusion network topology is constructed to realize the common network transmission of RFoG signal and PON signal. The 1550nm wavelength was applied downward and 1610nm wavelength was adopted upward .At the head end, the 1550nm & 1610nm optical signals of the RFoG and the 1490nm & 1310nm optical signals of the PON are mixed by WDM wavelength division multiplexing to realize single-fiber four-wave common fiber transmission.The RFoG optical signal and the PON optical signal are received by the four-wavelength fusion terminal at the user end.

The RFoG signals based on the DOCSIS 3.0 standard provide about Gigabit rate bandwidth (960Mbps), and PON signals also provide about Gigabit bandwidth (EPON 1.25G rate bandwidth, GPON 2.5G rate bandwidth), that is, the fusion network can provide dual Gigabit composite total bandwidth.

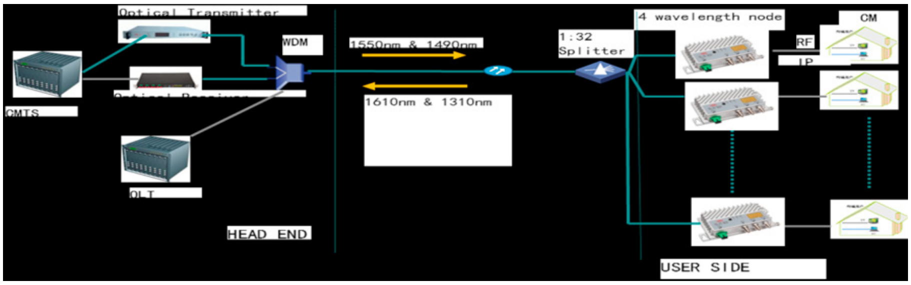

Fig2.a single-fiber four-wave FTTH fusion network topology

3.1 Key Technologies

3.1.1Four-wavelength fusion terminal

The four-wavelength fusion terminal mainly realizes RFoG signal reception and PON signal reception.The schematic diagram of the circuit is shown in Figure 3. It is composed of three parts:a four-wavelength optical component, a bidirectional RF signal processing circuit and an ONU module.In the part of bidirectional RF signal processing circuit, the optical AGC circuit is used to receive the downlink optical signal, and the output level remains constant in the range of - 8 dBm to 0 dBm optical power;the uplink uses the RFoG burst optical mode output.In the four-wavelength optical component, wave decomposition and multiplexing of the input four-wavelength signals are carried out, transmits the 1550nm & 1610nm wavelength optical signal for receiving and transmitting, and reflects the 1490nm & 1310nm wavelength PON optical signal to the ONU module, and the ONU module realizes photoelectric conversion output IP broadband signal.

2*Wavelength division device*

Wave decomposition and multiplexing principle is shown in Figure 4.Since the separated optical wavelengths of 1550nm&1610nm and 1490nm&1310nm are distributed in two intervals, it can be realized by means of high-wave length signal transmission and low-wave signal reflection, which can be designed as light transmission higher than 1520nm and light reflection lower than 1520nm. WDM optical device can be realized. relatively simple.

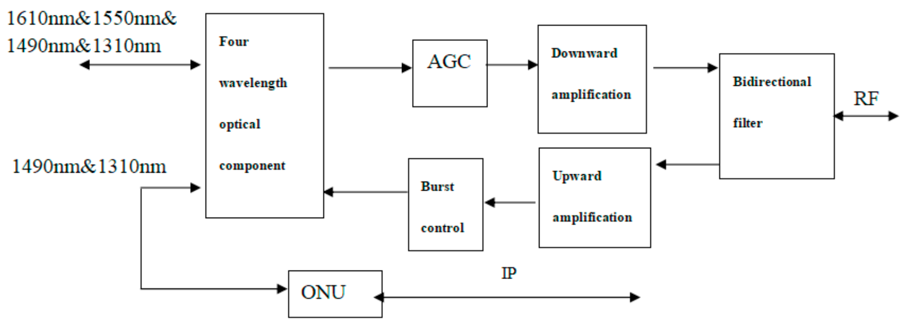

Fig3.Schematic diagram of four-wavelength fusion terminal

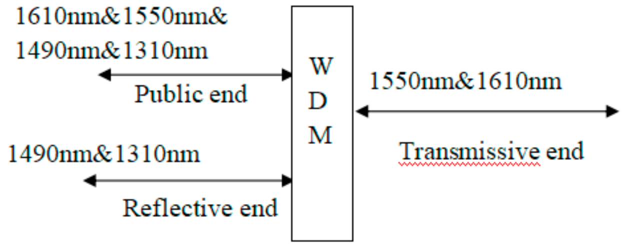

Fig4.Schematic diagram of four-wavelength division device

Table 1. Main technical indicators of four-wavelength fusion terminals

No.	Item	Unit	Index
1	Input wavelength	nm	1610 & 1550 & 1490 & 1310
2	RFoG wavelength	nm	1610 & 1550
3	PON wavelength	nm	1490 &1310
4	ONU output bandwidth	Gbps	1.25(EPON)or2.5（GPON）
5	1550nmReceived optical power	dBm	-10～+2
6	Receiving light AGC range	dBm	-8～0
7	Downlink RF bandwidth	MHz	87~1000
8	Output level	dBuV	80
9	Downlink RF flatness	dB	±1
10	Downlink CTB@0dBm	dB	65
11	Downlink CSO@0dBm	dB	60
12	Downlink CNR@-6dBm	dB	46
13	1610nmUplink optical power	dBm	3
14	Uplink operation mode		RFoG burst mode
15	Uplink RF bandwidth	MHz	5~65
16	Uplink input level	dBuV	80～100
17	Uplink RF flatness	dB	±1
18	NPR dynamic range	dB	≥15（NPR≥30dB）

4. Single-Fiber Six-Wave FTTH Fusion Network and Its Implementation

With the evolution of the DOCSIS protocol standard, upgrading from DOCSIS 3.0 to DOCSIS 3.1 systems can provide access bandwidths of up to 10 Gbps.For RFoG network equipment, it is mainly the upgrade of frequency bandwidth and frequency division, with the upgrade of frequency bandwidth from 1000MHz to 1.2ghz and 1.7ghz, and the upgrade of frequency division from 65/87 to 85/105 and 204/258.The next generation of PON access network is also upgraded from EPON and GPON to 10GPON access network. 1577nm wavelength is adopted downward and 1270nm wavelength is adopted upward to stagger the original EPON and GPON wavelength..Based on the development of above technologies, a single fiber six-wave FTTH fusion network is proposed to achieve the bandwidth capacity of 20Gbps composite access rate.

As shown in figure 5, a single-fiber six-wave FTTH converged network topology is constructed to realize the common network transmission of RFoG signal and EPON, GPON and 10GPON signals.RFoG's 1550nm & 1610nm wavelength signals, EPON, GPON's 1490nm & 1310nm wavelength signals, 10GPON's 1577nm & 1270nm wavelength signals, through the WDM wavelength division multiplexing at the head end, to achieve single-fiber six-wave common fiber transmission.The user side the RFoG optical signal through the six-wavelength RFoG optical node while reflecting the EPON, GPON, and 10GPON optical signals, and receives the PON signals with ONU.In the early stage of network application, the PON part adopts EPON or GPON equipment to provide Gigabit rate bandwidth; when the user's bandwidth demand cannot be satisfied, it is upgraded to 10GPON equipment and provides 10Gbps speed bandwidth.

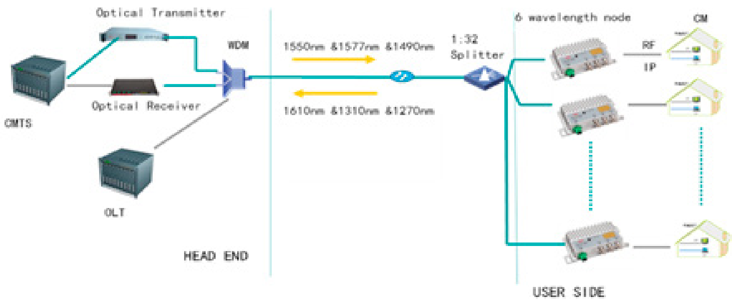

Fig5.Single-fiber six-wave FTTH fusion network topology

4.1. Key technologies

4.1.1Six-wavelength fusion terminal

As shown in figure 6 is schematic circuit which composed of optical module with six wavelength, bidirectional radio-frequency signal processing circuit and ONU.The part of bidirectional radio-frequency signal processing circuit is different from RfoG-ONU with four wavelength in that frequency range upgrade from 1000MHz to 1.2GHz,1.7GHz and frequency division from 65/87 to 85/105,204/258.At present,terminals fused by six wavelength that frequency range is 1.2GHz and division is 85/105 already partially used for commerce in physical net.As shown in form 2 is the main technical indicators of the products at this phase. In the optical module with six wavelength,input signal of six wavelength is wavelet decomposed and reused and produce transmission of optical signal that wavelengths are 1550nm&1610nm for receiving and transmitting,reflection of PON optical signal that wavelengths are 1577nm&1490nm&1310nm&1270nm for the ONU module,which realize photoelectric conversion to output IP-broadband signal.

4.1.2 Wavelength division device

The principle of wave decomposition multiplexing is shown in Figure 7.The difference from the four-wavelength demultiplexing is that it cannot be realized by a simple method of transmitting high-wavelength signals through low-wavelength signals.It must be realized by a CWDM coarse-wavelength division device cascade method.

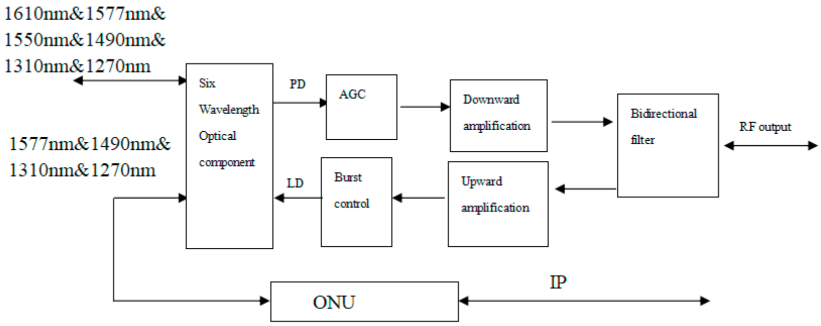

Fig6.Schematic diagram of six-wavelength fusion terminal

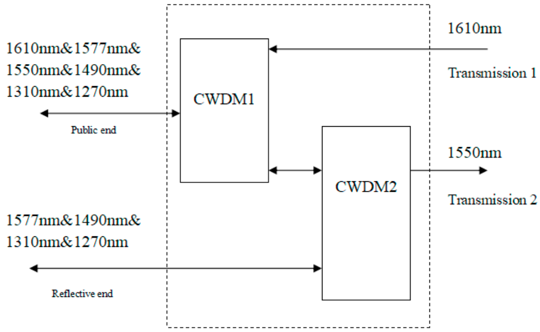

Fig7.Schematic diagram of six-wavelength division device

Table 2. Main technical indicators of six-wavelength fusion terminals

No.	Item	Unit	Index
1	Input wavelength	nm	1610&1550&1577&1490&1310&1270
2	RFoG wavelength	nm	1610&1550
3	PON wavelength	nm	1577&1490&1310&1270
4	ONU output bandwidth	Gbps	1.25(EPON)or2.5（GPON）or10（10GPON）
5	1550nmReceived optical power	dBm	-10～+2
6	Receiving light AGC range	dBm	-8～0
7	Downlink RF bandwidth	MHz	105~1200 or 258~1700
8	Output level	dBuV	80
9	Downlink RF flatness	dB	±1
10	Downlink CTB@0dBm	dB	65
11	Downlink CSO@0dBm	dB	60
12	Downlink CNR@-6dBm	dB	46
13	1610nmUplink optical power	dBm	3
14	Uplink operation mode		RFoG burst mode
15	Uplink RF bandwidth	MHz	5~85 or 5~204

16	Uplink input level	dBuV	80～100
17	Uplink RF flatness	dB	±1
18	NPR dynamic range	dB	≥15（NPR≥30dB）

5. Summary

Combined with RFoG technology and PON technology, FTTH fusion network based on wavelength division multiplexing can effectively improve the access network speed bandwidth and gradually reach the total bandwidth of 2Gbps and 20Gbps access network, providing a solution for the next step of upgrading the FTTH access network.

References

1. SCTE 174 2010, Radio Frequency over Glass Fiber-to-the-Home Specification[S].2010.