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Comparative Analysis of Different Modulation Techniques Used in Fiber Optical CATV System

Chaithran V[1], Pratheesh P[2]

PG Student [OEC], Dept. of ECE, TKM Institute of Technology, Kollam, Kerala, India[1]

Assistant Professor, Dept. of ECE, TKM Institute of Technology, Kollam, Kerala, India[2]

ABSTRACT: By the introduction of 1550 nm technology, fiber optic cable television (CATV) transport systems have recently been enhanced. The signal can be directly or externally modulated. Directly modulated system is an economic method,but laser chirping issues limit the system performance. External modulation eliminates laser chirp by using an external modulator which increases the capital expenditure. In order to provide an economic structure with advanced transmission performance direct modulation method is often combined with some improvement techniques to obtain high performance and low cost CATV system. The split band technique is one of the improvement technique used for the CATV transmission. Comparison of direct, external and split band technique is done by using an electrical power meter visualizer.

KEYWORDS: Cable Television (CATV),Direct modulation, Electrical power meter visualizer, Laser chirp, Split band technique

I. INTRODUCTION

Cable Television (CATV) initially introduced in rural areas that were beyond the range of broadcast transmissions and for those living in shadow zones in 1948.CATV transmission systems have promoted from coaxial cable based one way transmission to modern two ways hybrid fiber transmission.It originally stood for Community Access Television or Community Antenna Television, in areas where over-the-air reception was limited bydistance from transmitters or mountainous terrain. The first networks to include a fiber node type technology were built beginning in 1990. CATV networks today are built exclusively using Hybrid Fiber-Coaxial(HFC) design and older networks are being retrofitted to receive the benefits of HFC [1]. As a result, most CATV networks today are based on fiber node based architecture, but they also include elements of the older coaxial networks. The HFC network design helps reduce many of the amplification and attenuation issues and other issues associated with all coaxial cable plants. HFC cable networks can be extended significantly further than coaxial networks without the need for amplification. Because the signal travels over optical fiber, the physical distances between head end and subscriber can extend to more than 100 kilometres much further than in a coaxial based plant.

In an optical CATV system, the signal can be directly or externally modulated with light wave before it communicates.Long haul transmission of CATVtransport systems has becomewidespreadthroughoutthecable industry and isa promising prospect to combine themetroand access networks. Erbium doped fiber amplifiers (EDFAs) and single mode fiber is used to obtain high optical power, but this causes distortionslike composite second-order (CSO) composite triplebeat (CTB) [2] and also laser chirping issues when direct modulation is used. To overcome this, externally modulated transmitter is used, but it increases the capital expenditure. In order to provide an economic structure with advanced transmission performance direct modulation method is often combined with some improvement techniques to obtain high performance and low cost CATV system. The split-band technique is a powerful assistant for direct modulation CATV systems [3].

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II. RELATED WORK

In [4] authors proposed and experimentally demonstrated directly modulated fiber optical CATV system with split band technique employing side mode injection locked and semiconductor optical amplifier based optical single sideband modulation techniques. Excellent performances of carrier-to-noise ratio (CNR), composite second order (CSO), and composite triple beat (CTB) were achieved over single-mode fiber (SMF) transmission.

In [5] authors theoreticallyanalysed dispersion compensation effect of the chirped fiber grating (CFG) incable television (CATV) systems with directly andexternally modulated transmitters. Simulations aregiven for two kinds of modulations and for non-zero dispersion shift fiber (NZDSF)andstandard single mode fiber systems. It is proposed that directly modulated source can be used as atransmitter in CATV systems combined with tunable CFG dispersion compensator being adjusted precisely, whichis more costeffective than externally modulation technology.

III. SYSTEM MODELLING

In optical CATV systems, direct modulation method can provide an economic structure with advanced transmission performance as in external modulation system by combining it with other techniques.

A. *Direct Modulation*

Optical communication systems have been operating with direct modulation. That is, the input directly modulates the laser diode biasing current in order to produce a time varying output optical power. This method of modulation has proven satisfactory for low transmission rates [6]. The block diagram of a directly modulated CATV system is shown in Figure 1. Here the input signal from the signal generator is directly fed into laser source. An optical amplifier is placed after the laser source in order to amplify the modulated signal. Finally the amplified signal is received by the receiver. Direct modulation imposes limits to system performance because of laser diode non linearities and broader spectral line width. These two factors are very critical to high speed optical systems because they contribute to the undesirable pulse dispersion and the generation of relevant distortion products.

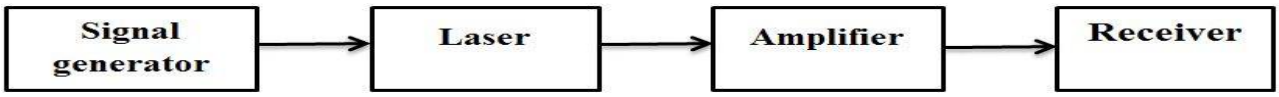

Figure 1: Basic block diagram of a directly modulated CATV system

B.*External Modulation*

The external modulation scheme provides better outcomes by eliminating the laser chirping issue. Nevertheless, an expensive external modulated transmitter is required, which increases the capital expenditures. The block diagram of an externally modulated CATV system is shown in Figure 2. Laser source and information signal are fed to an external modulator. Interaction of laser with input signal lead to phase modulation and this phase modulation is converted to intensity modulation within the external modulator. So that the spectral linewidth is broadened causing reduced stimulated Brillouin scattering effect and also eliminates laser chirping issues [7].

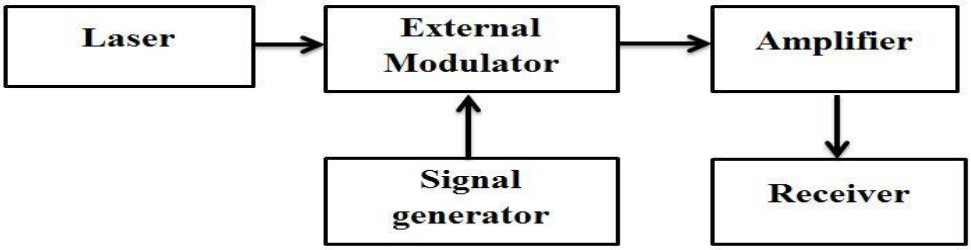

Figure 2: Block diagram of externally modulated CATV system.

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C. *Split Band Technique*

The split band technique is a powerful assistant for direct modulation CATV systems which is an improvement technique in direct modulation by eliminating the chirping issues. In this structure, the full channel loading is shared by additional laser diodes causing a wider optical line width to eliminate the Stimulated Brillouin Scattering (SBS)degradation.In split band technique, the full signal is shared by two lasers which broaden the spectral line width as shown in Figure 3. Then the signal from the lasers is amplified by an optical amplifier and the output is obtained from the optical receiver.

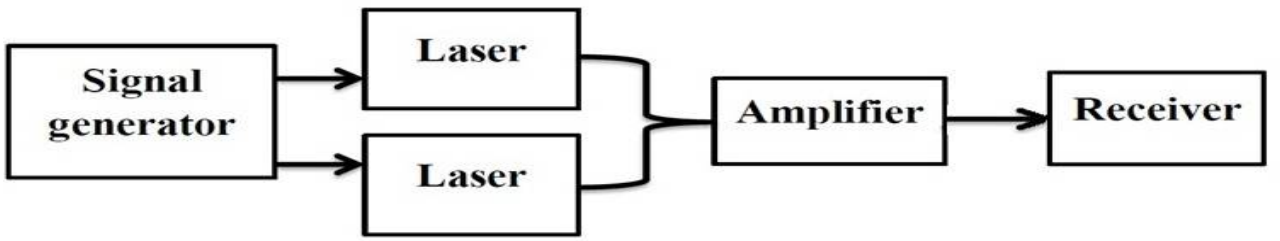

Figure 3: Block diagram of split band technique.

IV. DESIGN AND SIMULATION

Simulations of directly and externally modulatedCATV systems and the enhancement technique for direct modulation is executed by using OptiSystem software which is developed by Optiwave to perform complex optical communication simulation and also provides an easy user interface which is common to many other electrical engineering tools.

A. *Direct Modulation*

The input signal from the carrier generator which is a component which generatesa user-defined number of carriers and the output is a sum of sinusoidal electrical signals with constant amplitude. Carrier generator and Continuous Wave (CW) laser with 1550nm wavelength and power of 30dBm is given to amplitude modulator. After the signal is amplified by EDFA the signal passes through optical fiber and the optical signal is converted to electrical signals by optical receiver. Output power with different fiber length is obtained by the electrical power meter visualizer.

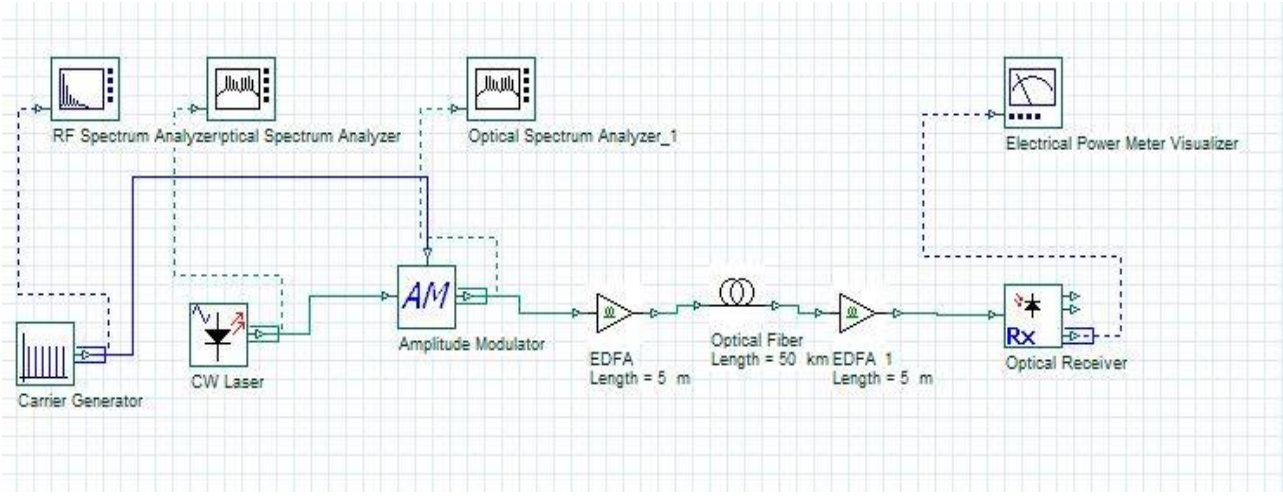

Figure 4: Simulation layout of directly modulated CATV system.

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B.*External Modulation*

Carrier generator and CW laser with 1550nm wavelengthand power of 30dBm is given to the Mach Zehnder modulator. The interaction of the 1550 nm laser light and the RF-generated electric fields leads to a phase modulation via the electro optical effect [5]. The phase modulation was then converted to intensity modulation within the external modulator. EDFA is placed in order to amplify the signal and passes through optical fiber. Electrical output power from the optical receiver is visualized by means of the electrical power meter visualizer.

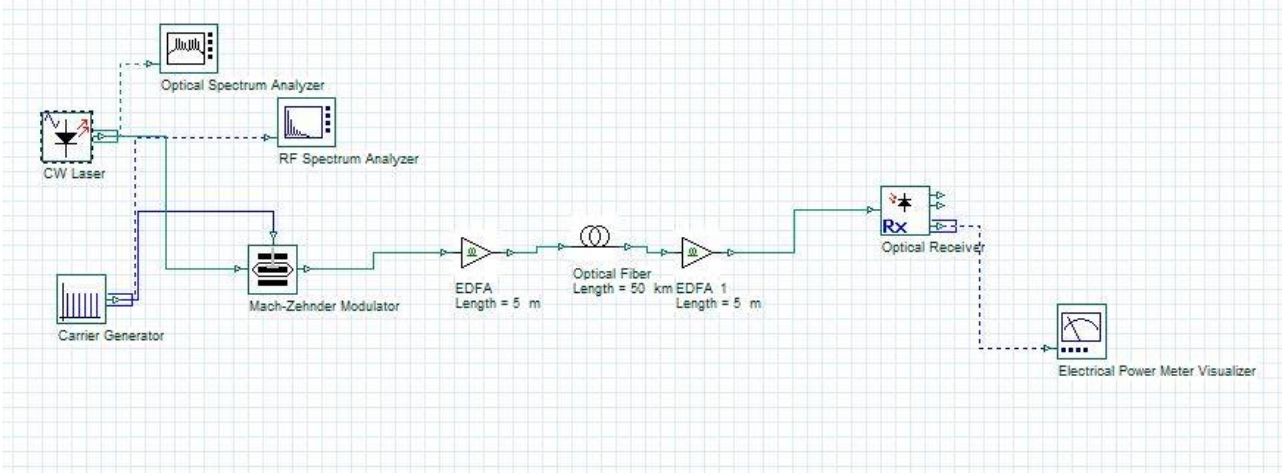

Figure 5: Simulation layout externally modulated CATV system.

C. *Split Band Technique*

Two directly modulated transmitter is used consisting of two carriergenerators, one with lower bands and other one with higher bands as shown in the simulation layout in Figure 6. The central wavelengths of the two CW laser diodes are 1550.5nm and 1555.7nm, respectively and both the lasers have 30dBm power. Then the power of these two signals is combined by a 2x1 power combiner passed through EDFA. Amplified signal passes through optical fiber and the signal is split by a power splitter and the signal is filtered by rectangular optical filter, then the optical signal is converted to an electrical signal by an optical receiver and the output power is visualized by the electrical power meter visualizer.

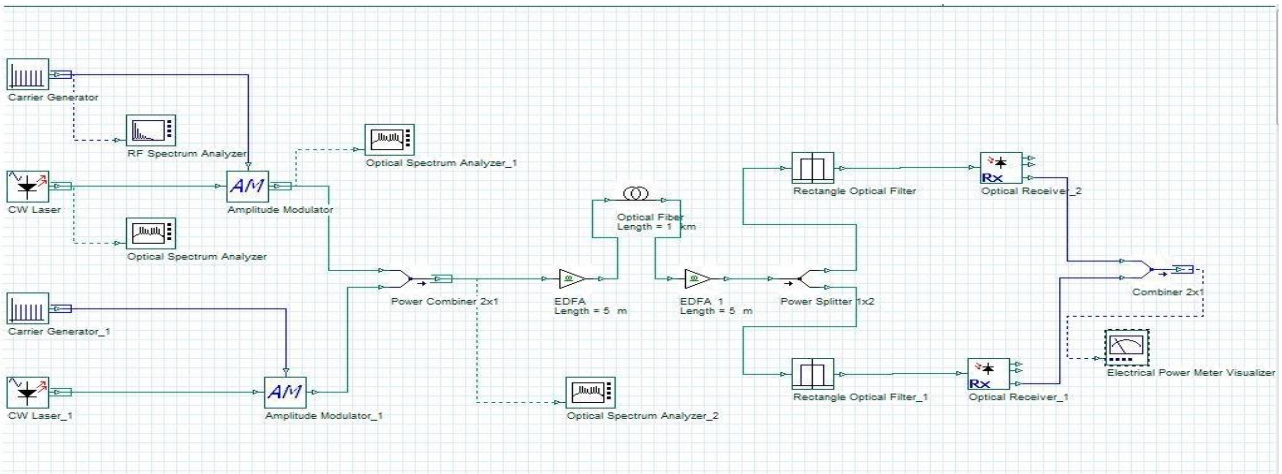

Figure 6.Simulation layout of split band technique.

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V. RESULTS AND DISCUSSIONS

Output power is obtained by means of the electrical power meter visualizer. This visualizer allows the user to calculate and display the average power of electrical signals and the power iscalculated at different fiber lengths. Figure 7 shows the power output for direct modulation and is of about 526.761 mW at 1Km fiber length.

Figure 7. Electrical power output of CATV system with direct modulation.

Electrical power output of external modulation at 1km fiber length is shown in Figure 8.Power is calculated for different fiber length and the output power decreases with increase in fiber length. At 1km fiber length 573.259mW power is obtained which is greater than direct modulation.

Figure 8. Electrical power output of CATV system with external modulation.

As the capital expenditure increases while using an external modulator, direct modulation is combined with split band technique in order to eliminate laser chirp. Split band technique with 1 Km fiber length is shown in Figure 9.

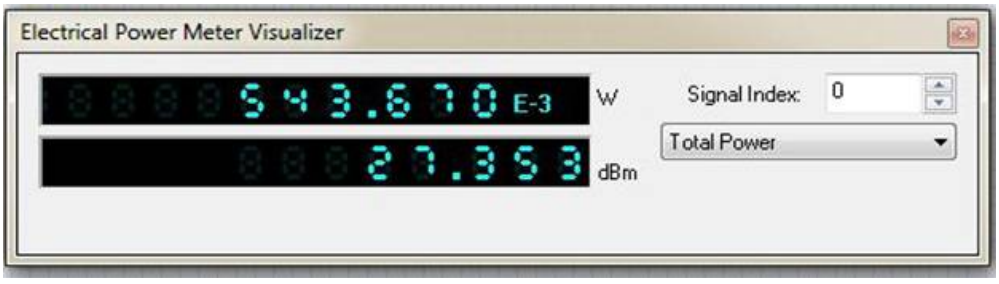

Figure 9. Electrical power output of CATV system with split band technique.

Graphical representation for comparison of direct and external modulation is shown in Figure 10. Direct modulation is indicated as blue and external modulation is indicated as red. From the graph it can be clearly seen that power for external modulation is higher than that of direct modulation. This is because laser chirp caused in direct modulation is not there in external modulation due to an external modulator.

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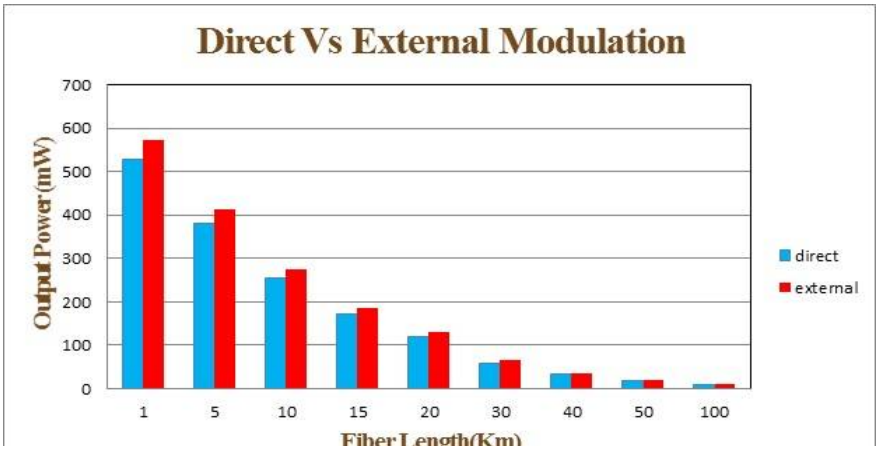

Figure 10. Graphical representations for comparison of direct and external modulation

From Figure 11 it can be clearly seen that split band technique hasmuch higher output power than direct modulation as thefull signal is shared by two lasers which broadens the spectral line width. Here split band technique is indicatedby redanddirect modulation by blue.

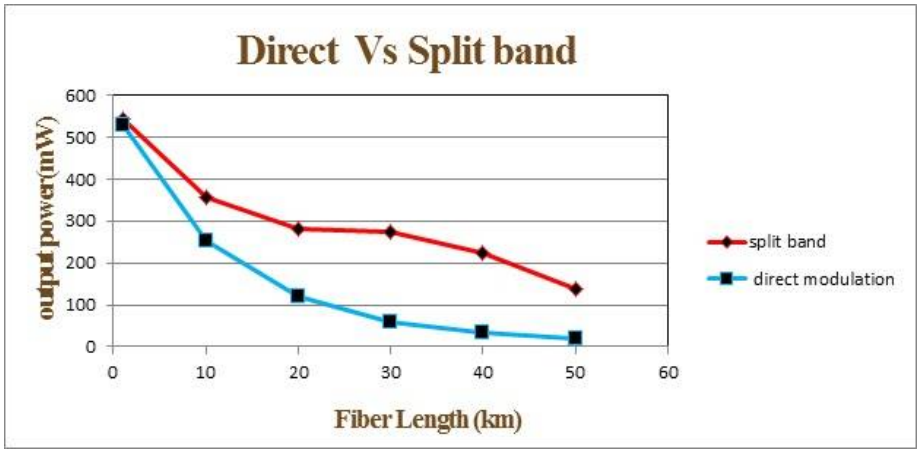

Figure 11. Graphical representations for comparison of direct and split band technique

VI. CONCLUSION

Fiber optical CATV systems have recently been enhanced by the introduction of 1550 nm technology. There are mainly external and direct modulations where external modulation is expensive, so that direct modulation with some improvement technique is done. In this work, output power at different fiber length is calculated for external and direct modulation in which external modulation has higher output power than direct because of the elimination of laser chirp. To obtain an economic structure with advanced transmission quality, split band technique which shares the full channel load from one laser diode to multiple laser diodes is used and has obtained much greater power than direct modulation. More improvement techniques such as light injection can be implemented to obtain more distorted less output.

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BIOGRAPHY

Chaithran Vreceived his B.Tech degree in Electronics and Communication Engineering from Cochin University of Science and Technology in 2014. He is currently pursuing second year M.Tech in Optoelectronics and Communication Systemsat TKM Institute of Technology.

Pratheesh Preceived his B.Tech degree in Electronics and Communication Engineering from University of Kerala in 2008 followed by M.Tech in Optoelectronics and Laser Technology from Cochin University of Science and Technology in 2011. He is currently working as Assistant Professor in the Department of Electronicsand Communication Engineering at TKM Institute of Technology.