

Design and Implementation of a Driving Circuit for an Optical System Transmitter and Receiver

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Abstract: For the laser driver circuit driving a laser diode to generate an optical output corresponding to an input data, thus, controlling the optical output based on an output current from a photodiode that detects the optical output. The output current is converted into a voltage signal whose amplitude is detected after filtering the voltage signal by a low-pass filter. Therefore, a reference signal corresponding to the input data is generated and its amplitude is detected. We have a modulator for generating a modulation current, it regulates the amplitude of the modulation current, according to the difference between the two detected amplitudes.

Key words: Corresponding, optical output, amplitude, voltage signal, detected, modulation

INTRODUCTION

A typical set up transmission system includes a transmitter, the receiver and a data channel as illustrated in Fig. 1. The signal at the transmitter will produce a suitable mode signal which transmits at the data channel, whereby the signal passes through the data channel and sends it to the receiver (Kumar, 2008). The data channel can be divided into two types, these are the unguided channel and the guided channel. The common example of unguided channel is by using the wave motion of atmosphere or air to transmit signal and an example of a guided channel is the optical fiber (Raj, 2015). In Fig. 2 illustrates the block diagram of the optical fibers

transmission system whereby the optical fibers transmitter includes a modulator, a carrier source and a channel coupler, thus, the optical fibers receiver includes an optical detector, amplifier and the signal processor, therefore, the data channel uses optical fibers as the guided line (Kharraz and Forsyth, 2013).

Significant of the statement: In accordance to the highlighted significance of the FSO communications and thus realizing it as an effective means in the modern day communications systems, it is therefore, worthy finding out the suitability of the system configuration and the parameters that optimized the system performance and reduces the setbacks of the atmospheric environment. The study undertaken in the research paper entails, giving out a general guideline and the performance characteristics in the study design, the simulation, the implementation, evaluation and the comparison of the proposed advanced link, through considering the performance of the current innovations in the radio over FSO system.

MATERIALS AND METHODS

Original signal: The original signal is possible with a sound wave, image or current signal (Chen *et al.*, 2012). Therefore, in an optical fiber communication system, irrespective to the conditions in place, the data must be converted to an electric signal before it's transmitted, thereafter, a transducer is used to convert the non-electric signal to electric signal (Majumdar, 2014). This is mostly when the microphone converts the sound wave to current

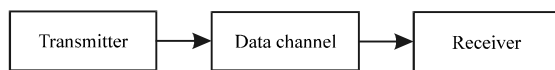


Fig. 1: The basic communication system

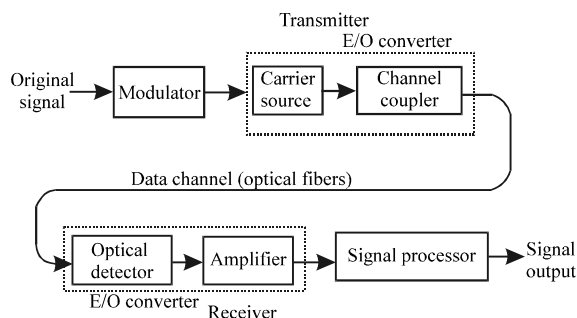


Fig. 2: The block diagram of optical fibers transmission system

signal while the video camera converts the image to current signal as McCormick (2014) puts it. Illustrations in Fig. 2 elaborates on how the transmitter receives the original signal, the signal then passes through a modulator which converts it to a suitable mode, thus, the signal is added to the carrier signal which is produced by the carrier source (Strobel, 2016).

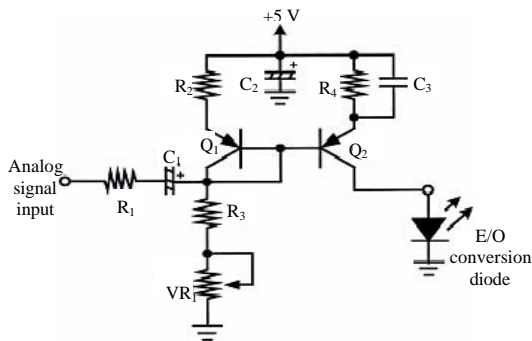


Fig. 3: The circuit diagram of analog signal modulated transmitter

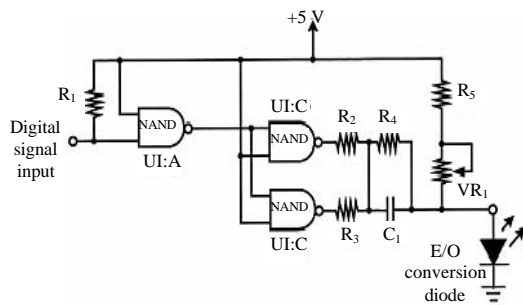


Fig. 4: The circuit diagram of digital signal modulated transmitter

In the optical fiber communication systems, Laser Diode (LD) or Light Emitting Diode (LED) is utilized to implement electron oscillator (also known as optics oscillator) for frequency radiation, the situation causes the fiberglass to become the effective optical transmission channel (Lehpamer, 2002).

Modulator: From the above-mentioned circuit, the primary objective of modulator is to convert the electric signal to suitable mode and this signal will be added to the carrier signal which is produced by the carrier source. Figure 3 is the circuit diagram of an analog signal modulated transmitter. The Q1 and Q2 is a current structure which converts the voltage signal to current signal and also provides bias for light source. The function of VR1 is therefore, to provide bias voltage to Q2 and adjust the magnitude of the output current. Since, the analogue signal is obtained at the collector of Q2, if the bias voltage is improper, then the output signal will incur distortion. Figure 4 is the circuit diagram of digital signal modulated transmitter. The U1 is a buffer which can recover the digital signal when the digital signal attenuates as Oyerinde (2011) discusses the process.

The voltage level is low during transmission. Resistor R1 is a rise Resistor; R2 and R3 is the current limited resistors; R4 and C1, comprises a low-pass filter to remove the high frequency noise of the digital signal; R5 and VR1 provide bias voltage for optical source and the intensity of the LED can be varied by adjusting the VR1, so that, the transmitter and receiver can operate properly.

Electric-to-Optical (E/O) conversion interface: In the Fig. 3-5, it's known that the modulated signal will be

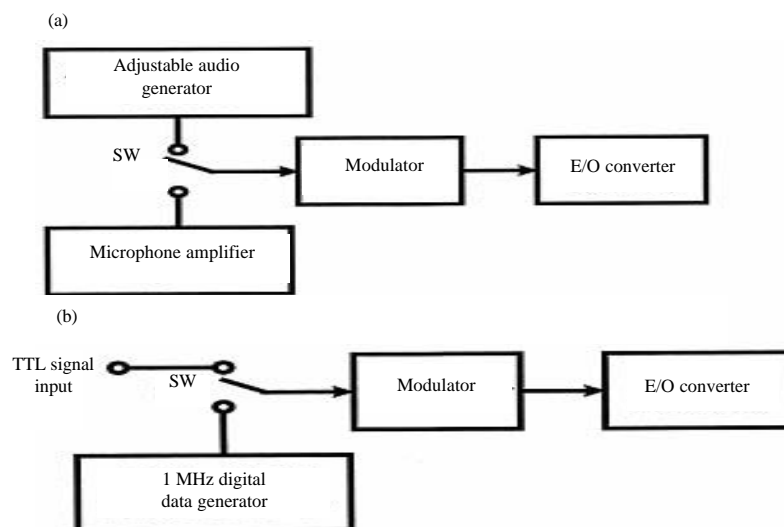


Fig. 5: a, b) The block diagram of the optical fibers communication transmitter

sent to Electric-to-Optical (E/O) conversion interface. Whereby, we have two common types of E/O conversion interfaces which are Light Emitting Diode (LED) and the Laser Diode (LD) (Tse and Viswanath, 2005).

The design and implementation of transmitter: The signal of the light can be used to transmit digital and analogue signals (Torres, 2013). The digital signal is the basic TTL signal with a voltage level that starts from 3.3 V to the voltage level of CMOS. Analogue signal includes the sine wave, the triangle wave and the square wave, therefore, the different types of modulations in the communication systems and the entire basic digital or the analogue signal can be transmitted by using the optical fibers or the free space (Oyerinde, 2011). In Fig. 5, we have the block diagram of the optical fibers communication transmitter. The diagram is divided into two main parts which are the block diagram of analogue transmitter as illustrated in Fig. 5a and the block diagram of digital transmitter as illustrated in Fig. 5b.

RESULTS AND DISCUSSION

Optical-to-Electric (O/E) conversion interface: The primary objective of the optical-to-electric converter in Fig. 6 is to convert the light wave to a current signal (Andrews and Phillips, 2005). The output current of the photo detector is proportional to the power of the incident wave and the variation of the light power contains the data signal, therefore, the output current of the photo detector also contains this data signal (Zhu and Khan, 2002). Generally, the common photo detector is the

photodiode which converts the light power to current signal. Basically, the photo detector can be classified into two types which entails direct conversion of photon to electron converter and heat parameter type converter (Skraparis *et al.*, 2010).

The photodiode belongs to the first type which can absorb the energy of photon and produce electron, hole, and then produce the current. To add on, the bolometer belongs to the second type, whereby its value of resistance can be varied by absorbing the energy of light. In the application of high speed of rate, the first type is more suitable (Bekkali *et al.*, 2009).

Signal processor: The main objective of the signal processor is to amplify and filter the signal from the O/E converter, the signal processors are analog received signal processor and digital received signal processor. Figure 7 is the circuit diagram of the analogue received signal processor. In the figure U1 is a $\mu A733$ IC which is manufactured by TI company. Figure 8 is the pins diagram of $\mu A733$. This IC is a video frequency differential amplifier whereby its frequency band can reach 100 MHz and the input impedance is 250 k Ω . In the circuit, the main

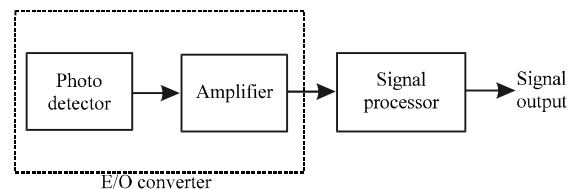


Fig. 6: The block diagram of optical fibers receiver

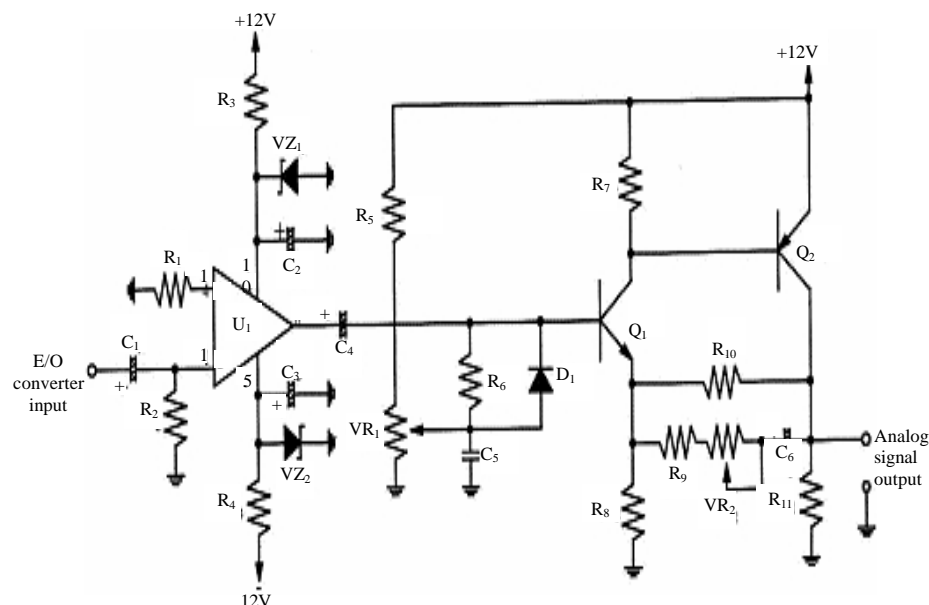


Fig. 7: The circuit diagram of analog received signal processor

function of $\mu A733$ is for amplification of small signal. Since, the O/E converter converts the signal, the amplitude of analogue signal is very small, thus, it needs a higher gain amplifier to amplify the analogue signal and if the gain control is not connected, then there are three selections of the gain of the differential amplifier which are 10, 100 and 400 times. Therefore, the selection depends on the characters at the numbers of IC. In Fig. 7, it's seen that the input signal is located at pin 1 and the output signal is located at pin 8. VZ1 and VZ2 are the voltage regulated components. Since, the operation voltage of $\mu A733$ is about ± 8 V, thus, the power supply of the whole circuit is ± 12 V. This means that, we need the voltage regulated components, so that, the amplifier can operate at a suitable voltage (Kreugle, 1998). Q1 and Q2 comprise of a Darlington pair series amplifier which amplifies the output signal of $\mu A733$. R9, VR2 and C6 which are the negative feedback channel of AC signal. R8, R10 and R11 are the DC bias components and R10 is also a negative feedback component. The total gain of the

circuit can, therefore be varied by adjusting VR1 and VR2, so that, the output amplitude is maximum without distortion.

In Fig. 8 shows the circuit diagram of digital received signal processor. As the signal received is possibly very small or very large, it leads to the utilization of the MC10116 IC from the Motorola Company. MC10116 is the differential amplifier which promptly process the digital received signal and also is suitable to use for long distance transmission (Kazaura *et al.*, 2007). In Fig. 9, there are three differential amplifiers that ensures the signal can be amplified and the noise can be removed effectively. Q1 and Q2 comprise a differential amplifier, whereby it's objective is to amplify the signal of MC10116. Since, the output of MC10116 is unable to reach the level of TTL, this makes room for transistors in achieving it for example when we design the operation mode of Q1 and Q2 as a switch and the output amplitude can be varied by adjusting VR14.

The larger the value of the resistor, the larger the output amplitude, however, the maximum need not exceed the TTL level.

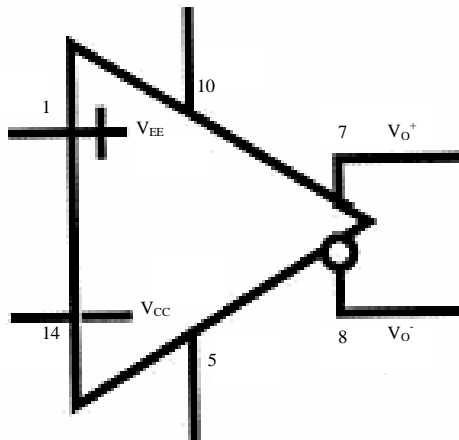


Fig. 8: The pins diagram of $\mu A733$

The design and implementation of receiver: In Fig. 10, it illustrates the block diagram of the optical fibers communication receiver that can be divided into two primary parts. The first part is the block diagram of the analogue signal receiver as illustrated in Fig. 10a and the other part is the block diagram of the digital signal receiver as illustrated in Fig 10b.

In Fig. 10a, the analogue signal receiver will not only recover the signal from the transmitter but will also amplify the analogue signal by using the amplifier (Mahdy and Deogun, 2004). In Fig. 10b of the digital signal receiver, it can be seen that the weak square wave signal is amplified to TTL level by using the differential amplifier.

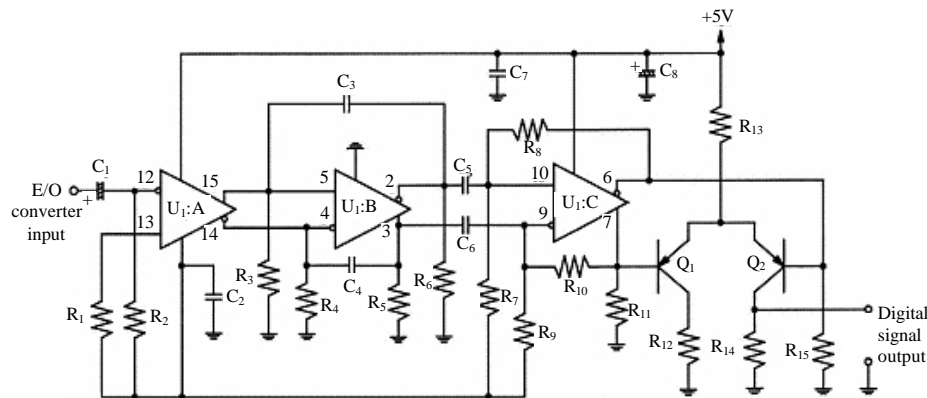


Fig. 9: The circuit diagram of digital received signal processor

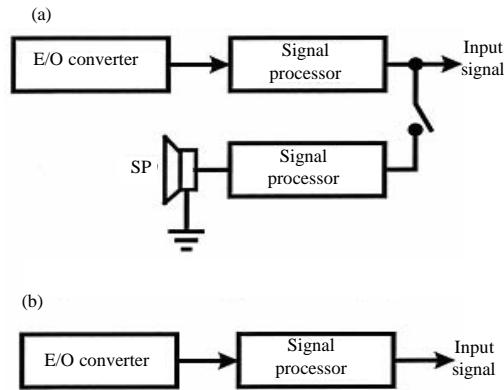


Fig. 10: a, b) The block diagram of optical fibers communication receiver

CONCLUSION

The project under study explains how to connect up and build a laser diode circuit. A laser diode is a diode which outputs a laser beam. Unlike the LED light, a laser's light output is more concentrated, meaning it has a smaller and more narrower viewing angle (Abaza *et al.*, 2013). This means it must be directed at its source more directly in order to be picked up. The laser light is also a monochromatic, meaning laser light isn't composed of several lights combined together but one light of the same wavelength and energy (Rahman *et al.*, 2012). The laser lights have a single spectral color and is almost the purest monochromatic light available. A laser diode circuit is built and a driver circuit for the laser diode is created. A driver circuit is a circuit which can limit appropriately the amount of current being fed into the laser diode, so that, it can function correctly (Manor and Arnon, 2003). Too much current and the laser diode will blow. Too little current and the laser diode will not have sufficient power to turn on and operate. Therefore, a driver circuit is needed to give precisely the correct range of current needed, so that, the diode will operate in build the driver circuit, a voltage source, a voltage regulator, a diode, an electrolytic capacitor and a few resistors are needed (Sangeethan *et al.*, 2014). All these parts were explained in the previous chapters under the study.

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