Transmission of Multiple Audio Signals Using Laser Communication System

Harman Malhotra
Department of Electronics and Communication
Bhagwan Parshuram Institute of Technology
New Delhi, India

Abstract—Communication is essential for every human being. Over time, several advancements have been made in the field of communication technology. This paper throws light on a new communication system that can replace the present day fiber optic communication systems.

Fiber optic communication systems involve a transmitter, and a receiver connected via an fiber optic cable that acts as the guiding medium. It does not seem pragmatic, to imagine a laser without a guiding medium being used for transmission of information. This system is ideal for situations where physical connections are not a possibility, for instance, between satellites or between army installations. In these situations longer range communication is made possible as the range is no longer a function of the length of the cable.

The elimination of the fiber optic cable gives way to lower cost, a much simplified system design and also improves the reliability of the system.

Keywords—Intensity Modulation, Frequency Division Multiplexing, Band pass Filter, Mixer Circuit, Fiber Optic

I.   INTRODUCTION

Free-space optical communication (FSO) systems (in space and inside the atmosphere) have developed in response to a growing need for high-speed and tap-proof communication systems. Links involving satellites, deep-space probes, ground stations, unmanned aerial vehicles (UAVs), high altitude platforms (HAPs), aircraft, and other nomadic communication partners are of practical interest. Moreover, all links can be used in both military and civilian contexts. FSO is the next frontier for net-centric connectivity, as bandwidth, spectrum and security issues favor its adoption as an adjunct to radio frequency (RF) communications [1].

Laser is an outstanding invention of the 20th century. It's a photonic device which stands for Light Amplification by Stimulated Emission of Radiation. The unique property of laser is that its light waves travel very long distances with very little divergence. Laser is a coherent source of light, hence unlike conventional sources of light where separate waves cancel each other at random, the laser light is narrow, powerful and easy to focus on a given object.

This paper is aimed at designing and realizing a transmission-reception system to transfer sound via Laser without a guiding medium, using Intensity Modulation, with little quality loss.

II.   BACKGROUND

The paper finds its roots in the paper "Sound Transmission using laser", which was aimed at the exhibition of the concept of Intensity modulation. The paper explained how lasers can be used to transmit sound without the use of any connecting media. This paper builds on my previous work, in this case multiple sound signals are being transmitted using the laser. This paper outlines how a cost effective and simple communication system, using the concept of Intensity modulation and Frequency Division Multiplexing can replace all the present day wired optical systems. The communication system proposed is particularly useful in case of inter- satellite communication

III.   SYSTEM MODEL

The system consists of basically two parts, the transmitter and the receiver. The transmitter consists of two amplitude modulators designed using AD633.The amplitude modulated signals are mixed using a mixer circuit built using an LM741.The signal obtained post mixing of the two amplitude modulated signals is used to modulate the laser beam.

The receiver consists of a solar panel, which also acts a demodulator. The received signal is demodulated and is separated into separate audio signals using band pass filters.

IV.   TRANSMITTER

The transmitter is composed of amplifiers, modulators; adder and the laser (modulated using multiple audio signals).
The input baseband signals are first amplified to desirable voltage levels using amplifiers designed with LM386 has the focal point.
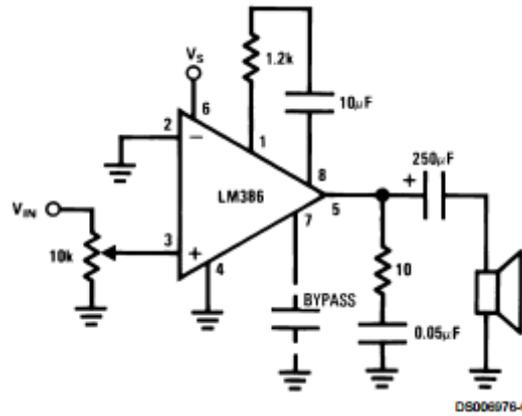
Fig 1: Amplifier Circuit Used [2]

The amplified mp3 signals are then amplitude modulated on   separate carrier waves with different frequencies. The amplitude modulator is designed using AD633.The number of amplitude modulators required is equal to the number to signals that are required to be transmitted simultaneously.
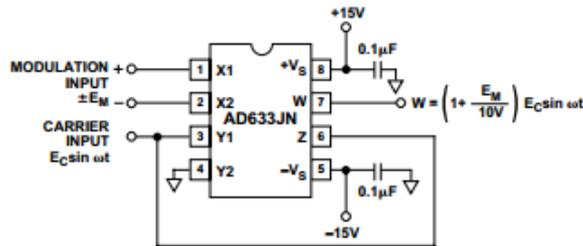

Fig 2: Amplitude Modulator Circuit Used [3]

The amplitude modulated signals are then added together using a mixer circuit designed using LM741 opamp IC.
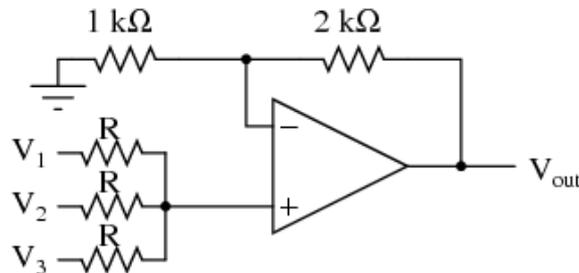

Fig 3: Mixer Circuit used [4]

The outputs of the mixer are fed to the laser, this intensity modulates the laser beam. The laser beam now acts as a carrier medium for multiple sound signals being transmitted simultaneously. The concepts of both Intensity Modulation and Frequency Division Multiplexing now come into the picture.

V.   RECEIVER

The receiver in this system is responsible for both receiving the incoming signals as well as the demodulation and separation of the amplitude modulated signals into separate baseband signals.

The laser beam strikes the solar panel and is converted into the equivalent voltage signal. This voltage signals consists of both the amplitude modulated baseband signals. This unified signal is amplified using the same amplitude modulator discussed in the transmitter section. Post amplification the signals are fed to two band pass filters centred around the carrier frequencies used to modulate the two baseband signals.
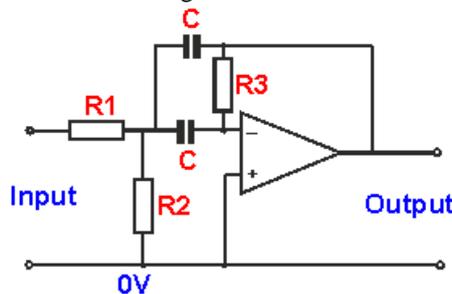

Fig 4: Band pass filter used [5]

The separated out baseband signals are demodulated using envelope detectors. Post demodulation we obtain demodulated, separated baseband audio signals that were supplied at the input of the modulator.
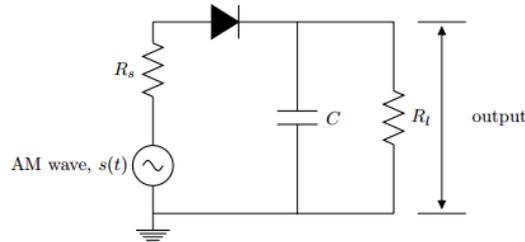
Fig 5: Envelope Detector used [6]
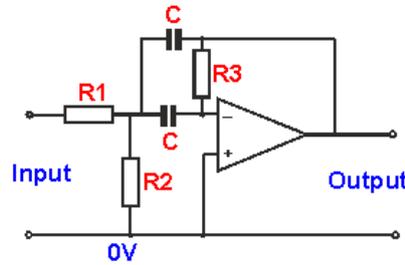
VI.   EQUATIONS USED

a) Amplitude Modulator

$W=(1+Em/10)EcSin(wt)$

Where is the output of the amplitude modulator in volts.
Em is the peak amplitude of the baseband signal in volts.
EcSin(wt) represents the carrier signal. [3]

b) Bandpass Filter

$$R1 = \frac{Q}{H_0 \, \omega_0 \, C}$$

$$R2 = \frac{Q}{(2Q^2 - H_0) \, \omega_0 \, C}$$

$$R3 = \frac{2Q}{\omega_0 \, C}$$

$$H_0 = gain \ \& \ \omega_0 = 2\pi f$$

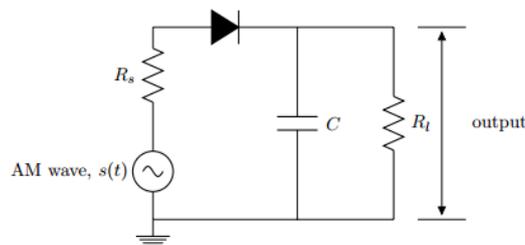Fig 6: Equations for designing an active Band Pass filter [5]

c) Envelope Detector

Fig 7: Designing an envelope detector [6]

$1/fc \ll RlC \ll 1/W$

Where. fc is the frequency of the carrier wave.
W is the message bandwidth.
Rl,C are the components used while designing the envelope detector. [6]

VI.   WORKING

1. The baseband mp3 signals are amplified and fed to the amplitude modulators
2. The amplitude modulators modulate the baseband mp3 signals over carrier waves with different frequencies.
3. The two amplitude modulated signals are then mixed using a mixer circuit to obtain a single unified signal. This signal is composed of both the amplitude modulated baseband mp3 signals.
4. The mixed signal is fed to the LASER, which in turn intensity modulated the laser beam.
5. This intensity modulated beam is then transmitted and is received at the receiver.
6. The beam upon impingement on the solar panel is converted into an equivalent voltage signal.
7. The voltage signal is effectively a mixed signal that contains both the baseband amplitude modulated signals.
8. This mixed signal is passed through band pass filters centered on the carrier frequencies of the baseband signals.
9. The output of the band pass filter is a single amplitude modulated signal (the one which the band pass filter does not block).
10. This amplitude modulated signal is then demodulated to extract the baseband audio signal.
11. The same process results in the yield of the second baseband audio signal.

VII.   RESULTS

A laser based communication system for successful transmission of multiple audio signals has been designed and fabricated.

The communication system successfully exhibits the fact that the infinite bandwidth of the laser beam can be used to transmit multiple signals using the concept of frequency division multiplexing.

The successful transmission of multiple signals simultaneously, shows the fact that present day transmission reception systems that require cabling, access rights and can be replaced by the proposed system.

REFERENCES
[1]   Requirements and challenges for tactical free-space lasercomm. In IEEE Military Communications Conference . San Diego (USA), 2008.
[2]   http://www.ti.com/lit/ds/symlink/lm386.pdf
[3]   http://www.utdallas.edu/~kamran/AD633.pdf
[4]   http://www.allaboutcircuits.com/vol_3/chpt_8/8.html
[5]   http://www.radioelectronics.com/info/circuits/opamp_band_pass_filter/op_amp_bandpassfilter.php
[6]   http://kisi.deu.edu.tr//sebnem.seckin/EED3014/Experiment%202.pdf