Free Space LASER Communication

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Abstract - In space, radio frequencies (RFs) are usually used for long-distance linkage. However, recent progress in optics and laser technologies, especially in fiber optics, is ushering in an era of inter-orbit communications using laser beams. Communication technology has experienced a continual development to higher and higher carrier Frequencies, starting from a few hundred kilohertz at Marconi's time to several hundred terahertz since we employ lasers in fiber systems. The main driving force was that the usable bandwidth - and hence Transmission capacity - increases proportional to the carrier frequency. Another asset comes into play in free-space point-to-point links. The benefits are due to optical waves' high frequency. In Europe, the European Space Agency (ESA) in its Semiconductor Laser Inter satellite Link Experiment (SILEX) has routinely used a 50Mbps optical communication link twice a day between a low earth orbit (LEO) and geostationary earth orbit (GEO) satellite since 2003. In Japan, the Optical Inter-orbit Communications Engineering Test Satellite (OICETS) developed by the Japan Aerospace Exploration Agency (JAXA) was launched in August 2005 and a laser communication link with the SILEX terminal was successfully established. After these experiments, ground-to-OICETS laser communications experiments including four optical ground stations (OGSs) were conducted and laser beam propagation data were acquired. Laser communication is one of the key area in wireless Communications. This paper includes analysis, optimization, and design and system level development of signal transformation between satellites or any two sources. Which work similarly to fiber optic links, except the beam is transmitted through free space While the transmitter and receiver must require line-of-sight conditions, they have the benefit of eliminating the need for broadcast rights and buried cables . Finally the area and power estimation report is discussed.

I. INTRODUCTION

The Optical Inter-orbit Communications Engineering Test Satellite (OICETS), developed by the Japan Aerospace Exploration Agency (JAXA), was launched in August 2005, which led to the world's first successful bidirectional inter-satellite laser communications experiment, between the OICETS and the Advanced Relay Technology Mission Satellite (ARTEMIS), a geostationary earth orbit (GEO) satellite of the European Space Agency (ESA). Laser Communication is one of the emerging area of wireless communication system. Due to its low noise ratio makes its one of the well suited communication medium for exchange of information. Currently laser commutation is adopted in satellite communication for space research activities and due to its efficiency on low noise ratio, inexpensive , low power and its flexibility and its resistance to the radio interferences makes laser communication as one of research area in wireless communication. In this process, this paper comprises the one such application of laser communication for information exchange between any two devices. Space communication, as employed in satellite-to satellite links, is traditionally performed using microwaves. For more than twenty five years, however, laser systems are being investigated as alternatives. One hopes that mass, power consumption, and size of an optical transceiver module will be smaller than that of a microwave transceiver. Also, fuel consumption for satellite attitude control when quickly re-directing antennas should be less for optical antennas. On the other hand, a new set of problems had to be addressed in connection with the extreme requirements for pointing, acquiring, and tracking the narrow-width laser beams. Laser communications systems are wireless connection through the atmosphere. Which is focused on decreasing the noise ratio in optical communication system? Laser communications systems work similarly to fiber optic links, except the beam is transmitted through free space. In Laser Communication the transmitter and receiver must require a line-of-sight conditions and Laser communications systems have the benefit of eliminating the need for broadcast rights and buried cables. Laser communications systems can be easily deployed since they are inexpensive, small, low power and do not require any radio interference studies. The carrier used for the transmission signal is typically generated by a laser diode. Two parallel beams are needed, one for transmission and one for reception. Laser

II. RELATED WORK

A scenario typical for the transmission system in question asks for point-to-point data transfer between two spacecraft (see Fig. 1). The distances to be bridged may extend anywhere from a few hundred kilometers to 70 000 km (e.g. in near-earth applications) up to millions of kilometers in case of signals transmitted by a space probe.4) Today the data rates in mind range from several hundred kbit/s to some 10 Gbit/s. Terminals for optical communication in space are mostly designed for bi-directional links, at least concerning the optical tracking function. They comprise both a transmitter and a receiver that generally share the optical antenna. Another peculiarity is the necessity of beam steering (or pointing) capability with sub-microradian angular resolution and possibly with an angular coverage exceeding a hemisphere. Related discussions have begun in the Consultative Committee for Space Data Systems (CCSDS). This paper presents current trends in free space laser communications, mainly based on the reports from GOLCE2010. The received radiation also passes the antenna and the fine pointing assembly, and is then directed to the receive part of the terminal with the aid of the duplexer. A beam splitter (BS) directs one part of the received beam to the data detector (DD) for demodulation and further signal processing in the data electronics unit (DE).

Difference to fiber system: While in fiber systems dispersion and non-linearity is a major concern, no such effects exist for the free space channel. Coupling the transmit signal into the channel - which is free space - requires an antenna, usually in the form of a telescope. Further, background radiation - e.g. caused by the Sun - may pose a problem, and, of course, no in-line amplifiers or regenerators can be implemented.

Switching techniques: These define the way and time of connections between input and output ports inside a switch. Various switching techniques are circuit switching, packet switching, cut-through switching and Wormhole switching. Circuit switching is advantageous when the messages are infrequent and long. Packet switching is used for short and frequent messages. It fully utilizes the communication link while circuit switching may keep the reserved path ideal for some time. If the laser operates continuously or in a pulsed mode producing a periodic pulse train, an external modulator (M) is utilized to impress the data signal onto the beam. Alternatively, internal modulation may be employed with some lasers. In Wormhole switching the message is divided into flits to decrease the buffer size at routers and to achieve much faster routers. The input and output buffers of a router are large enough to contain flits.

Data receiver

For space applications, good receiver sensitivity is an extremely valuable asset, not at least because no inline amplification is possible. It is often characterized by the minimum number of input photons per bit to achieve a bit error probability of 10-6. If other sources of noise than that due to the quantum nature of radiation are negligible, a direct detection receiver needs n = 6.6 photons/bit. As an example for a coherent receiver, a homodyne receiver with PSK modulation would require n = 5.6 photons/bit.

Pointing, acquisition, and tracking.

To establish an optical link in space, a sophisticated spatial pointing and acquisition procedure must be initiated. Information on the position of the two space terminals has to be available. Still, because of position uncertainty and incomplete knowledge of the spacecraft's orientation (attitude uncertainty), one terminal's beam width has to be widened deliberately as to illuminate the second terminal despite the uncertainty in position. A spatial search operation by the (narrow beam) receive path of the second, and subsequently, of the first terminal have to follow before acquisition is completed and switching to the tracking mode can occur. Wide-field of- view acquisition detectors in the form CCDs are most helpful. During data transmission, the angle between the line-of-sight and the transmit beam axis must be kept to within a fraction of the transmit beam width θ which may be as small as a few μrad. To maintain sufficient alignment of the transmit and receive antennas despite platform vibrations, both terminals have to be equipped with a tracking servo loop. Optical beacons have to be provided in both directions to render input information for the control loops. The data carrying beams themselves may serve as beacon, or separate optical beams may be implemented, e.g. in a one-way link. Tracking should ensure a misprinting of typically less than 1 μrad. Whenever the tracking loop signals optimum receive position, the transmitted beam (or beacon) will be correctly directed to the opposite terminal. This would require a perfect coaxial alignment for the optical transmit and receive path within each transceiver. However, some bias, or point ahead angle, has in general to be introduced into the alignment, as was discussed in Sect. To ensure short acquisition time and adequate tracking accuracy .

III. TRANSMITTING AND RECEIVING DATA

. Laser communications systems are wireless connection through the atmosphere. Laser communications systems work similarly to fiber optic links, except the beam is transmitted through free space. In Laser Communication the transmitter and receiver must require a line-of-sight conditions and Laser communications systems have the benefit of eliminating the need for broadcast rights and buried cables. Laser communications systems can be easily deployed since they are inexpensive, small, low power and do not require any radio interference studies. The carrier used for the transmission signal is typically generated by a laser diode. Two parallel beams are needed, one for transmission and one for reception. Laser communications plays a key role, as a solutions for satisfy ever increasing high demand of bandwidth. In Laser communications systems bandwidth could be distributed in neighborhoods by putting systems on top of homes and pointing them towards a common transceiver with a fast link to the Internet. It supports possible transmit speeds of up to a gigabit per second, Other applications of Laser communications systems technology include temporary connectivity needs (e.g. sporting events, disaster scenes, or conventions), or space based communications.

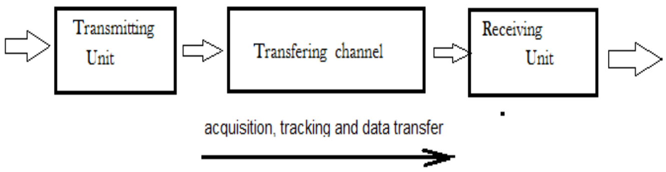

Fig 1 Block diagram of transmitting and receiving data

The delivery of packets passes through three stages: flitization, network delivery, and assembly. To achieve good network utilization and system throughput, flits should be admitted as fast as possible. However, the more flits admitted in the network, the higher contentions may occur, leading to performance degradation. Similarly, a slower ejection of flits will make the ejection become performance bottleneck. .An ideal ejection, which ejects flits immediately once they reach their destinations, may overdesign the switch.

IV. FSLC DESIGN FLOW:

An FPGA is a piece of hardware whose internal functional structure can be modified by its user in contrast with a microprocessor whose function is fixed. The FPGA can be reconfigured to perform different tasks by changing the contents of the memory cells. Because reconfiguration only involves loading new data into memory cells, it can be done quickly and an unlimited number of times. The design flow mechanism can be shown as follows:

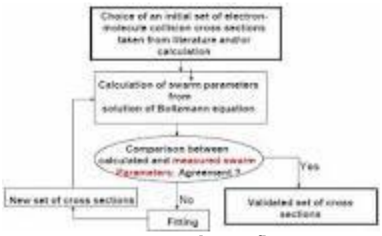

Fig 2 FSLC design flow

V. IMPLEMENTATION OF THE FSLC

The voltage variation on the solar panel is amplified by a low-voltage audio power amplifier LM386 and reproduced by a speaker. The maximum output of audio amplifier LM386 is 1 watt, while its voltage gain is 20 to 200. The circuit consists of a transmitter and a receiver. Both the transmitter and the receiver are built around IC LM386, powered by a 9V battery. Fig. 1 shows the transmitter circuit Here a laser diode (LD1) with maximum operating voltage of around 2.6V DC and maximum operating current of 45 mA is used to transmit the audio signal. The voltage divider network formed by R2, R3 and VR3 keeps the voltage as well as the current for the laser diode in the safe region. In place of the laser diode, you can also use a laser pointer. Remove the battery from the laser pointer. Extend two wires from terminals of LD1 and connect them to the battery terminals of laser pointer. The spring inside the laser pointer is the negative terminal. The output power of the laser pointer is 5 mW. Take care while working with laser, as direct exposure to the laser beam can be hazardous to your eyes. Point the laser beam to the solar panel. Potmeter VR1 (10-kilo-ohm) is used to change the level of the input audio signal. The audio input (Vin) is taken from the preamplifier output of the music system (CD player, DVD player, etc). Capacitor C2 and preset VR2 are used to vary the gain of the LM386. Fig. 2 shows the receiver circuit. The audio signal transmitted by the laser diode (LD1) is received by the calculator's solar panel and amplified by IC2. The gain of the amplifier is fixed by capacitor C7. Preset VR4 is used to change the signal level from the solar panel. This signal is fed to input pin 3 of IC2 through coupling capacitor C5 so that the DC value from the solar panel can be eliminated. The amplified output from IC2 is fed to the speaker, which plays the music from the CD player connected at the input (Vin) of IC1.

Assemble the transmitter and receiver circuits on separate PCBs and enclose in suitable cabinets. In the transmitter cabinet, fix two terminals for connecting the audio signal. Fix switch S1 on the front panel and the laser diode (LD1 or laser pointer) to the rear side of the cabinet. Keep the 9V battery inside the cabinet. In the receiver cabinet, fix the calculator's solar panel to the rear side such that the transmitted beam directly falls on it. Fix switch S2 on the front panel and the speaker to the rear side. Keep the 9V battery inside the cabinet. The above diagram shows the block diagram of Laser Communication System, which mainly comprise of 2 sections such as Transmitter section and Receiver section. Transmitter section is used to transmit the data and sound signals, which comprised by microphone, Conditioning ckt, analog to digital converter and laser diode to generate medium for transmission of signals. The receiver section is used to receive the laser beam, using photo transmitter, which incorporated with the data or sound signals from the transmitter comprised of Conditioning, MCR and Digital to Analog converter to extract the data signals from the received laser beam and given as a input to the speaker.

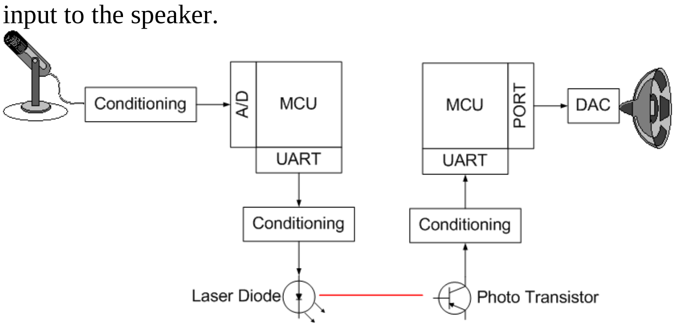

Fig 3 FSLC structure

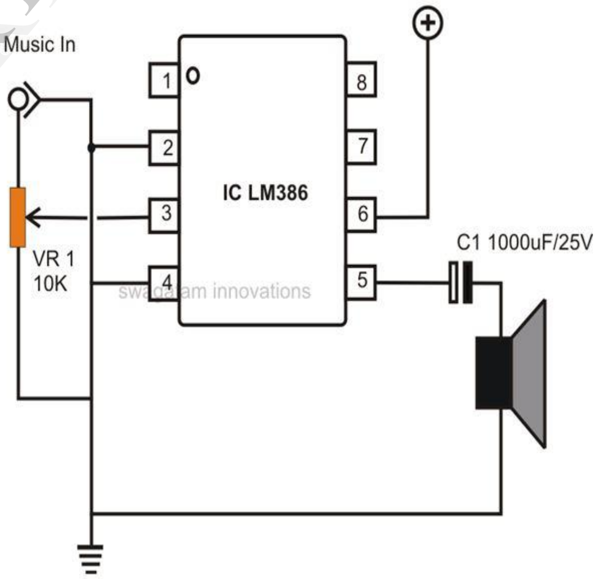

Figure 4 Block schematic of switch (Data word width: 8 bits and ports:2)

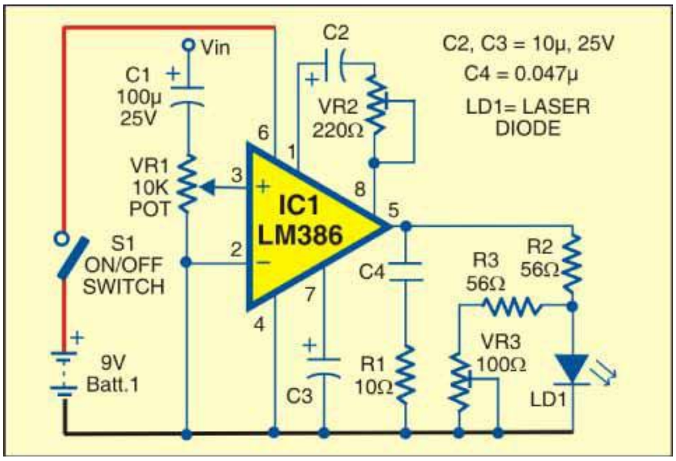

Figure 4 Transmitter schematic (Data word width: 8 bits and ports: 2)

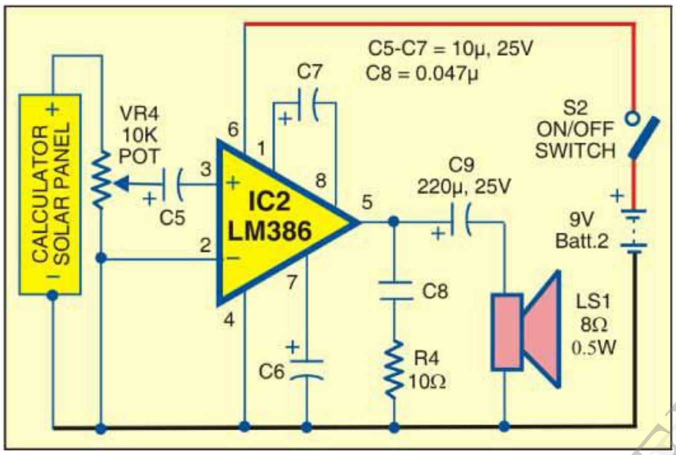

Figure 5 Receiver schematic (Data word width: 8 bits and ports: 2)

VI SIMULATION RESULTS

RESOURCE UTILIZATION

The resource utilization report generated after the design of the Switch is implemented on FSLC, for a fixed data word width (= 8 bits), but for different number of ports is illustrated in the figure below. The report indicates an increase in the resource utilization with an increase in number of ports. The same analysis is repeated for a data word width equal to 16 and 32 bits, with similar conclusion.

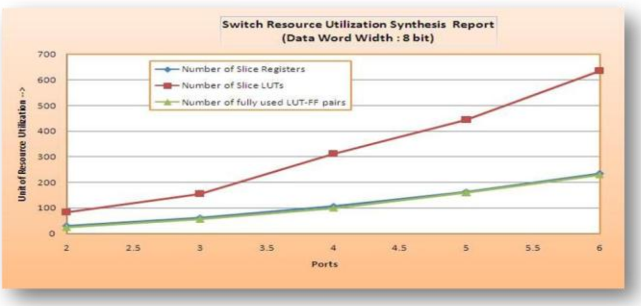

Fig 6 Switch resource utilization (Data Word Width: 8 bits)

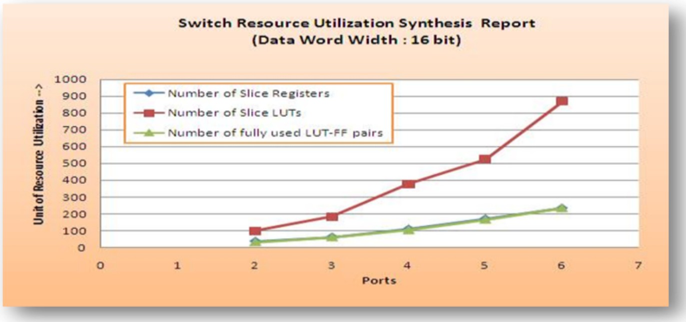

Fig 7 Switch resource utilization (Data Word Width: 16 bits)

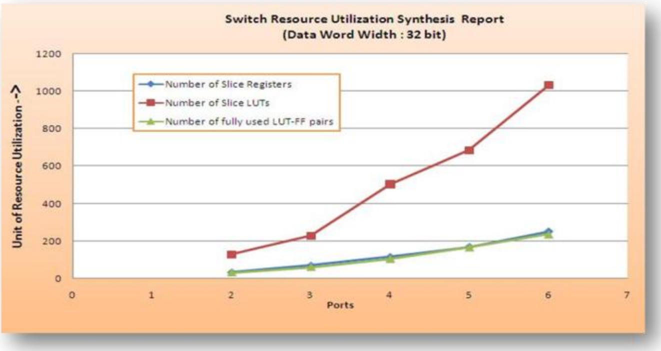

Fig 8 Switch resource utilization (Data Word Width: 32 bits)

Number of Slice Registers	149760
Number of Slice LUTs	149760
Number of fully used LUT-FF pairs	7,707

TABLE 1 TOTAL AVAILABLE RESOURCES

AREA ESTIMATION:

The following figure 9 illustrates the expected cell area for the Entrance module. The cell area increased as the number of ports is increased. The expected cell area of the Matrix module for a data word width of 8 bits shows an increase with the number of ports. A similar analysis is repeated for a data word width of 16 and 32 bits. The figure 4.1.3 indicates that for a constant number of ports, the expected area is higher for a higher data word width.

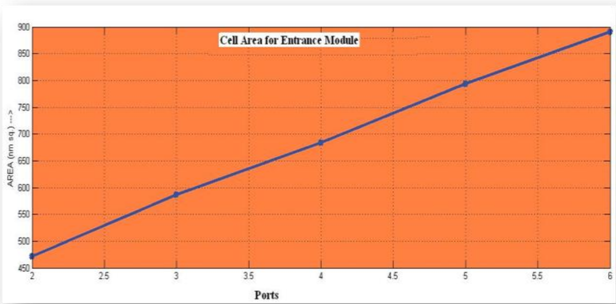

Fig 9 Area estimation for the Entrance module

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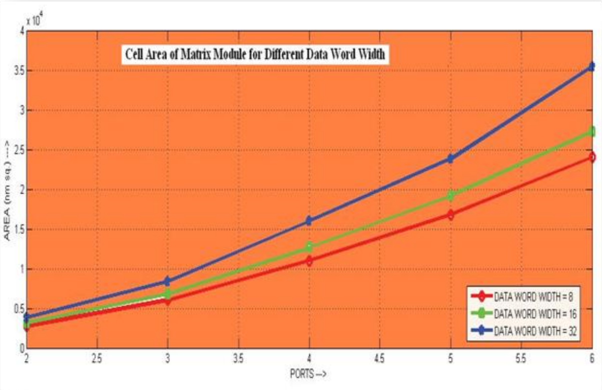

Fig 10 Cell area of Matrix module

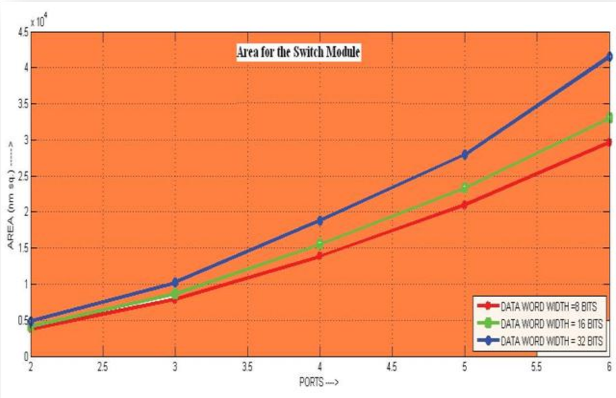

Fig 11 Cell area for Switch module.

POWER ESTIMATION

The Synthesis report for power estimation is generated for the different modules of switch. The results are illustrated in the figure 4.1.6. Similar inference can be deduced from the variation of dynamic power associated with different modules analyzed. The dynamic power increases with increase in the number of ports. Also, a higher power is expected for a higher data word width

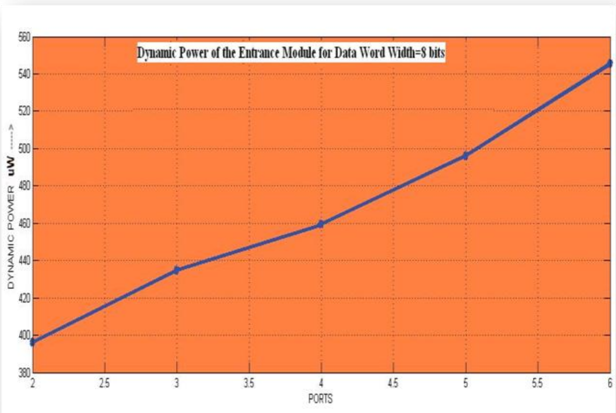

Fig 12 Power estimation of the different modules

VII CONCLUSION

This is new wireless technology to transmit the data or sound signal from one section to other section through the laser beam of the system. This system is safety and without radiation. so it is not harm to living beings. The system can likely transmit data and sound much faster than the other system (like 1GB/s). Because of this laser communication system became more popular system than the other system. The paper firstly analyzed the components of maritime laser communication system, the paper made some explanations on the components and functions of the servo system, Recent trends in research and development on space laser communications were introduced based on the reports of the international workshop on After the international collaborative campaign for common laser experiments using OICETS, space-to-ground laser propagation data acquired in each country were collected, and are expected to actively contribute toward building a free-space propagation model. These activities will also encourage standardization of the free-space optical link in stages such as CCSDS and ITU. In R&D trends, the US is mainly advancing projects for laser communications in deep space exploration. In Europe, there is active promotion of laser communications in data relay systems and a German LCT is scheduled to be mounted. Overall, full-fledged adoption of AO systems is becoming the trend and some organizations have begun system demonstration. Moreover, there are moves to employ laser communication systems for small satellites given the successful conducting of several laser communication demonstrations with LEO satellites in space. From here forward world trends in space laser communications R&D are sure to attract increasing attention.

VIII FUTURE WORK

Microwave systems have the ability to achieve a high link quality (error performance and availability) for distances of up to 100 km. Measurements on a 600 m first generation free space laser communications link carried out by Swiss Telecom in the area of Berne, showed a significant lower quality. The degradation effects can be categorized as follows:

- Propagation effects and
- Mechanical in sufficiency's.

The origin of the first category is quite obvious, e.g.: if heavy fog, snow or smoke blocks the line-of-sight between the units or the sun is interfering the laser beam. Unfortunately, there are not many countermeasures to improve the situation in such cases. The source for the second category can be found in the narrow optical beam. Therewith the link performance is sensitive to vibration, wind sway, and thermal expansion of the equipment. Last but not least it should be noted, that a microwave link designer has – within limits – the possibility to reduce the influence of the propagation effects and to optimize the desired link quality and its costs by choosing the frequency, antenna diameters, diversity protection, etc. A free space laser communication system has to be taken as it is.

performance constraints without buffer overrun for specific applications.

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