REVIEW ON DIFFERENT ATP TECHNIQUES FOR LASER COMMUNICATION

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Abstract - Higher data rate is core requirement of any communication system. Traditional RF communication link has limited supported data rate in terms of Mbps. Nowadays laser is used instead of RF carrier in communication. Laser communication provides high security, low weight, low power consumption and lesser size for system. Laser communication can be established for ground to satellite which is known as FSO and also satellite to satellite which is known as DSOC. In FSO and DSOC there are platform disturbances which can disturb Line of Sight. To maintain Line of Sight for high data rate communication an embedded system is used which is ATP system. If line of sight is not aligned properly between receiver and transmitter data rate get slower or diminishes completely. This paper contains survey of various ATP techniques for FSO and DSOC.

Index terms – Laser communication, FSO, DSOC, ATP.

I. INTRODUCTION - For space based communication, specifically downlink requires high data rate to send voluminous data like large data of remote sensing LEO satellites, high definitions images of planetary missions. Use of laser communication helps in obtaining high throughput links for such inter-satellite space based communication. FSO communication has unique features viz. large bandwidth, license free spectrum, high data rate, easy and quick deployability, less power and low mass requirements. FSO communication mostly uses optical carrier in the near infrared (IR) band to establish either terrestrial links within the Earth's atmosphere or inter-satellite/deep space links or ground-to satellite/satellite-to-ground links.[5] In remote sensing, radio astronomy, military, disaster recovery it is widely used. FSO provides high data rate of the order of Gbps. In FSO one limitation is stringent pointing requirements. To facilitate pointing, ATP sub-system is used which is responsible for acquisition, tracking & pointing of a target station/satellite.

1. Working of ATP subsystem - ATP subsystems objective is to acquire a target through coarse acquisition, track & pointing the target within certain pointing accuracies. ATP function is divided into mainly coarse tracking and fine tracking. Coarse tracking is completed in acquisition phase wherein the target is coarse acquired through known location information & corrected through gimbal or similar compensating mechanism. An acquisition detector which is usually a CCD sensor is used for obtaining angle of incidence information of target station/satellite. When target is captured, CCD computes the position offset (miss-distance between the target and the center of CCD) and servo controller receives the miss-distance transmitted by CCD which is turn drives the dual axis Gimbal. In this mode accuracy requirement is lower but FOV is wide and system has low operating bandwidth about to several Hz. Fine tracking, consists of tracking and pointing phase having high bandwidth usually from hundreds to thousands Hz, faster response, high tracking accuracy. It uses higher sensitivity PSD or QD to compute the miss-distance of gimbal and target in very small FOV & finer resolution. This high bandwidth fine error is compensated by FSM. [2]

CCD sensor - Charged Couple Device image sensor is used to capture image of target. It is basically converts photons into electrons. It is made up of arrays of p-doped metal-oxide-semiconductors (MOS) capacitors.

PSD/QD detector - It consists of four separate silicon photodiodes, or quadrants, arranged in a quadrant geometry. Its operation principle is based on conversion of optical energy into electrical energy. The photodiodes A, B, C, D convert incoming light into currents IA, IB, IC, ID, and then the currents are transformed into relative voltage levels VA, VB, VC, VD, by the operational amplifier circuits. If the center of beam falling on detector and center of detector is same then currents are generated are same, otherwise unequal so based on that offset is calculated [2].

Dual axis Gimbal - It is mechanical assembly with servo or stepper motors attached in both azimuth and elevation.

FSM - Fast steering mirror is reflective mirror which can move in both azimuth and elevation direction using magnetic field according to voltage applied on each direction.

II. CURRET TECHNIQUES OF ATP:-

As per current work there are several techniques which follow same ATP coarse and fine tracking but the implementation of the individual is different. Following are some techniques for ATP.

1. ATP subsystem for CUBESAT

CubeSat: is a type of miniaturized satellite for space research that is made up of multiples of 10*10*10 cm cubic units. Their mass is not more than 1.33Kgs per unit. CubeSats used for scientific and educational missions, particularly for developing countries, because of its relatively low cost and simplicity of delivering them into orbit. However, they have constraints like Swap (Small size, weight and power) [4].

1.1 Implementation of coarse tracking - Here coarse tracking is not part of optical tracking but it uses separate RF link for finding Object in wide range which is known as attitude determination and control subsystem (ADCS). By using this system it will locate dual axis gimbal in small FOV nearby target. For this system extra ADCS RF link is required.

1.2 Implementation of fine tracking - fine tracking implementation is same as with QD or PSD to find out miss-distance and then by driving FSM to cover this distance and lock the target.

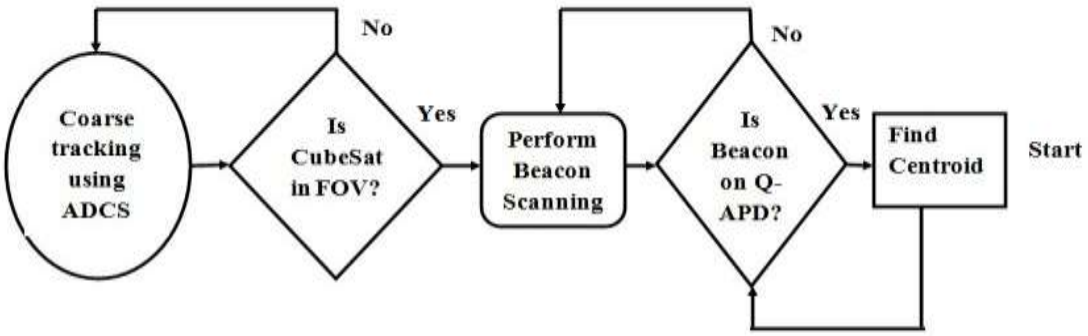

Figure 1.Flowchart of the sequence used for the ATP operation [4]

2. ATP subsystem without beacon beam for FSO - Without beacon system become smaller and power consumption reduced as well as size and weight also reduced [1].

2.1 Implementation of coarse tracking - It can be done with RF telemetry command or ADCS subsystem as given in CubeSat.

2.2 Implementation of fine tracking - Here optical signal itself is used for fine tracking with PSD or QD with FSM. Due to same signal used for communication and tracking it slow down time to establish link between transmitter and receiver.

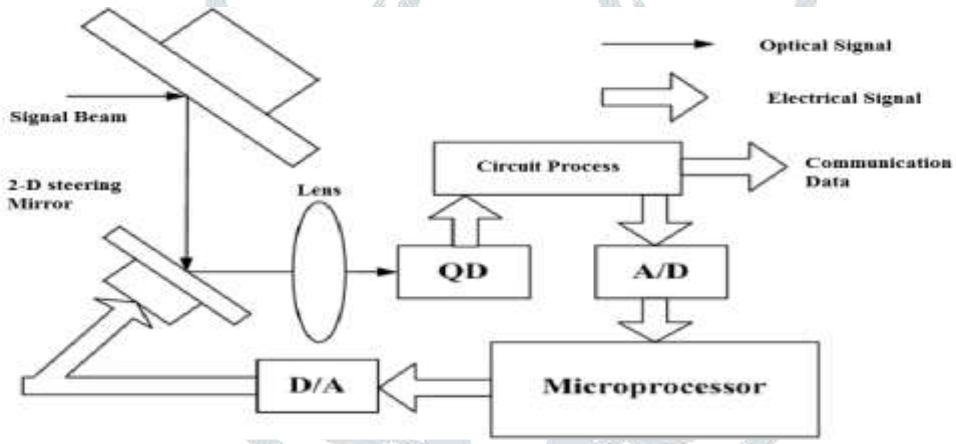

Figure 2. Block Diagram of Simultaneous Fine Tracking and Signal Detection System [1]

3. Active ATP subsystem for mobile terminal in telecommunication system - Here laser communication is used for telecommunication where mobile terminals are available for that proposal of beam control system is introduced [3].

3.1 Implementation of Active beam tracking - In this case special Galvanic scanner is used which consists of motor assembly and mirrors. A separate link is used to transmit transmission angle of transmitter' mirrors. At receiver end positioning QD detector will adjust as per given angles. So using beam control system continuously tracking possible for mobile terminal.

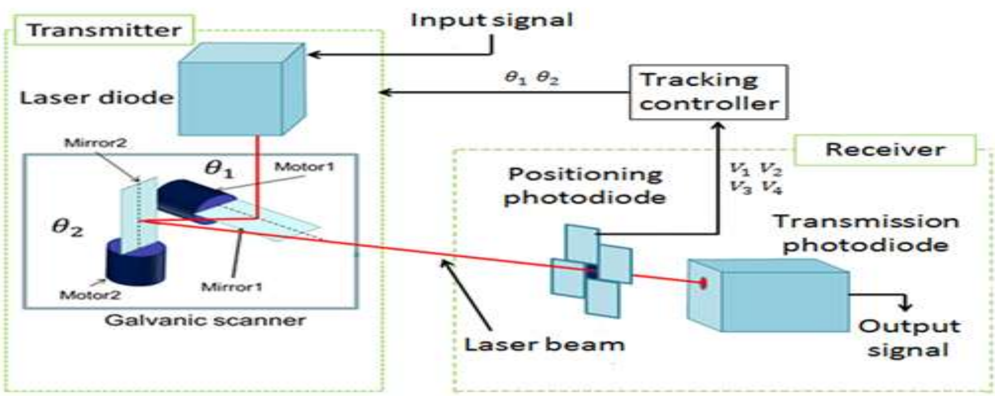

Figure 3. Active free space optics system [3]

4. Compound ATP subsystem for FSO - In this ATP technique both tracking mode works separately and individual detector is used. Here coarse tracking stage's error is corrected in fine racking stage. No extra RF link is used for assembly. It is fully optical carrier operated ATP subsystem [2]. This type of ATP subsystem has more size, weight and more power consumption with respect to other techniques.

4.1 Implementation of coarse tracking - Coarse tracking done with CCD detector and dual axis gimbal assembly with beacon beam.

4.2 Implementation of fine tracking - Fine tracking done with QD or PSD detector and FSM assembly with beacon beam.

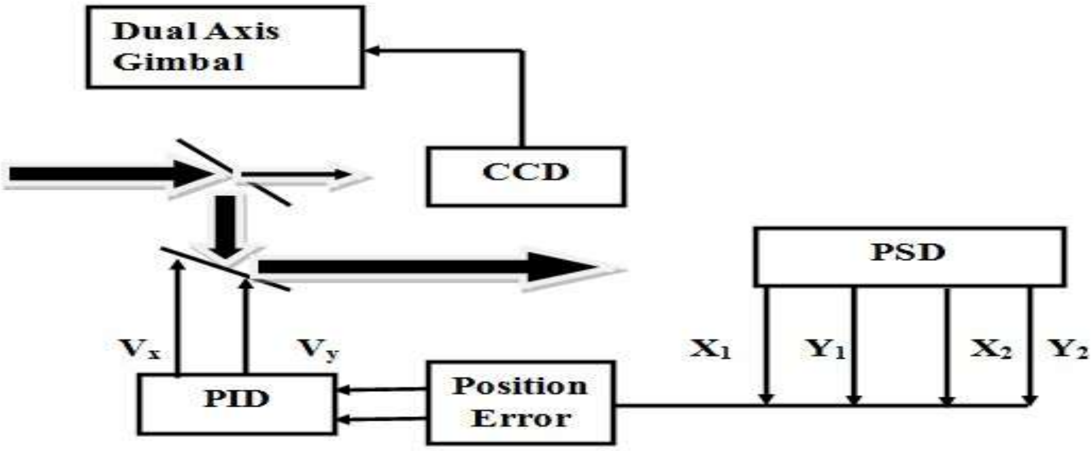

Figure 4. Compound tracking system [2]

III. CONCLUSION – In laser communication; to maintain line of sight is most important and critical task. Pointing inaccuracies is directly dependent on data throughput. On other end; for FSO SWaP constrains are there, so in order to meet real time scenario and physical parameters, proper ATP technique must be employed. Although in this paper various available techniques are shown but still single technique is not a solution for all laser communication system.

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