DOWNLOAD PDF SPACE OPTICS

Chapter 1 : About Space Optics / Space Optics / Space Engineering & Technology / Our Activities / ESA

At SORL, we are focused on producing optics to the highest levels of precision possible. After over a half-century in the optical industry, we remain the leader in producing high quality aspheric optical systems and instrumentation for a wide range of research and test applications.

A technology that can be installed license-free worldwide, and can be installed in less than a day. A technology that offers a fast, high ROI. That technology is free-space optics FSO. This line-of-sight technology approach uses invisible beams of light to provide optical bandwidth connections. It enables optical communications at the speed of light. And it forms the basis of a new category of products â€" optical wireless products from LightPointe, the recognized leader in outdoor wireless bridging communications. This site is intended to provide valuable background and resource information on FSO technology. And for providing high-speed connections, across Enterprises and between cell-site towers, it is the best technology available. FSO is a line-of-sight technology that uses invisible beams of light to provide optical bandwidth connections that can send and receive voice, video, and data information. FSO technology requires light. The use of light is a simple concept similar to optical transmissions using fiber-optic cables; the only difference is the medium. Light travels through air faster than it does through glass, so it is fair to classify FSO technology as optical communications at the speed of light. History Originally developed by the military and NASA, FSO has been used for more than three decades in various forms to provide fast communication links in remote locations. LightPointe has extensive experience in this area: FSO technology enables bandwidth transmission capabilities that are similar to fiber optics, using similar optical transmitters and receivers and even enabling WDM-like technologies to operate through free space. Read more on the ultra high-speed multi-gigabit wireless laser. How it Works FSO technology is surprisingly simple. Each optical wireless unit uses an optical source, plus a lens or telescope that transmits light through the atmosphere to another lens receiving the information. At this point, the receiving lens or telescope connects to a high-sensitivity receiver via optical fiber. This FSO technology approach has a number of advantages: Requires no RF spectrum licensing. Is easily upgradeable, and its open interfaces support equipment from a variety of vendors, which helps enterprises and service providers protect their investment in embedded telecommunications infrastructures. Requires no security software upgrades. Is immune to radio frequency interference or saturation. Can be deployed behind windows, eliminating the need for costly rooftop rights. Optical or Radio Frequency Wireless? Speed of fiber â€" flexibility of wireless Optical wireless, based on FSO-technology, is an outdoor wireless product category that provides the speed of fiber, with the flexibility of wireless. It enables optical transmission at speeds of up to 1. This is not possible with any fixed wireless or RF technology. Optical wireless also eliminates the need to buy expensive spectrum it requires no FCC or municipal license approvals worldwide , which further distinguishes it from fixed wireless technologies. Challenges with first generation nm FSO bridges as opposed to new nm LightPointe wireless bridges While fiber-optic cable and FSO technology share many of the same attributes, they face different challenges due to the way they transmit information. While fiber is subject to outside disturbances from wayward construction backhoes, gnawing rodents, and even sharks when deployed under sea, FSO technology is subject to its own potential outside disturbances. Optical wireless networks based on FSO technology must be designed to combat changes in the atmosphere, which can affect FSO system performance capacity. And because FSO is a line-of-sight technology, the interconnecting points must be free from physical obstruction and able to "see" each other. All potential disturbances can be addressed through thorough and appropriate network design and planning. Among the issues to be considered when deploying FSO-based optical wireless systems: The primary challenge to FSO-based communications is dense fog. Rain and snow have little effect on FSO technology, but fog is different. Fog is vapor composed of water droplets, which are only a few hundred microns in diameter but can modify light characteristics or completely hinder the passage of light through a combination of absorption, scattering, and reflection. The primary answer to counter fog when deploying FSO-based optical wireless products is through a network design that shortens FSO link distances and adds network redundancies. FSO installations in extremely foggy cities such as San Francisco have successfully achieved carrier-class reliability. Absorption occurs when suspended water molecules in the terrestrial atmosphere extinguish photons. This causes a decrease in the power density attenuation of the FSO beam and directly affects the availability of a system. Absorption occurs more readily at some wavelengths than others. However, the use of appropriate power, based on atmospheric conditions, and use of spatial diversity multiple beams within an FSO-based unit helps maintain the required level of network availability. Scattering is caused when the wavelength collides with the scatterer. The physical size of the scatterer determines the type of scattering. When the scatterer is smaller than the wavelength, this is known as Rayleigh scattering. When the scatterer is of comparable size to the wavelength, this is known as Mie scattering. When the scatterer is much larger than the wavelength, this is known as non-selective scattering. In scattering â€" unlike absorption â€" there is no loss of energy, only a directional redistribution of energy that may have significant reduction in beam intensity for longer distances. Flying birds or construction cranes can temporarily block a single-beam FSO system, but this tends to cause only short interruptions, and transmissions are easily and automatically resumed. The movement of buildings can upset receiver and transmitter alignment. When combined with tracking, multiple beam FSO-based systems provide even greater performance and enhanced installation simplicity. Heated air rising from the earth or man-made devices such as heating ducts create temperature variations among different air pockets. This can cause fluctuations in signal amplitude which leads to "image dancing" at the FSO-based receiver end. Called "Refractive turbulence," this causes two primary effects on optical beams. Beam wander is caused by turbulent eddies that are larger than the beam. Beam spreading â€" long-term and short-term â€" is the spread of an optical beam as it propagates through the atmosphere. To those unfamiliar with FSO technology, safety can be a concern because the technology uses lasers for transmission. The proper use and safety of lasers have been discussed since FSO devices first appeared in laboratories more than three decades ago. The two major concerns involve eye exposure to light beams and high voltages within the light systems and their power supplies.

Chapter 2 : Free-space optical communication - Wikipedia

An uncorrected copy, or prepublication, is an uncorrected proof of the book. We publish prepublications to facilitate timely access to the committee's findings.

How to cite the article ; suggest additional literature Optical data transmission on Earth is in most cases done via optical fibers , because these allow the transmission over relatively large distances without excessive power losses, alignment issues, and disturbing influences of the atmosphere. However, it is also possible to transmit data optically via free space or similarly, through water , not exploiting any kind of waveguide structure. This kind of optical communications has early origins, e. Usually, it requires an unobstructed line of sight between sender and receiver, and normally also some special free-space optics such as telescopes. The light source used is nowadays virtually always some kind of laser possibly combined with an amplifier , because the high directionality of a laser beam is obviously a vital ingredient for high-performance communications. The prominent role of a laser is emphasized by the term laser communications. Transmission Issues Particularly for large transmission distances, it is essential to direct the energy of the sender accurately in the form of a well- collimated laser beam in order to limit the often still very large loss of power between the sender and the receiver. In order to limit the beam divergence , it is necessary to arrange for a large beam radius from an optical source with high beam quality. Ideally, one uses a diffraction-limited source and a large high-quality optical telescope for collimating a large beam. Due to the short wavelength of light, the beam divergence of an optical transmitter can be much smaller than that of a radio or microwave source of similar size. Simple setup for free-space optical communications. Although the transmitter signal is approximately collimated , part of the transmitted power may miss the detector. It is also advantageous to have a high directionality on the side of the receiver: Both high sensitivity and high directionality can be achieved by using a large telescope at the receiver end. Of course, high directionality also requires high precision in the alignment of the sender and receiver. It may then be necessary to stabilize the alignment with an automatic feedback system. For ground-based receivers of signals from remote satellites see below , it is considered to use adaptive optics to increase the directionality further by reducing the influence of atmospheric disturbances. The remaining power at the receiver largely determines the possible data transmission rate, even though this is also influenced by the modulation format, the acceptable bit error rate , and various noise sources, in particular laser noise , amplifier noise , excess noise in the receiver e. The latter can often be efficiently suppressed with additional narrow-band optical filters , since the optical bandwidth of the signal is fairly limited, whereas background light is usually very broadband. Severe challenges can arise from the effects of atmospheric disturbances such as clouds, dust and fog, which can cause not only strong signal attenuation but also intersymbol interference. To solve this problem, sophisticated techniques of digital signal processing have been developed, which amazingly allow for reliable high-capacity optical links even through thick clouds. Space Applications Some space applications require large amount of data to be transferred. An examples is the transmission between different Earth-orbiting satellites inter-satellite communications , which was first demonstrated by ESA in ESA. It is possible to transmit tens of megabits per second or more over many thousands of kilometers, using moderate laser average powers of the order of a few watts. Data can also be exchanged between a more remote spacecraft and a station on or near Earth. For example, planetary probes can generate a lot of image data, and a major challenge is to send large amount of data back to Earth. Until recently, radio links operating e. Currently, optical data links are considered particularly for the downlink, where the desired data volumes are much larger than for the uplink, and optical communications could greatly expand the transmission capacity to hundreds of kbit or even several megabits per second. The spacecraft then has a pulsed laser source employing pulse position modulation, for example and an optical telescope of moderate size targeting the receiver. The latter can be a large ground-based telescope or a transceiver in an Earth orbit. The basic advantage of optical technology over radio links is that the much shorter wavelength allows for a much more directional sending and receiving of information, resulting in much lower power requirements and higher data rates. In technical terms, the antenna gain can be much higher. This is particularly important for bridging interplanetary distances. On the other hand, optical links are more sensitive to weather conditions. Short-range Free-space Optical Data Links Technologically much less challenging are data links between metropolitan buildings LAN-to-LAN connections , where a free-space laser data link over distances of hundreds of meters or even over a few kilometers can be much simpler and more cost-effective to install than any kind of cable, particularly if a road or some other kind of barrier has to be crossed, or if a connection is required for only a limited time. It is then possible e. The laser powers required are very moderate, as a significant fraction of the sent power can hit the receiver e. Therefore, there are usually no significant laser safety issues, particularly if eye-safe lasers emitting in the 1. However, the availability of services is smaller than with a cable, because the link may be disturbed either by atmospheric influences e. In this respect, free-space transmission is less robust than other wireless technologies such as radio links, but it has a higher potential for transmission capacity, is immune against electromagnetic interference, and does not raise concerns in the context of electro-smog. Also, it does not lead to interference between different data links, so it does not need a license to be operated, and it is superior in terms of data security, since it is more difficult to intercept a tightly collimated laser beam than a radio link. Finally, the reliability can be enhanced in various ways, e. For not too long distances e. It is even possible to establish short-range optical data connections without a direct line of sight. When ultraviolet light is used, this is strongly scattered in the atmosphere, and it is possible to receive some of that light. That technology has become more interesting with the advent of light-emitting diodes LEDs emitting in the deep UV UV-C , and also of suitable semiconductor photodetectors. Essential advantages of laser data links over radio frequency RF or microwave links are the possible high data rate, low power requirements, compact size and lower probability of signal interception by unauthorized parties. Also, there is no need for governmental frequency assignment and no risk of mutual interference of different laser data links. These lasers are available with IR eye-safe wavelengths and with different output powers.

Chapter 3 : Optical space - Wikipedia

Free space optics technology (abbreviated as FSO), also referred to as open-air photonics or optical wireless or infrared broadband, transmits data from point-to-point and multipoint using low-powered infrared lasers. Unlike traditional copper wires or fiber-optic technology, which transmits data by.

They will learn how to use the software, building lens systems and performing the performance analysis of the optical design. An introduction to lens system optimization and tolerance analysis will be given. The course is including both the theoretical part as well as practical implementation in the software. The participants will have the possibility to analyze and optimize all the examples of the course on their own laptop. Application Engineer, LightTec Lecturing: He is there responsible for the technical support of CodeV customers, the organization of Information days and trainings, the customer training, pre-sale support and the representation of the company at exhibitions. Glass, metal and ceramic will be addressed. Grinding-lapping-polishing is the main subject but other techniques like replication, single point diamond turning and material deposition technique will also be addressed. During more than three decades he contributed to most of the space projects at REOSC either as lens designer, manufacturing and testing engineer, program manager, sales manager and plant director. Today he focuses on business development. His main task is to explore new business opportunities for REOSC and act as expert in lens design, manufacturing and testing. Current research is on freeform optics for astronomy and space. This is of interest in particular in harsh environments, such as aviation and space, but also vacuum science and high power laser machining. Packaging of optical systems poses various challenges - different materials have to be joined together, components and their optical performance are stress and alignment sensitive, heat from active sources and conversion materials needs to be dissipated, and steep temperature gradients causing thermomechanical stress can occur. Well designed and optimized packaging and bonding technologies address these needs. The talk will focus on bonding techniques for metallic and non-metallic, amorphous and crystalline materials, emphasizing on the development and application chain from bonding geometry design, optimization by simulation of stress and the resulting birefringent or laser-optical performance, and practical issues of processing and equipment when applying different bonding technologies. Specific technologies to be discussed are gluing, soft soldering by means of laser reflow, hydrophilic bonding and plasma assisted bonding as well as two-photon absorption based laser welding. The basics as well as design and parametrization of these techniques will be discussed, followed up by boundary conditions and restrictions. Examples will demonstrate the application of the different technologies in reality. Amongst them is the green laser for the Raman experiment of the upcoming ExoMars Mission, a nanosecond fiber laser for a space LIDAR and an entangled photon source for a satellite quantum payload. Optics Packaging Technologies for Harsh Environment Erik Beckerts works in the field of micro assembly, system integration and packaging of micro- and laser-optical systems for more than 15 years now. His experience covers components and systems such as the green laser for the EXOMARS Raman-experiment, a space-suitable entangled photon source as well as many technology studies for lens and laser bench mounting technologies. We will then detail a methodology for design and review some examples of freeform optics from design to manufacture. Since, my interest in optical instrumentation has spanned a wide range of applications with a focus on head-worn display for the consumer market, microscopy, and space optics. In , as a faculty at the University of Rochester, NY I led the launch of the National Science Foundation NSF Center for Freeform Optics CeFO headquartered in Rochester, NY, targeted at advancing the science and engineering of freeform optics across a wide range of applications, including space optics, in partnership with industry and government www. Today my main research activities lie in optical system design and metrology of freeform optics. Design intent should be captured in the specification of the optic, for example in a drawing that is in accordance with ISO We will discuss freeform optics specifications that flow down to measurands that can be estimated en route to establishing that a specific optical surface meets the design intent. Does the designer have a specific manufacturing process in mind? Can this be captured in the surface specification -- and should it be? We will review the range of optics metrology methods available and discuss tools for rational comparison between available options. We will review commercially available technologies and emerging methods. Metrology for Freeform Optics cv present: Engineer, Group Leader, National Institute of Standards and Technology Lithographic Grating Technology - Uwe Zeitner Gratings are key components in space-borne spectrometers for earth observation and scientific missions. Their optical properties determine the achievable spectral resolution and signal quality of the instrument. Based on the specific requirements of contemporary spectrometers an overview of state-of-the-art fabrication technologies for the required high-end optical gratings will be given. This includes methods like ruling, holography, and direct write lithographic structuring. Their potential and limitations for the realization of a desired grating profile and related properties like high polarization independent diffraction efficiencies, good wave-front qualities, and low stray-light levels will be discussed. Lithographic Grating Technology cv Worked at the Friedrich-Schiller-University Jena, Germany, in the field of fabrication of micro-optical elements and systems by e-beam lithography and resonator internal laser beam shaping. Rules of thumb for the general coating design are discussed and a brief excurse in theory and praxis of thin-film optical coatings in general will be provided. Emphasis will be put on the state-of â€"the-art manufacturing technology for the manufacturing of hard optical coatings, especially the sputtering technology and the ion-assisted deposition technology. Additional necessary technology for the on-line monitoring of coating layer thickness will be reviewed. A third major point is related to coating qualification for space applications. Typical qualification requirements and lessons learned from space projects will be reported. Scramblers from the class of spatial pseudo-depolarizers are compact, passive components with high performance that are well suited for space applications. They have or are currently been built for several spectro-imagers to make the measurements insensitive to polarization: In this course we will present their design, performance, manufacturing and testing. The Dual Babinet [1] is the most important design and will be assumed for the general discussion. Other types such as the HV depolarizer, the Meris scrambler, the plane-parallel scrambler and a few recent patents will be also presented. McGuire, Analysis of spatial pseudodepolarizers in imaging systems, Opt. Optical designer at TNO, working on designs with freeform mirrors, pushbroom spectrometers and polarization optics Lecturing: Polarization Scrambler â€" Concepts, Optical Design, Manufacturability and Performances cv He worked 9 years at the European Space Agency as consultant and optical performance engineer on instruments for future Earth observation missions. At ESA he also followed and contributed to breadboarding activities on polarization scramblers, slit homogenizers, characterization and modelling of speckles from calibration diffusers. It is therefore very important to predict and measure stray light performance of the optical instrument accurately. This lecture is focusing on light scattering of mechanical surfaces and of diffusers. Special emphasis will be put on how to measure and model optically rough surface scatter. A second part will focus on the minimization of mechanical surface scatter by "black"coatings and a review of achievable performances. Physics, Optical Engineer Position: STOP analysis is the tool used to verify compliance with the tight image quality budgets of the focal plane instruments. Structural-Thermal-Optical Performance STOP Analysis of the Euclid Space Telescope cv Since he works at Thales Alenia Space formerly Alenia Spazio as optical analyst and engineer for a wide range of applications, including laser metrology systems and interferometers, X-ray telescopes, optical communication, quantum sensors. Software Engineer for movement and technology control for 3D cutting laser machines â€" Astronomical Observatory of Turin. Research in the field of non-linear optical propagation and self-collimation in photorefractive crystals. The method described and practiced in the lecture is based on the fact that any alignment activity shifting and tilting of optical elements influences only the low order aberrations of the optical system. Based on analysis of the as-built model of the telescope and probing of the pre-aligned telescope optics sensitivities of low order WFE contributions to all optical alignment Degree Of Freedoms can be evaluated. Based on these sensitivities the next step of alignment improvement can be calculated, executed and verified. Recursive application of these technique converges to a perfect optical alignment after two or three iterations. For Korsch type telescopes including Three Mirror Anastigmats TMA the typical aberration and aberration sensitivities field gradients are discussed and their utilisation for the alignment is described and practiced. Design, technology and characterization of detectors and the relevant topics will be discussed. Such lens type might be part of the payload for planetary exploration. The participants will work in groups of two. For the design the participants can make use of the optical software CodeV, for which a 1-day introduction is given in the Begin of the course. For the hardware implementation three stock lenses from Edmund Optics and structural material will be provided. The lens performances in MTF and telecentricity shall be verified by test. In his position in the TEC Directorate he supports projects regarding optical design, straylight, manufacturing of optics and testing. Course academic programme manager Lecturing: Hands-on application worked 23 years at the European Space Agency in the Optics section as optical engineer. During his career he was responsible for technology developments on telescopes, spectrometers and lightweight ceramic mirror materials. Further on he was supporting the following optical flight instruments: The registration for the course is closed. Accreditation For those students that request the accreditation of credits from the European Credit Transfer and Accumulation System ECTS for their course attendance the course will offer a written test at the end of the course. The evaluation of the test, together with the evaluation of the hands-on activity, will output a "positive" or "negative" mark, which will be documented by the course certificate and an additional document stating the successful passing of the examen. The Faculty of Electronic Engineering of the University of Cagliari, Italy has already formally approved that 4 ECTS will be recognised to their students by participating at the course and passing the final exam University record no. Sponsor The event is sponsored by the companies represented below by their logo.

Chapter 4 : Free Space Optics Market|Communication Technology|Industry Analysis|Forecast

Free Space Optics (FSO) is a technology that uses laser beams via a line of sight optical bandwidth connection to transfer data, video or voice communications across.

These robust systems, which establish communication links by transmitting laser beams directly through the atmosphere, have matured to the point that mass-produced models are now available. Optical wireless systems offer many features, principal among them being low start-up and operational costs, rapid deployment, and high fiber-like bandwidths. These systems are compatible with a wide range of applications and markets, and they are sufficiently flexible as to be easily implemented using a variety of different architectures. Because of these features, market projections indicate healthy growth for optical wireless sales. Although simple to deploy, optical wireless transceivers are sophisticated devices. The many sub-systems require a multi-faceted approach to system engineering that balances the variables to produce the optimum mix. A working knowledge of the issues faced by an optical wireless system engineer provides a foundation for understanding the differences between the various systems available. This paper aims to examine the many elements considered by the system engineer when designing a product so that the buyer can ask those same questions about the systems they are evaluating for purchase. Currently available Free Space Optics FSO hardware can be classified into two categories depending on the operating wavelength â€" systems that operate near nm and those that operate near nm. There are compelling reasons for selecting nm Free Space Optics FSO systems due to laser eye safety, reduced solar background radiation, and compatibility with existing technology infrastructure. Eye-Safety Laser beams with wavelengths in the range of to nm emit light that passes through the cornea and lens and is focused onto a tiny spot on the retina while wavelengths above nm are absorbed by the cornea and lens, and do not focus onto the retina, as illustrated in Figure 1. It is possible to design eye-safe laser transmitters at both the nm and nm wavelengths but the allowable safe laser power is about fifty times higher at nm. This factor of fifty is important as it provides up to 17 dB additional margin, allowing the system to propagate over longer distances, through heavier attenuation, and to support higher data rates. Atmospheric Attenuation Carrier-class Free Space Optics FSO systems must be designed to accommodate heavy atmospheric attenuation, particularly by fog. Although longer wavelengths are favored in haze and light fog, under conditions of very low visibility this long-wavelength advantage does not apply. However, the fact that nm-based systems are allowed to transmit up to 50 times more eye-safe power will translate into superior penetration of fog or any other atmospheric attenuator. Receiver There are a number of factors to consider when examining the effectiveness of the receiver in an FSO system; these include the type of detector used, the sensitivity rating and size of the detector, the size and design of the receiver optics, and the operating wavelength itself. In order to correctly assess the efficiency of the overall system, one must also take into account the number and power of the lasers being used to generate the signal. Types of optical detectors used in FSO equipment come in two flavors: The PIN detector is a lower cost detector that has no internal gain, while the APD is a more expensive but also more sensitive detector with internal gain. Although at first glance it would seem that systems using APD detectors should have a performance advantage; however, the performance of a system must also take into consideration the transmit characteristics. Thus, the SONAbeam is a much more powerful system, which allows it to outperform other products at the same distance, under the same weather conditions. The size of the receiver optics is also important; a larger area receive optic contributes to reducing errors due to scintallation. Scintillation is atmospheric turbulence due to solar loading and natural convection, causing temporally and spatially varying refractive index changes in the air. This is quite similar to the apparent twinkling of the stars or distant city lights, which is due to the same effect. The result is that an FSO communications receiver can experience error bursts due to surges and fades in the receive signal strength. One way to combat this scintillation effect, and thus improve the error-rate performance, is to use a large aperture receiver. A collecting aperture that is much larger than the spatial scale of the scintillation provides an averaging effect of the localized surges and fades, thus improving the error rate. This large-aperture approach is more effective for scintillation reduction than multiple smaller apertures, which perform less averaging at each lens. Another way to mitigate the effects of scintillation is to use multiple transmitters, each of which takes a slightly different path through the atmosphere, which also contributes an averaging effect. The net result is that a properly designed system can defeat scintillation impairments. The operating wavelength of an FSO system also contributes to the performance of the receiver. It is generally true that high-quality photodiodes at both nm and nm achieve comparable quantum efficiencies. However, longer wavelengths enjoy an advantage in the receiver due to their lower photon energies. Specifically, a nm photon has half the energy of a nm photon. Consequently, for the same total energy i. Watts of power , a beam of nm light has twice the number of photons as a beam of nm light. This results in twice the photoelectrons photocurrent from the receiver photodiode. Hence, nm has a fundamental 3 dB advantage over nm in receiver sensitivity. Commercial Infrastructure nm wavelength range is the most commonly specified for terrestrial fiber-based optical communications and consequently the supporting infrastructure for this wavelength such as a wide selection of passive components, lasers, modulators, practical optical amplifiers, and receiver photodetectors is vast and growing. Narrow transmitting beamwidth a. Much narrower beams can be achieved with an actively pointed system, which includes an angle tracker and fast steering mirror or gimbal. Ideally the angle tracker operates on the communication beam, so no separate tracking beacon is required. Larger receiving optics captures a larger fraction of the total transmitted power, up to terminal cost, volume and weight limitations. And high receiver sensitivity can be achieved by using small, low-capacitance photodetectors, circuitry which compensates for detector capacitance, or using detectors with internal gain mechanisms, such as APDs. APD receivers can provide dB improvement over PIN detectors, albeit with increased parts cost and a more complex high voltage bias circuit. These four parameters allow links to travel over longer distance, penetrate lower visibility fog, or both. Poorly designed Free Space Optics FSO receivers may have a constant background error rate due to scintillation, rather than perfect zero error performance. Another element of Free Space Optics FSO system design that must be considered by a prudent buyer is the challenge of maintaining sufficiently accurate pointing stability. A number of Free Space Optics FSO systems employ an active pointing-stabilization approach, which represents an effective approach for addressing this challenge. However, the cost, complexity, and reliability issues associated with active-pointing approach can be avoided in some applications particularly for shorter ranges and lower data rates by utilizing the fixed-pointed approach schematically shown in the figure. According to this approach, the transmitted beam is broadened significantly beyond its near-perfect minimum beam divergence angle, and the receiver field of view is broadened to a comparable extent. Well engineered hardware exploits this approach of designing for loose alignment tolerances. Therefore, it is possible to perform initial alignment of the transceivers at opposite ends of the link during installation and then leave them unattended for many years of reliable service. Of primary importance to prospective buyers will be selecting the right system for the situation. Network Protocol â€” Transparent or Managed? For carriers today the issue of interoperability of systems within their multi-faceted networks made up of both legacy and next generation networks is crucial. Most Free Space Optics FSO systems currently available are physical layer devices that act the same way as fiber optic cables and receivers and are therefore able to work with all protocols while not being limited to any of them. Should a carrier wish to add such switching functionality to networks incorporating physical layer products there are many switches available on the market, all of which will interoperate with a physical layer device. Reliability â€” Built to Last? Every buyer wants to know the expected failure rate of the equipment they are investing in, for outdoor or industrial applications the ruggedness of a system becomes even more important. A system can be engineered and designed for exceptional reliability. Engineering a product for long-life includes selecting top-quality, long-life components from reliable vendors. Telecom grade components are preferred, as are low-stress electronics. The system must also be designed to maintain an optimum operating environment for the selected components and sub-systems. A rugged, environmentally-sealed housing is the first defense of a system against the elements. Appropriate heating and cooling mechanisms should be also in place in order to maintain optimum temperature and humidity within the device. In addition, a system design that incorporates a mechanism for reducing laser power during clear weather will extend the life of the laser drivers and the product itself. Active cooling of each laser will further enhance the lifespan of these relatively expensive sub-systems. If these considerations are taken into account, the system should have an impressive MTBF mean time before failure.

Chapter 5 : What is free space optics? Webopedia Definition

An optical system consisting of three imaging mirrors and a plane-scanning mirror along with the mechanical components must be able to cope with the extremely high stress in space and meet the highest accuracy requirements.

The Ancient Greeks used a coded alphabetic system of signalling with torches developed by Cleoxenus, Democleitus and Polybius. Bell considered it his most important invention. The device allowed for the transmission of sound on a beam of light. Optical telephone communications were tested at the end of the war, but not introduced at troop level. Military organizations were particularly interested and boosted their development. However the technology lost market momentum when the installation of optical fiber networks for civilian uses was at its peak. Many simple and inexpensive consumer remote controls use low-speed communication using infrared IR light. This is known as consumer IR technologies. Usage and technologies[edit] Free-space point-to-point optical links can be implemented using infrared laser light, although low-data-rate communication over short distances is possible using LEDs. Infrared Data Association IrDA technology is a very simple form of free-space optical communications. On the communications side the FSO technology is considered as a part of the optical wireless communications applications. Free-space optics can be used for communications between spacecraft. Consistently, studies find too many dropped packets and signal errors over small ranges to meters. This is from both independent studies, such as in the Czech republic, [10] as well as formal internal nationwide studies, such as one conducted by MRV FSO staff. Fog consistently keeps FSO laser links over meters from achieving a year-round bit error rate of 1 per , Several entities are continually attempting to overcome these key disadvantages to FSO communications and field a system with a better quality of service. As of October [update] , none have fielded a working system that addresses the most common atmospheric events. All four failed to deliver products that would meet telecommunications quality and distance standards: No known spin-off or purchase followed this effort. There is no indication this product is currently commercially available.

Chapter 6 : Free Space Optics Market Set to Encounter Paramount Growth with Myriad Advances - Newsie

Safran designs, develops, manufactures and integrates a complete range of high-performance optics and high-precision opto-mechanical equipment for satellites, large telescopes and high-energy lasers. Thus, throught its company Safran Reosc, Safran is nÂ°1 worldwide in high-performance space optics.

Edit To understand how a FSO link is created lets first create a dual mode optical link between two generic CAT-5 copper based Ethernet switches using fiber. FSO link should be seen as a dual mode fiber converter, but instead of using a fiber cable the free air a medium is used. Ethernet standard specifies three different voltage levels output at the PHY layer. See OpticPosts and OpticalManufacturers. Get hold of a http: Will be releasing first shematics in a day or two. Free space optics Edit Url of this page: The Ronja has range of 1. With a loupes of 11cm on Tx and a 20cm Fresnel lens for Rx the distance is 2. The latency is as the same as with fiber switches, nearly unlimited repeater nodes can be created. Lets presume there are houses in a CommunityBlockNetwork. Create as many FSO hotspots as possible. The more hotspots the less DsLam and MeshNetworking nodes will have to be installed reducing the cost of the network considerably. Designate one home as the hotspot and lets presume ten surrounding houses have a short range 1km LOS to this hotspot. Install ten FSO links at multiple points on the roof. Connect these FSO links which each have an Ethernet port to a switch router. Inter-building nodes are created in the same way inside a CBD area connected to CctvCameras for surveillance. Note the scalability of a line-of-sight transmitter. To set up a mesh, one can install multiple tubes at one site - http: Create a network by cabling 50 homes in a street with DsLam. If these homes hot-spots in turn are connected with 1Gig FSO links we could cover the entire Gauteng area in a matter of months providing everybody with UnlimitedBandwidth. Short range 10Gig links with laser Edit Beyond 50m scintillation effects requires OpticPatents methods. Below 50m using the Terabeam http: These short range links is an alternative to cutting the roads in the Norht-South direction as per TelephoneNetworkRollout with MicroDuct under the roads. Each home on such a 10Gig backbone functions as a repeater node receiving data at the front and exiting at the back of the home. The two FSO nodes on either side of the home are bridged with fiber inside the roof. Kilometers of houses can be connected in a line, FSO is like a fiber switch, there are no latency issues. From this backbone 2. Hundreds of houses peer of this backbone. Extending Ronja to 10km Edit Url of this page: In this patent laser diode light is collimated by a collimating lense and received by a receiving lens. EDFA Erbium doped fiber amplifier are used to receive the laser diode light. Seven fibers are spliced into one dual-mode fiber micron. Method for combining multiple optical beams in a free-space optical communication system. The patent idea can be used to increase the Ronja FSO system [url] http: Combine multiple TransimpedenceAmp [url] http: With 13cm Loupes at both Tx and Rx the distance is 1. The larger the lenses the longer the optical distance. The TZA allows 1. Adapt this patent and use multiple RonjaChips http: This fiber light source in turn is focused [url] http: Another idea is to focus the FresnelLens energy unto a CPC compact parabolic concentrator and then unto fiber optic cable as per http: Mutliple fiber cables combined are focused on to the http: Multiples of these cables can be spliced together to increase the energy of the fiber point source as per http: After getting it to work a more compact board can be made 4 or 6layer. This concept can be extended to any type of digital data implemented with an USB or Ethernet data stream. I believe single fiber strands are actually cheaper than running CAT-5 cable over extended distances and it allows for the use a digitized video stream directly form the source. USB can only go 5m and analogue -to - Ethernet cameras are much more expensive. I have looked long and hard for a solution and believe this is the most efficient way of concentrating multiple digitized camera streams over any distance at a single source using off the shelf mass produced equipment. Instead of using fiber the Ronja FSO design can be deployed which will be a more cost effective solution over longer distances. The BT is a single integrated chip with audio and video for which Linux drivers are available. Reverse engineering the PCB would be trivial to do, the hardware is the easy part, the software IP cores is the issue. A single MAX is the preferred solution, allowing mass production. With LED based FSO systems the transmission side of things is where the difficulty lies because of the limited bandwidth compared to laser systems. With Laser FSO atmospheric conditions beyond

50meters becomes the problem resulting in unacceptable transmission errors which can only be corrected with Reed-Solomon on FpGa http: Below 50meters a highspeed link to cross a road is possible without atmospheric interference having an effect. At night or in cloudy conditions a long range 4km p-t-p laser link is possible without OpticPatents methods, allowing a full Internet experience during night time instead of 24hours would be acceptable in most circumstances. The TZA post amplification stage, http: Using the the TZA TransimpedenceAmp considerably simplifies the design because no manual calibration is needed making mass production a cost effective option. Use bandpass filters at Tx and Rx. Hacking FSO designs Edit There are many single chip FSO solutions that implements the entire optical,electrical,Ethernet stage one either a single or two chips such as http: Contact them to find out which companies have released commercial products in FSO using their chipsets then reverse engineer those boards releasing the PCB, Gerber files on the Internet. Get hold of a commercial FSO system such a from http: With laser based systems the issue is software. Hack the design and publish on the Internet. Increase receiver size Edit OpticalManufacturers makes any size Loupes loop lens. Use a solar cooker parabolic reflector: A large parabolic or Fresnel focusing lens collects a huge area of the incoming LED Ronja signal, extending the range of a Ronja. With FSO hundreds of decentralized nodes are created for commercial Internet distribution. Not all users would need a bulky parabolic setup, the usual Loupes design for 1. Refer their web catalogue]:

Chapter 7 : Global Free Space Optics Market Professional Survey Report â€“ Market Intelligence Data

Free Space Optics (FSO) technology is ideal for organizations desiring maximum signal/data security and speed The Technology at the Heart of Optical Wireless Imagine a technology that offers full-duplex Gigabit Ethernet throughput.

This article does not cite any sources. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed. September Learn how and when to remove this template message Optical spaces are mathematical coordinate systems that facilitate the modeling of optical systems as mathematical transformations. An optical space is a mathematical coordinate system such as a Cartesian coordinate system associated with a refractive index. The analysis of optical systems is greatly simplified by the use of optical spaces which enable designers to place the origin of a coordinate system at any of several convenient locations. In the design of optical systems two optical spaces, object space and image space, are always employed. Additional intermediate spaces are often used as well. Optical spaces extend to infinity in all directions. The object space does not exist only on the "input" side of the system, nor the image space only on the "output" side. All optical spaces thus overlap completely. Typically, the origin and at least some of the coordinate axes of each space are different. It may not be possible to discern from an illustration to which space a point, ray, or plane belongs unless some convention is adopted. A common convention uses capital letters to label points and lower case letters to indicate distances. Unprimed letters indicate object space and primed letters image space. Intermediate spaces are indicated by additional primes. The same letter is used to indicate a conjugate relationship either between points or distances. The term "object point" does not necessarily refer to a point on a specific object but rather to a point in object space; similarly for "image point". One may wonder how an object point can exist on the "output" side of an optical system or conversely how an image point could be located on the "input" side of an optical system. The answer in both cases is that the points are virtual. Optical spaces are divided into real and virtual parts. Thus, an object point on the "output" side of the system is in the virtual part of object space and is referred to as a virtual object point. Object points on the "input" side are in the real part of object space and are real object points. The situation is reversed for image points. It is common practice to designate the horizontal axis of an optical space as the z-axis with the positive direction left to right. Similarly, the y-axis is vertical with the positive direction upward.

Chapter 8 : Free Space Optics

Global Free Space Optics market is anticipated to grow at a CAGR of XX% by , according to a new report published by Marketintelligencedata Inc. The report segments the market and forecasts its size, by volume and value, on the basis of application, by products, and by geography (North America, Europe, Asia-Pacific, MEA and South America).

Chapter 9 : fSONA: Technology

Free-space optical communication (FSO) is an optical communication technology that uses light propagating in free space to wirelessly transmit data for telecommunications or computer networking.