

# PAV – The FSO Company

## PAV – Leaders in Free Space Optics

This document is intended to give you an overview of PAV and PAV's Free Space Optics (FSO) technology. PAV's business is FSO. As a privately owned company founded in 1990, PAV are a true innovator of new technologies, an optoelectronics specialist focussed on developing FSO technology that delivers connectivity solutions.

From the initial product design PAV have been the FSO market leaders, with first shipments in 1994 when the company commenced commercial production.

- 1990 - FSO R&D company founded
- 1994 - Commercial operation started
- 1996 - First export sales to South Africa
- 1999 - Regional office in Dubai, UAE
- 2000 - Regional office in Kuala Lumpur
- 2001 - Queen's Award for Enterprise - Innovation & International Trade
- 2001 - The Sunday Times ARM Tech Track 100 survey
- 2002 – MBO/MBI

PAV's Research and Development team in collaboration with a number of Optoelectronic Specialists from the Imperial College (London) and UMIST have continued to enhance the product design and performance over thirteen years. PAV's experience and knowledge in the FSO industry has enabled PAV to become the FSO Company of choice for major GSM and Enterprise customers across the globe.



**PAV Headquarters in the UK**

With this background PAV has developed and grown a customer base with the technology providing connectivity solutions where other technologies simply cannot reach. With a global presence of over 7,000-installed FSO systems world wide, in all types of terrain and environment, PAV have a truly resilient and proven technology.

PAV have consistently been able to penetrate new markets, with sales into the GSM and Cellular market place being especially strong. PAV's installed base in the GSM Mobile World is testament to the reliability of the product and the "availability" that can be achieved from the technology.

Some typical examples of PAV's GSM partners provided below are utilising FSO as a tool within microcell deployment:

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|--|---|
| <ul style="list-style-type: none"> <li>• Mobinil Egypt</li> <li>• China Mobile, China</li> <li>• Ta Ta Teleservice, India</li> <li>• Click, Egypt</li> <li>• Wataniya, Kuwait</li> <li>• Orascom Algeria, Algeria</li> <li>• MobiLink, Pakistan</li> </ul> | <ul style="list-style-type: none"> <li>• Idea Cellular, India</li> <li>• TDCA, Afghanistan</li> <li>• Vodacom, South Africa</li> <li>• DishNet, India</li> <li>• MobiStar, Belgium</li> <li>• OmniTel, Italy</li> <li>• BelgiCom, Belgium</li> <li>• Jaztel / Telephonica, Spain</li> <li>• China Telecom, China</li> </ul> |
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However, the PAV technology is also deployed in many Enterprise organisations across the world. Through a channel of quality trained partners/resellers built up over a period of thirteen years PAV have successfully installed their FSO technology across a wide range of customers always providing a reliable connectivity solution.

The ability to offer true wire speed connectivity across distances up to 4 kilometres has offered the Enterprise customer a solution not available from PTT's or alternative technologies. Some typical end user organisations utilising PAV's technology are listed below:-

- Boeing
- Total Elf Fina
- Formula One Race Teams
- G8 Summit Headquarters
- France Telecom
- JFK Airport
- Nuclear Electric
- Nortel Networks
- EuroMoney
- Fox Broadcasting
- Central Statistics Organization  
(e -Government) in Bahrain
- Kuwait Airways
- Mashreq Bank
- Prince Sultan Medical & Educational Program
- Saudi National Guard
- King AbdulAziz Airport
- Gulf Air
- UAE University
- Aga Khan University & Hospital
- Dubai Municipality
- Toyota
- Chevron Texaco
- Emirates Airlines

## Engineering

PAV has built on this success, with the R&D department continually focussed on improving the performance and availability of the technology. With many years experience within FSO and the unique feedback from a significant customer base PAV have a design philosophy that is simple but effective.

PAV's philosophy for all improvements and enhancements is to consult with customers as to what they require, and after extensive consultation across a wide ranging customer base, it was decided the best way forward was not to complicate the design but rather simplify it. The idea of MODULARITY that already existed in the PAV product was taken to another level and simplified even further. The three key features of the modular improvements are:

- Improve system performance and availability
- Reduced cost of ownership
- Improve ease of system maintenance and installation

As with all successful designs, you need to make the correct choice of trade off. It is no different when considering FSO.

In order to produce the optimum design, PAV have traded off factors such as, cost of components, availability of components, total system complexity and safety of the system to the end user.

PAV system design goals were to:

- Remain within Class 1M Laser Safety Regulations for systems operating up to 2 Km and 3B for systems up to 4 Km.
- Achieve distances of up to 4Km
- Have a product range capable of bandwidths from 1.5Mbps – 1.25 Gbps
- Design Innovative circuitry using standard components to reduce noise and heat emission

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In order to achieve these goals PAV researched the most suitable type of laser to use and selected a laser offering performance, availability and resilience. The unit needed to be cost effective and easily sourced, ensuring PAV became supplier independent.

Wavelengths of 850nm, 910nm and 1550nm were trialled and a 910nm laser was chosen for its superior performance in terms of the amount of power that could be transmitted whilst still allowing the output to be Class 1M at the faceplate in systems functioning up to 2Km and 3B in systems functioning up to 4Km.

During research it was found that lasers using an 850nm wavelength achieved slightly better attenuation characteristics in very humid conditions of 2dB/km but the availability and cost of the laser was not as desirable as the 910nm laser. Also, and most importantly, it was simple to compensate for this attenuation by transmitting more power, up to +20dBm. This would not be possible using 850nm VCSEL's. Care has to be taken when modulating infra red optical sources closer to the visible light spectrum e.g. 850nm as this wavelength is inherently not as eye safe as a 910nm wavelength light source. To generate more power using these types of device i.e. VCSEL's it is possible to use multiple beams, which increases the costs and complexity of the system, making the overall system less reliable.

It was also found that using a 1550nm wavelength laser, although a large amount of optical power could be generated and still remain eye safe, was very expensive and the receiver design needed to be complicated due to the increased inherent noise produced within an APD at this wavelength.

The PAV product using a laser emitting at 910nm was found to be optimal, outperforming 850 nm and 1550 nm VCSEL based products.

In order to achieve the design goal of 4Km operating distances, advanced optic techniques have been incorporated into the product range which ensures that the laser transmitter produces a highly predictable beam spread and power intensity profile. The accurate control of these parameters ensures that enough optical power is available at the far field to ensure the link can always be available @  $\geq E-10$  as long as the power of the received optical signal does not fall below 31nW or -45dBm. PAV products produce a beam divergence of 11mrad, which gives the best performance trade off against tower movement and bird strikes.

Features such as adaptive power control and tracking, although to the none initiated appear useful, simply increase the complexity of the system, and therefore the cost, whilst decreasing reliability, with no real benefit at data rates  $\leq 1.25$  Gbps. PAV products launch with as much power as possible whilst remaining eye safe so that the end customer can be confident of achieving the maximum power transfer the system is capable of at all times. Carefully controlling the beam profile and its spread ensures that tracking is not necessary and this has been shown not only through analysis but also by data accumulated from actual systems in the field. There can be no better test than actual working systems, working 100% for cellular operators, who have chosen to mount systems on towers.

PAV, by using innovative circuit design, is able to achieve bandwidths ranging from 1.5Mbps – 1.25Gbps. Laser drive circuitry benefits from thermal stabilisation techniques, which ensures less than 0.1 nm temperature drift, creating a highly stable optical source, which greatly limits attenuation effects around the 810/910 nm window. Coupled with high power transmission any attenuation effects at this wavelength are negligible.

The entire product range can be produced from just 9 modules, which ensure customers are able to keep a stock of spares, which will cover the systems they will need to maintain. The end customer due to the unique modular design of PAV products, can carry out most repairs, unlike many other FSO vendors whose equipment needs to be removed from site, returned to the vendor and upon return realigned; a time consuming and costly exercise.

The PAV product range benefits from the latest digital technology and the circuits have been optimised to produce very low noise figures and heat dissipation. This ensures that systems will operate in extreme climates, from -50 degrees to +65 degrees. Again PAV have systems working in Siberia and in the Arabian Desert, two of the most extreme climatic environments on the Earth.

## Reduced cost of ownership

The PAV philosophy is to continually evaluate methods of driving the cost out of the system and pass the savings on to the customer without compromising on quality through modularity. PAV products have been designed to be modular from the manufacture of the individual circuit boards to the complete system. All components are standard, high quality, very reliable off the shelf components. This ensures that PAV are always capable of sourcing the raw materials at the best price.

In the past PAV systems and circuits were manufactured and assembled in house and were effectively custom built. Although the manufacturing process was acceptable for small order quantities it became apparent that for large quantities it would be necessary to redesign and simplify the entire product range.

The number of individual circuit types has been reduced from 50 to just 9. These 9 circuits are now manufactured in state-of-the-art manufacturing plants in the UK and the systems are assembled at PAV where they are quality controlled and tested. This has greatly reduced the complexity of the manufacturing process enabling cost to be driven out of the product.

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## Improve ease of system maintenance and installation

The end user can easily maintain the PAV product. There is an option for the electronic intelligence to be removed from the outdoor unit and placed inside an indoor unit, which gives the end user the ability to upgrade the system in terms of bandwidth without touching the outdoor unit. Once the unit is in place it need never be realigned again. Bringing the electronic intelligence into the indoor unit also gives the end user the ability to visually inspect the status of the system via LED alarms. All systems can be monitored via RS232, GSM or SNMP.



**PAVLight Linkhead**

## Enterprise environment

In the Enterprise environment, the systems can be either monitored from a PC based GUI driven Windows application via a standard RS232 (RS485 Optional) connection, or from within an SNMP based management environment such as HP OpenView. System health status and alarm information is sent to the management platform via an external SNMP proxy agent. The proxy agent is connected to the management system via a standard Ethernet connection. The agent hardware comes either as a tabletop enclosure or within a standard 19" rack mountable chassis that can be directly mounted into a telecommunication rack. The scalable rack mountable unit is available with different power supply options and can be scaled to monitor up to 32 link heads at a single location. In addition the proxy agent hardware is equipped with standard alarm dry contacts.

## Cellular or GSM environment

In the Cellular or GSM environment PAV has a very comprehensive management platform provided by the Nimbus management package. Up to 2400 links can be monitored from a central location. Management is provided out of band and can be interfaced into any standard GSM microwave system.

Reduction in the number of circuits required to build PAV technology now means the customer can hold fewer spares but still be able to maintain his network of FSO systems.

Alignment has been greatly simplified and improved by the introduction of the PAA (PAV Alignment Aid). This is a precision tool, allowing trained personnel to align a system. It reduces the time required to install and align a system but greatly enhances the accuracy of fine alignment. This is a great advantage over other vendors who simply use telescope alignment techniques, which do not allow for fine alignment. This is important as the optics in any FSO system are manufactured to certain tolerances; fine alignment enables the differences in tolerance to be compensated for especially in installations where the FSO systems are mounted non-horizontally. In fact the system can still be aligned with one end inverted and the other end normally mounted due to the fine alignment technique only offered by PAV.

There are now thousands of PAV systems installed worldwide in more than 40 countries spanning Europe, the Middle East, Africa, the Far East, Australasia and North America. As FSO continues to find its place of providing high bandwidth over distances up to four kilometres then PAV technology continues to lead the way providing our customers with robust, cost effective and reliable solutions to their connectivity requirements.

The company is currently headquartered on Merseyside, UK, with regional sales and support offices in UAE and Malaysia. For further information on PAV please take the time to review some of our solutions and our technology at [www.pavdata.com](http://www.pavdata.com).