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1 Safety Precautions

PLEASE READ THESE SAFETY PRECAUTIONS!

Optical Energy Health Hazard

All CableFree FSO (Free Space Optics) systems contain laser emitting devices. The overall FSO system complies fully with European Standard EN 60825-1 (2001), under Classification Class 1M.

The equipment described in this guide uses optical infrared laser transmitters. Ensure that relevant safety guidelines are followed when installing or operating the equipment.

WARNING: Energy Exposure Limits and Applicable Rules for 785 and 980nm laser radiation. It is recommended that the radio equipment operator refer to the laser exposure rules and precautions applicable in the relevant territory for the frequency in use and other applicable rules and precautions with respect to transmitters, facilities, and operations that may apply due to laser emissions for each deployment site.

Appropriate warning signs must be properly placed and posted at the equipment site and access entries.

Laser radiation hazards

Laser radiation predominantly causes injury via thermal effects. Even moderately powered lasers can cause injury to the eye.

The coherence, the low divergence angle of laser light and the focusing mechanism of the eye means that laser light can be concentrated into an extremely small spot on the retina. A transient increase of only 10 °C can destroy retinal photoreceptor cells. If the laser is sufficiently powerful, permanent damage can occur within a fraction of a second, literally faster than the blink of an eye. Sufficiently powerful in the visible to near infrared laser radiation (400-1400 nm) will penetrate the eyeball and may cause heating of the retina. Infrared lasers may be hazardous since the body's protective “blink reflex” response is triggered only by visible light.

The classification of a laser is based on the concept of accessible emission limits (AEL) that are defined for each laser class. This is usually a maximum power (in W) or energy (in J) that can be emitted in a specified wavelength range and exposure time. It is the responsibility of the manufacturer to provide the correct classification of a laser, and to equip the laser with appropriate warning labels and safety measures as prescribed by the regulations.

A Class 1M laser is safe for all conditions of use except when passed through magnifying optics such as microscopes and telescopes. Class 1M lasers produce large-diameter beams, or beams that are divergent. The MPE for a Class 1M laser cannot normally be exceeded unless focusing or imaging optics are used to narrow the beam. If the beam is refocused, the hazard of Class 1M lasers may be increased and the product class may be changed. A laser can be classified as Class 1M if the total output power is below class 3B but the power that can pass through the pupil of the eye is within Class 1.
Protection from Lightning

Article 810 of the US National Electric Department of Energy Handbook 1996 specifies that radio and television lead-in cables must have adequate surge protection at or near the point of entry to the building. The code specifies that any shielded cable from an external antenna must have the shield directly connected to a 10 AWG wire that connects to the building ground electrode.

Do not turn on power before reading Wireless Excellence product documentation.

Risk of Personal Injury from Fibre Optics

DANGER: Invisible laser radiation. Avoid direct eye exposure to the end of a fibre, fibre cord, or fibre pigtail. The infrared light used in fibre optics systems is invisible, but can cause serious injury to the eye.

WARNING: Never touch exposed fibre with any part of your body. Fibre fragments can enter the skin and are difficult to detect and remove.

Warning – Turn off all power before servicing

Warning – Turn off all power before servicing.

Safety Requirements

Safety requirements may require a switch be employed between the CableFree FSO external power supply and the CableFree FSO power supplies.

Proper Disposal

The manufacture of the equipment described herein has required the extraction and use of natural resources. Improper disposal may contaminate the environment and present a health risk due to the release of hazardous substances contained within. To avoid dissemination of these substances into our environment, and to lessen the demand on natural resources, we encourage you to use the appropriate recycling systems for disposal. These systems will reuse or recycle most of the materials found in this equipment in a sound way. Please contact Wireless Excellence or your supplier for more information on the proper disposal of this equipment.
2 System Description

2.1 About This Manual

This manual is written for those who are involved in the “hands-on” installation of the CableFree FSO/laser products as a point-to-point link, such as installation technicians, site evaluators, project managers, and network engineers. It assumes the reader has a basic understanding of how to install hardware, use Windows® based software, and operate test equipment.

2.2 Introduction

The family of CableFree FSO/laser products provide high capacity transmission, flexibility, features, and convenience for wireless digital communications networks. CableFree FSO represent an advanced architecture that is designed to address universal applications for IP, SDH, PDH and other network platforms. This advanced technology platform is designed to provide the flexibility to customers for their current and future network needs.

The CableFree FSO/laser platform is available in a few fixed-function variants to support a wide range of network interfaces and configurations. It supports full duplex links for 4x E1/T1, 100BaseTX Ethernet, 1000BaseX Ethernet, STM-1, STM-4. The CableFree FSO/laser platform enables network operators (mobile and private), government and access service providers to offer a portfolio of secure, scalable wireless applications for data, video, and Voice over IP (VoIP).

An FSO terminal is composed of a CableFree FSO/laser ODU (head unit) and power supply or POE Injector. Systems requiring SNMP management may include the optional SmartAgent. The solutions are flexible and intercompatible with mix/match capability.

CableFree FSO/laser products include integrated Operations, Administration, Maintenance, and Provisioning (OAM&P) functionality and design features enabling simple commissioning when the FSO network is initially set up in the field at the customer’s premises.
The Diagram below shows a typical deployment (not showing optional SmartAgent component).

**Figure 2-1. Typical FSO Deployment Architecture**
2.3 System Features

- Choice of FSO head units with varying capacity (2 -1500Mbps) and distance (200m – 4km) capabilities
- Modular Interface cards fitted in FSO head units, with PDH (E1, T1, 4xE1, 4xT1), IP (100, 1000Mbps), SDH (STM-1, STM-4) and other options
- High performance digital laser modulation and reception
- Automatic Transmit Power Control (ATPC)
- Sophisticated on-board Management capability including RS-232 serial port, and optional Ethernet Management using SmartAgent
- Multiplexed options including 4xE1, 4xT1, 100Mbps+E1, and others
- Overhead admin serial channel interface (transported as side-channel over the link)
- 18 to 24V DC Power interface to FSO head unit. Optional 48V converter modules.
- Optional POE connection for 100Mbps Ethernet interface
- FSO indicator LEDs indicate RSSI (signal level), Power-on, Alarm and Fault status
- External FSO Alignment Modules have easy-to-align features including voice circuit, audible tones, on-screen readout of signal levels, control of ATPC features.
2.4 Physical Description

The following section details the physical features of the CableFree FSO/Laser system

2.4.1 FSO Head unit (ODU)

The FSO Head unit is a highly integrated weather-sealed unit which contains the various components required for wireless transmission and reception of signals. The FSO Head unit has a removable back panel to access the connections and readout indicators during installation. After installation is complete, the back panel is replaced and sealed.

2.4.2 Network Interface Module

The FSO Head Unit contains a Network Interface Module which is typically factory-fitted at time of manufacture. It can be upgraded or swapped on-site to increase system capacity or change of use. The Network Interface Module contains appropriate processing circuitry, indicators, and connectors for fibre optic or copper (twisted pair or coaxial) depending on the specific interface format required.

2.4.3 Mains 115/230V AC to 24V DC power Supply

The Mains AC to 24V DC power supply is provided with every system. It is a switch-mode power supply device with passive cooling. This PSU is ideal to mount in an indoor rack location, cupboard or an outdoor waterproof housing. Note that the PSU is not weather sealed so any outdoor housing must take account of this.

2.4.4 4GPSU module

The 4GPSU module takes incoming 24V DC from the mains power supply and provides surge suppression, a 9 pin RS232 serial interface connection, and an 8 way power connector for connection up to the FSO Head Unit. The 4GPSU has a fuse to protect the power supply against overload or similar power fault condition. The 4GPSU is ideal to mount in an indoor rack location, cupboard or an outdoor waterproof housing. Note that the 4GPSU is not weather sealed so any outdoor housing must take account of this.

2.4.5 Optional SmartAgent unit

The SmartAgent is a 1U rack-mount device which takes the serial RS232 telemetry from the head unit, and converts to Ethernet/IP protocols, with HTTP/web, proprietary, and SNMP traps supported. The SmartAgent is ideal to mount in an indoor rack location, cupboard or an outdoor waterproof housing. Note that the SmartAgent is not weather sealed so any outdoor housing must take account of this.

2.4.6 Pan and Tilt Adaptor

The Pan and Tilt Adaptor mounts physically to the bottom of the FSO Head Unit, acting as a physical interface between the Head unit and the mounting bracket that is secured to the building or mounting structure. The Pan and Tilt Adaptor enables 360 degrees of horizontal adjustment and +/- 30 degrees of vertical adjustment. The adjustment is made manually to align the link. After the link is aligned, the screws are tightened to ensure correct long-term alignment of the link.
2.4.7 Mounting Bracket (choice of options)

There is a range of Mounting Brackets to account for the various types of building or structure that the FSO Head Unit needs to be attached to. Most common options include:

- Wall Mounting Bracket
- Pole Mounting Bracket
- Plinth Mounting Bracket
- Roof Mount Pole, with spreader plate
- Custom or Semi-custom brackets

The most common type is a Wall Mounting Bracket, which is supplied by default with every FSO unit.

2.4.8 Connections to FSO Head Unit (ODU)

Power Supply Input

<table>
<thead>
<tr>
<th>DC Input</th>
<th>24 VDC</th>
</tr>
</thead>
</table>

24v (Isolated Input); 8-pin connector. The CableFree FSO ODU requires an input of -24 volts dc nominal, between 18 and 24V at the FSO head unit power connector. The total required power is dependent on the option cards and specific ODU version.

It is recommended that the CableFree power supply be used be able to supply a minimum of 60 W to the IDU.

A mating power cable connector is supplied with the CableFree FSO ODU. It is an 8-pin plug. This connector has screw clamp terminals that accommodate 24 AWG to 12 AWG wire. The power cable wire should be selected to provide the appropriate current with minimal voltage drop, based on the power supply voltage and length of cable required. The recommended wire size for power cables under 30m in length supplying -48 Vdc is 1.5 sq mm.

RS232 Management Serial Interface

| Command Line Serial Interface | DB9 modular port connector on PSU or SmartAgent for RS422/RS-232 data. Telemetry protocol is proprietary, use the provided software to interface with this |

100Mbps Ethernet Module: Ethernet 100BaseT Connections

| 100 Mbps Copper | 100Base-TX RJ-45 modular port connector for the network Fast Ethernet interface. Does not AutoNegotiate. Ensure connected equipment ports are set to “non-autonegotiate” when connecting to the FSO unit |
### 100Mbps Ethernet Module: Ethernet 100BaseFX Connections

| 100 Mbps Fibre | 100Base-FX SC fibre optic connector for the network Fast Ethernet interface. Options of Single Mode (SMSC) or Multi Mode (MMSC) interfaces at time of order. |

### 1000Mbps Ethernet Module: Ethernet 1000BaseFX Connections

| 1000 Mbps Fibre | 1000Base-FX SC fibre optic connector for the network Gigabit Ethernet interface. Options of Single Mode (SMSC) or Multi Mode (MMSC) interfaces at time of order. |

### E1/T1 Interface Module: 1x E1/T1

| E1/T1 | One T1/E1 (RJ-48C) interface connection. |

### E1/T1 Interface Module: 4x E1/T1

| E1/T1 | Four T1/E1 (RJ-48C) interface connections. |

### Other Interface Options:

We have several other specialist interface options. Please contact Wireless Excellence for details.

### Ground Connection

| Ground | Please ensure that the mounting bracket connected to the CableFree FSO ODU is connected to mains or building earth |
2.5 System Description

The overall FSO architecture consists of an integrated All Outdoor FSO head unit (ODU) with cables connecting to indoor infrastructure (PSU, network equipment). The modular Network Interface Module is typically factory-fitted within the FSO head unit, and can be replaced in the field.

![CableFree FSO Head Unit Block Diagram, single laser versions](image)

2.5.1 Transmitter

The FSO transmitter consists of a laser modulator circuit and the solid state laser device. The laser is a solid-state electro-optical device that emits light at a specific wavelength, which can be modulated with digital data signals at high speeds. The lasers used in CableFree units emit light in the infrared part of the spectrum at 785nm (partially visible to the human eye) or 980nm (completely invisible). The 980nm lasers are capable of high output power but are restricted to low data rates, the 785nm lasers are capable of very high data rates but are restricted to low output power. Atmospheric conditions such as Fog attenuate 980nm less than 785nm, hence 980nm is suited for longer distance links.

The optical power generated by the laser is coupled to focal point of a transmission lens using a customised short length of fibre optics, to ensure the signal is uniform and safe. The lens then collimates the light into a beam with a factory-preset divergence (in most systems this is 0.5 degrees full angle or 8mRad) to allow for alignment tolerance, vibration and movement laser head caused by mast/tower/building sway. This divergence approximately equates to a 1m diameter footprint for every 100m travelled.

2.5.2 Receiver
The FSO receiver uses a precision optical lens to focus the incoming beam onto a very sensitive Avalanche Photodiode (APD). A photodiode is a device that converts photons (light) into electrical signals. The photocurrent depends on the amount of incident incoming light. This detected current provides the received signal (both data and telemetry) and the receive signal strength (RSSI) readout value. Sophisticated electronic circuits remove distortion and interference introduced by the atmosphere, recovering the original transmitted data. The acceptance angle from which a received signal can be detected by the photodiode is also nominally 0.5 degrees full angle (8mRad).

2.5.3 Network Interface Module

The FSO Head Unit contains a Network Interface Module which is typically factory-fitted at time of manufacture. It can be upgraded or swapped on-site to increase system capacity or change of use. The Network Interface Module contains appropriate processing circuitry, indicators, and connectors for fibre optic or copper (twisted pair or coaxial) depending on the specific interface format required.

2.5.4 Embedded Management CPU

The FSO Head unit contains a sophisticated embedded management CPU which monitors and controls operation of the FSO unit. It runs custom-designed software which can communicate with either the remote end FSO terminal, and local end management devices such as PCs, laptops and SmartAgent devices. The Management CPU also runs the ATPC system which dynamically adjust the laser transmit power to overcome fade conditions caused by poor weather conditions, misalignment, dust and dirt.

2.5.5 Solid State Cooling

Solid state Laser devices are sensitive to temperature, which affects lifetime. At high output powers, high temperatures can dramatically reduce the lifespan of the laser device. The high power CableFree FSO Head units contain a solid state cooling system which uses Peltier-effect device to remove heat from the laser device, hence ensuing long lifespan in all climatic conditions.

2.5.6 DC power supply

CableFree FSO units contain onboard DC-DC power regulation to provide appropriate power to all the functional systems. The input power is in the range 18 to 24V DC. There are optional converters to enable direct connection to 48V DC telecom power. There are optional POE versions of the Fast Ethernet FSO systems.

2.6 1+1 Protection

With two FSO ODUs installed on each site, the CableFree LC IDU can also support 1+1 protection as an option for a critical link. Each FSO ODU contains required functions to communicate as a complete link. The power supply, ODU, and all cabling are separate and hence protected. Switch-over is performed by external devices such as multiplexers, routers or switches. Depending on network architecture, the switchover decisions are made at Layer 1, 2 or 3. 1+1 protection is therefore effectively Protected Diversity as there are two separate Line-of-Sight paths being used. Hitless switching with sub-50ms fail-over is possible with appropriate network design and equipment.

Please contact CableFree for more information about 1+1 protected links using our FSO products.
2.7 Automatic Transmit Power Control (ATPC)

Almost all CableFree FSO links include Automatic Transmit Power Control (ATPC). This system adjusts the transmitted laser signal power to overcome signal loss and attenuation caused by fade conditions such as fog, rain, dust, sandstorms, link misalignment, dirt deposits on the optical surfaces.

Traditionally, FSO links from other vendors do not have ATPC and suffer regular outages as the dynamic range of the optical receiver is limited, and therefore has very limited ability to cope with excess attenuation of the signal. By using ATPC, CableFree FSO links enjoy a huge improvement in uptime, availability and user satisfaction.

2.7.1 Dynamic Range

The dynamic range is the total receive signal range over which the system will pass data error free and is related to the performance of the receive element. This varies from minimum signal were no errors just occurs, up to maximum signal were errors just occur again as the photodiode goes into saturation, where an excess of signal overloads the internal amplification process. The available dynamic range depends on the specific FSO product used.

2.7.2 Fade Margin

The fade margin is the excess power level above the minimum required for operation in clear air over the range at which the link will be installed. This is to allow for atmospheric effects as they can either increase or decrease the amount of optical power arriving at the receiver. The difference between the operating RSSI value and the maximum RSSI were errors occur is called the headroom. The headroom must be kept to a minimum to ensure maximum fade margin during bad atmospheric conditions while avoiding saturation during good atmospheric conditions (bright sunny day). Figure 2 below shows the relationship between the bar graph, the dynamic range and the fade margin. Also shown is a comparison between the new and legacy production range to show the improvement.

Fade Margin and Dynamic Range of CableFree FSO Products
2.7.3 Atmospheric Effects

The fade margin is the excess power level above the minimum required for operation in clear air over the range at which the link will be installed. This is to allow for atmospheric effects as they can either increase or decrease the amount of optical power arriving at the receiver. The difference between the operating RSSI value and the maximum RSSI were errors occur is called the headroom. The headroom must be kept to a minimum to ensure maximum fade margin during bad atmospheric conditions while avoiding saturation during good atmospheric conditions (bright sunny day). Figure 2 below shows the relationship between the bar graph, the dynamic range and the fade margin. Also shown is a comparison between the new and legacy production range to show the improvement.

2.8 CableFree FSO Network Management

All of the CableFree FSO links are manageable in various ways:

- Using the FSO Alignment Modules during installation
- Using FSOmanager software, connected to the RS232 serial port on the 4GPSU module
- Using optional SmartAgent hardware platform, and a standard PC web browser using HTTP protocols over an IP network
- Using optional SmartAgent hardware platform, using FSOmangaer software, over an IP network

Please see relevant datasheets and documentation for management platforms

2.8.1 IP Address

The optional CableFree SmartAgent is configured independently for network parameters such as IP address, subnet, and gateway.

2.8.2 IP Network NMS Operational Principles

The CableFree IDU does not provide routing capability. Therefore, all SmartAgents must be on the same subnet as the PC being used to access the SmartAgents. If the SmartAgents and/or the PC are on different subnets, a router must be used, with the gateway addresses set appropriately.

2.8.3 Third Party Network Management Software Support

The optional CableFree FSO SmartAgent supports SNMP V1 traps for use with the CableFree TrapMangaer or third party network management software. The SNMP agent will send SNMP traps to specified IP addresses when an alarm is set or cleared. Information contained in the trap includes:

- IP address
- System uptime
- System time
• Alarm name
• Alarm set/clear detail

These traps may be read and integrated into 3rd party Network Management Software. Please contact Wireless Excellence for more information on these features.
3 Installation

3.1 Unpacking

The following is a list of possible included items with a CableFree FSO link.

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CableFree FSO Head Units</td>
<td>2</td>
</tr>
<tr>
<td>CableFree Pan and Tilt Adaptors</td>
<td>2</td>
</tr>
<tr>
<td>CableFree Wall Mounting Brackets (or plinth brackets, or others, if ordered)</td>
<td>2</td>
</tr>
<tr>
<td>Mounting screws for Pan and Tilt Adaptors</td>
<td>2 sets</td>
</tr>
<tr>
<td>CDROM containing documentation and FSOmanager software</td>
<td>1 disc</td>
</tr>
</tbody>
</table>

Be sure to retain the original boxes and packing material in case of return shipping. Inspect all items for damage and/or loose parts. Contact the shipping company immediately if anything appears damaged. If any of the listed parts are missing, call the distributor or the factory immediately to resolve the problem.
3.2 Notices

3.2.1 CAUTION

- Do not dismantle the CableFree FSO system under any circumstances.

- At short distances <100m, always use approved attenuators to reduce power incident on the sensitive optical receiver. Failure to do this may cause damage.

3.2.2 WARNING NOTICES

- Do not operate or apply power to the FSO units if the internal fibre optic cable connecting to the laser is damaged or disconnected. Dangerous/unsafe optical power levels may be present if the cable is damaged or unplugged.

- High voltages are present on the APD bias circuit inside the unit. Though this is at very low current, users should avoid making contact with it. Avoid dismantling the unit.

- High voltages are present in the mains PSU module. Do not attempt to repair or dismantle this module. There is a risk of electric shock if attempting to dismantle this unit even after the power has been disconnected.

- Only qualified and trained personnel should attempt disassembly or repair of CableFree FSO units.
3.3 Optional – Indoor Bench-top Testing

It may be useful to test the CableFree FSO system in table-top bench testing prior to installation, maintenance swap-out or for training. This is possible using the standard product but requires use of attenuators to avoid reflections and possible damage to the sensitive optical receivers at such short range.

3.3.1 Setting up for Bench Testing

Table-top or bench testing prior to final installation is highly recommended in order to gain familiarity with the product. The following additional equipment is required for back-to-back testing:

- CableFree FSO optical attenuators, at least 12 dB each, rated for specific ODU frequency.
- CableFree FSO Plinth Mount brackets

The FSO units should be mounted on the pan and tilt units as supplied, and the plinth mount brackets which can then be placed on a bench or table. Take care not to let the metal brackets scratch any office furniture.

Use the optical attenuators to ensure at least 12dB attenuation on each unit. The attenuators may be temporarily stuck to the front optical face plates using sticky tape or similar. Failure to use attenuators may result in either

- Signal reflections preventing data throughput
- Damage to the sensitive optical receivers

If you do not have the correct CableFree optical attenuators, and a bench top test is urgently required (for example, when testing a suspect link returned from a customer site) it is possible to fabricate makeshift attenuators from either card or coloured plastic sheets, please contact us for suggestions.

3.3.2 Running a Bench Test

The FSO link can be aligned using the pan and tilt brackets as per a normal installation. Please note, the alignment is far more critical across the bench, because of the close proximity of the units and narrow optical beams. Conversely, it is far easier to align at the full distance. Be especially careful to avoid reflected signals which will provide corrupt data and either no or low throughput.
3.4 Overview of Installation & Commissioning

The installation and testing process is accomplished by performing a series of separate, yet interrelated, procedures, each of which is required for the successful implementation of a production CableFree FSO network. These procedures are as follows:

- Site Evaluation: gathering specific information about potential CableFree FSO installation sites.
- Cable and Installation: Testing and installing cables and optional interface devices at FSO installation sites.
- CableFree FSO Head Unit Mounting, Mounting FSO units to a pole or wall,
- CableFree FSO Alignment: performing link alignment and performance verification.
- CableFree FSO Testing: Performing throughput checks for links, and the management data.
3.5 Site Evaluation

A site evaluation consists of a series of procedures for gathering specific information about potential CableFree FSO locations. This information is critical to the successful design and deployment of a network.

Site evaluations are required to confirm whether or not a building meets network design requirements. The main objectives are as follows:

• Confirm
  • Line of sight for each link
  • FSO Unit mounting locations
  • Site equipment locations
  • Cable routes
  • Any other potential interference sources
  • Prepare site drawings and record site information

3.5.1 Preparing for a Site Evaluation

The following tools are required to perform a site evaluation:

• RF and network design diagrams (as required)
• Binoculars
• Global positioning system (GPS) or range finder
• Compass
• Measuring tape and/or wheel
• Digital camera
• Area map
• Aerial photograph (if available)
• List of potential installation sites (“targeted buildings”)
The following tasks must be completed prior to performing a site evaluation:

- Prepare the initial network design by performing the following:
  - Identify potential buildings by identifying targeted customers (applicable if you’re a service provider)
  - Identify potential links by selecting buildings based on the high probability of line of sight
- Arrange for access with the facility personnel into the buildings, equipment rooms, and architectural plans to become familiar with the location of all ducts, risers, etc.

### 3.5.2 Site Evaluation Process

The following steps must be completed to perform a successful site evaluation. Each step in the process is detailed in the following subparagraphs:

- Ensure Safety compliance: Ensure that appropriate warning signs are properly placed and posted at the equipment site or access entry. For a complete list of warnings, refer the Safety Precautions listed at the beginning of this manual.

- Ensure Compliance with Laws, Regulations, Codes, and Agreements: Ensure that any installation performed as a result of the site evaluation is in full compliance with applicable federal and local laws, regulations, electrical codes, building codes, and fire codes.

- Establish Line of Sight between antennas: **The most critical step in conducting a site evaluation is confirming clear Line of Sight (LOS) between a near FSO unit and a far FSO unit. If LOS does not exist, another location must be used.**

  FSO Link terminals must have a clear view of each other, or “line of sight”. Binoculars may be used evaluate the path from the desired location of the near FSO unit to the desired location of the far FSO unit.

  To confirm Line of Sight:
  
  - Ensure that no obstructions are close to the transmitting/receiving path. Take into consideration trees, bridges, construction of new buildings, unexpected aerial traffic, window washing units, etc.
  
  - Ensure that each FSO Head Unit can be mounted in the position required to correctly align the FSO Head Unit with its partner.

  The antennas must also have a clear radio line of sight. If a hard object, such as a mountain ridge or building, is too close to the signal path, it can damage the radio signal or reduce its strength.

  Note that unlike radio or microwave system, FSO/laser links have no effective Fresnel zone – only pure “optical” Line of Sight needs to be considered.

  - Determine FSO Head Unit Mounting Requirements: FSO Head Units can be mounted on a sturdy antenna mast, brick, masonry or wall. Refer to detailed installation sections specific for each mounting bracket type.

  - Determine CableFree FSO PSU and other equipment Location: Indoor items including PSU and SmartAgent can be installed tabletop or cabinet, wall mount, or rack mount. The site must provide DC or AC power. Refer to detailed installation sections.
• Measure the Link Distance: The two ways to measure link distance are as follows:
  
  - GPS: record the latitude and longitude for the near and far FSO Head Unit sites and calculate the link distance. Record the mapping datum used by the GPS unit and ensure the same mapping datum is used for all site evaluations in a given network.
  
  - Range finder: measure the link distance (imperial or metric units may be used).

Once the link distance has been measured, verify that the link distance meets the availability requirements of the link.

• Select the Grounding Location for both the FSO Head Unit and indoor items: The indoor items must be properly grounded in order to protect it and the structure it is installed on from lightning damage. This requires
  
  - Grounding all FSO Head Units to building earth system
  
  - Grounding all indoor items to the rack, or building mains earthing system.

• Determine the Length of Interconnect Cable from FSO Head Unit to indoor location: The primary consideration for the outdoor interconnect cable from the FSO Head Unit to IDU is the distance and route between the FSO Head Unit and IDU. This cable should not exceed 100m for Twisted Pair Ethernet, and shorter lengths for the power cable.

• Confirm the Presence of AC Power for the CableFree Power Supply.

• Ensure Building Aesthetics: Ensure that the FSO Head Unit can be mounted so that it is aesthetically pleasing to the environment and to the property owner. Aesthetics must be approved by the property owner and the network engineer.

• Take Site Photographs

• Sketch the Site
3.6 Installation of CableFree FSO links

The following sections provide installation guides for:

• Indoor Component Installation

• FSO ODU Installation

3.6.1 Installing the CableFree FSO indoor components

The indoor components (PSU, optional SmartAgent) should be:

• Located where you can easily connect to a power supply and any other equipment used in your network, such as a router or PC.

• In a relatively clean, dust-free environment that allows easy access to the rear grounding post as well as the front panel controls and indicators. Air must be able to pass freely over the units.

• Accessible for service and troubleshooting.

• Protected from rain and extremes of temperature (it is designed for indoor use).

Options for installation include:

• The CableFree FSO indoor components can be placed on a tabletop or cabinet shelf. In order to prevent possible disruption, it is recommended to use a strap to secure the items.

• An installation option for the IDU is mounting the unit to a wall. Consult factory for details.

• If the wall mount option is being considered, plan to position the CableFree FSO PSU at a height that allows LEDs, the connectors on the front panel, and the rear grounding post to be visible at all times and easily accessible. Also, including plastic clamps to support and arrange the ODU/PSU Interconnect Cable should also be considered.

• To maintain good airflow and cooling, it is preferred that the PSU is installed in a slot that has blank spaces above and below the unit.

• To rack-mount the PSU, use a suitable rack shelf to secure the PSU to the rack cabinet.
3.6.2 Mounting Brackets

**Wall Mount Bracket**

The Wall Mount Bracket is used to support CableFree FSO systems where permanent installation is required on vertical wall surfaces. The heavy duty wall bracket should be used for installations where extreme weather conditions could cause the laser head to move.

**Heavy Duty Wall Mount Bracket**

**Figure 1 Wall Mount Bracket**

**Figure 2 Heavy Duty Wall Mount Bracket**

**Roof Pole Mount**

Wall Mount Pole
Up to 3m long, to give vertical clearance of 2m

**Wall Mount Pole**

Roof Mount Pole:
0.5m, 1m and 1.5m lengths.
300mm square base

**Figure 3 Roof Mount Pole**

**Figure 4 Wall Mount Pole**

**Plinth Mount Bracket**

The Plinth Mount is used to mount systems on flat surfaces like parapets

**Figure 5 Plinth Mount**
3.6.3 Routing the ODU/IDU Interconnect Cable

1. Select where the cable will enter the building from outside.

2. Determine the length of cable required. Allow one metre on each end to allow for strain relief, as well as any bends and turns.

3. Route the cable.

The cables are typically

- Power/control cable which is usually a 5-core cable with 1.5 or 2.5 sq mm cores
- Fibre optic or CAT5/5e/6 twisted pair data cable

In outdoor locations these are usually run in plastic conduit, which is essential to:

- Protect against UV damage to the cable cladding (most cables are not rated for outdoor use)
- Protect against mechanical damage to fragile fibre optic cables
- Prevent tight cable bends which may damage or destroy the cabling

Based on an evaluation of the cable routing path, pull the interconnect cables from one unit to the other, utilizing cable trays, ducts, or conduit as required. Take care that the interconnect cables are not kinked or damaged in any way during installation. Be sure to protect any connectors from stress, damage and contamination during installation (do not pull the cable by the connectors). If multiple interconnect cables are to be installed along the same route, the cables should all be pulled at one time. Be sure the installed cable does not have any bends that exceed the specified cable bend radius. Interconnect cables should be adequately supported on horizontal runs and should be restrained by hangers or ties on vertical runs to reduce stress on the cable. Outside the building, run the cable inside weatherproof conduit and support and restrain the cable as required by routing and environmental conditions (wind, ice).

The FSO installation must be properly grounded in order to protect it and the structure it is installed on from lightning damage. This requires that the FSO ODU, any mounting pole or mast and any exposed interconnect cable be grounded on the outside of the structure. The indoor PSU components must be grounded to a rack or structure ground that also has direct path to earth ground.

Provide a sufficient but not excessive length of cable at each end to allow easy connection to the FSO ODU and Indoor PSU without stress or tension on the cable. Excessive cable length, especially outdoors, should be avoided to provide a more robust and reliable installation. Use of connectors, tools and termination procedures specified by the cable manufacturer is recommended.

Once the cable has been installed but before connection has been made to either unit, a continuity test should be made to verify the integrity of the installed cable. A DC continuity tester or digital multimeter may be used to verify a lack of DC continuity between the cable center conductor and outer conductor, with the opposite end of the cable unconnected. With a temporary test lead or shorting adapter connected to one end of the cable, DC continuity should be verified between all the conductors at the opposite end.

In the case that Category 5/5e/6 copper data cabling has been used up to the FSO ODU, it is strongly recommended to use an approved cable tester to ensure the cable is in good condition and terminated correctly, and that the installation passes the requirements for Ethernet/IP data transfer.
3.6.3.1 Grounding the FSO Head Unit

It is strongly recommended to ground the FSO Head Unit. The simplest way to achieve this is to put a tag on one of the screws connecting into the base of the FSO Head Unit to the pan and tilt, and then connect from this to the building earthing system or pole to which it is mounted. Please consult and follow rules or advice if required from the building owner also.

3.6.3.2 Grounding the Indoor Components

It is essential to provide grounding for the indoor components (PSU, 4GPSU, and optional SmartAgent). Normally the mains power supply is connected to the system or building electrical ground point.

In the case of a SmartAgent, it is wise to ground the case of the SmartAgent to the 19" rack that it is mounted in using appropriate wire and screws.

3.6.4 Connecting up the power supply and power cables

Please note the following carefully when connecting power from the PSU to the FSO Head Unit. Incorrect wiring will damage the FSO Head Unit and invalidate warranty.

5 core cable is used between the power supply and the laser head. (Maximum length 80m)

NOTE: If the cable length is less than 50m 1.5mm² cable will be required. If the cable length exceeds 50m 2.5mm² cable is required.

### 4GPSU Power Supply Wiring

<table>
<thead>
<tr>
<th>Pin</th>
<th>Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vin+ (Black)</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Vin- (Black)</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Gnd (Green &amp; Yellow)</td>
</tr>
<tr>
<td>7</td>
<td>TX (Blue)</td>
</tr>
<tr>
<td>8</td>
<td>RX (Brown)</td>
</tr>
</tbody>
</table>

### PSU24 Power Supply Wiring

<table>
<thead>
<tr>
<th>Pin</th>
<th>Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vin+ (Black)</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Vin- (Black)</td>
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<td>4</td>
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<td>5</td>
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<td>6</td>
<td>Gnd (Green &amp; Yellow)</td>
</tr>
<tr>
<td>7</td>
<td>TX (Blue)</td>
</tr>
<tr>
<td>8</td>
<td>RX (Brown)</td>
</tr>
</tbody>
</table>

Table 1 FSO Head Power Connector

Wiring Diagram for Connection Between the PSU 24 & Laser head

[Diagram showing connection between PSU24 and Laser head with screws upwards]
3.6.5 Connecting up a serial management cable from 4GPSU to a PC

A 3 wire RS232 cable is used between the power supply and the PC. If the PC has no RS232 port, please use a suitable high quality USB-to-serial converter and follow the instructions for installing it.

Please note the following carefully. Failure to do so may cause damage the FSO Head Unit and invalidate warranty.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Cable</th>
<th>Pin</th>
<th>Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>TX (Blue)</td>
<td>2</td>
<td>RX (Brown)</td>
</tr>
<tr>
<td>3</td>
<td>RX (brown)</td>
<td>3</td>
<td>TX (Blue)</td>
</tr>
<tr>
<td>5</td>
<td>GND (Green &amp; Yellow)</td>
<td>5</td>
<td>GND (Green &amp; Yellow)</td>
</tr>
</tbody>
</table>

Table 3 Power supply RS232 pin description

Table 4 PC RS232 pin description
3.7 ATPC & CableFree FSO Alignment module

The CableFree Alignment Module is an essential element used to align CableFree FSO links. Key features of the CableFree Alignment Module include:

- Over-the-beam Voice communication circuit with inbuilt headset
- Audible alignment tones, local & remote
- Onscreen readout of signal level and other parameters, local & remote
- Control and monitoring of ATPC feature

3.7.1 Introduction to the ATPC system

The installation of a CableFree FSO link with Automatic Transmit Power Control (ATPC) requires the use of alignment modules which have inbuilt ATPC functionality. This functionality has been implemented as an interactive menu system. The ATPC menu system is accessed via the two buttons (labelled 1 and 2) located on the side of the alignment module. These buttons operate the ATPC menu system, which is summarised in the diagram at the end of this section.

3.7.2 Boot up sequence

When turning on the CableFree alignment module, it will cycle through the boot up sequence “CableFree Solutions”, “Firmware version” then “RSSI Level”. Repeatedly pressing button 1 cycles through this main menu system, which comprises of “Info”, “ATPC” and the default “RSSI Level” screen. If the alignment module receives no input from the buttons, it will default to the “RSSI Level” screen after 60 seconds.

3.7.3 Info Mode

1. From the default “RSSI Level” screen, press button 1 until the “Info” screen is displayed.
2. Press button 2 to Enter.
3. Cycle through the various information screens about the local and remote laser heads using button 1.
4. To exit this menu at any time press buttons 1 & 2 simultaneously. This will exit to the “Info” screen.

3.7.4 ATPC Mode set

The ATPC mode set has three modes of operation.

- **ATPC Manual**: This allows the local transmit power to be adjusted manually.
- **ATPC Auto**: The local transmit power is adjusted automatically to maintain a constant remote RSSI value. The default value is set between 8 and 9 bars (170 to 190 decimal) (Note the alignment module does not allow this default value to be adjusted.)
- **ATPC Off**: Turns ATPC off. The laser heads will default to maximum transmit power.

After setting any of these modes the alignment module will return to the default “RSSI Level” screen.

Note: Pressing buttons 1 & 2 simultaneously exits to previous menu, except in ATPC manual mode: See following instructions.
3.7.5 Before alignment set the laser head to ATPC Manual

1. From the default “RSSI Level” screen, press button 1 until the “ATPC” screen is displayed.
2. Press button 2 to Enter.
3. The “ATPC Manual” setting will be displayed.
4. Press button 2 to Enter.
5. This screen displays the RSSI for the remote laser head. By reducing - (pressing button 1) or increasing + (pressing button 2) the transmit power of the local laser head; the remote RSSI can be adjusted accordingly.
6. Set the manual transmit power to 0.0dB on both ends of the link.
7. Once the desired remote RSSI is achieved press buttons 1 & 2 simultaneously to select the current transmit power level.
8. “DONE!” will be displayed on the alignment module.
9. The alignment module will automatically return to the default “RSSI Level” screen.

3.7.6 After alignment set the laser head back to ATPC Auto

1. From the default “RSSI Level” screen, press button 1 until the “ATPC” screen is displayed.
2. Press button 2 to Enter.
3. “ATPC Manual” will be displayed.
4. Press button 1 until “ATPC: Auto->” is displayed.
5. Press button 2 to Select. This will set the local laser head into automatic ATPC. The laser head will automatically adjust its transmit power to maintain the remote RSSI to a preset value. The default value is between 8 and 9 bars (170 to 190 decimal). This preset value cannot be adjusted using the alignment module.
6. “ATPC -> AUTO” will be displayed and the alignment module will return to the default “RSSI Level” screen.

3.7.7 Setting the laser head to ATPC Off

1. From the default “RSSI Level” screen, press button 1 until the “ATPC” screen is displayed.
2. Press button 2 to Enter.
3. “ATPC Manual” will be displayed.
4. Press button 1 until “ATPC Off” is displayed.
5. Press button 2 to select, ATPC will be turned off and the local laser head transmit power will automatically be set to maximum.
6. “ATPC -> Off” will be displayed.
7. The alignment module will return to the default “RSSI Level” screen.
ATPC ALIGNMENT MODULE MENU SYSTEM

Boot up Sequence

Info Mode

ATPC Mode Set

Default Setting: After 60 secs alignment module will return to this.

RSSI L160 Level R 80

EXTFM: 2.004
xBKPL: 2.009

Serial L C1CD0000
Number R C1CD0001

ODU L 25.0V
Volts R 25.3V

Unit L +25.4 °C
Temp R +26.0 °C

Laser L +20.0 °C
Temp R +20.0 °C

Laser L 43 mA
Bias R 40 mA

Info:
2 = Enter
1 = Next

ATPC:
2 = Enter
1 = Next

ATPC Mode Set:

ATPC:
2 = Yes
1 = No

-> Manual?
1 = No

-> Auto?
1 = No

-> Off?
1 = No

ATPC - > Auto

ATPC - > Off

ATPC Man:
1 = -
R RSSI 80
2 = +

DONE!

Press Button 1
Press Button 2
Press Button 1 & 2 simultaneously

L Local head
R Remote head

Content © Wireless Excellence 2018  Note: Due to policy of continuous product improvement, product specifications may change without notice
3.8 Using the Pan and Tilt Adaptor

3.8.1 Introduction

CableFree FSO head units are mounted on Pan and Tilt brackets, which allow for independent vertical and horizontal axis alignment. Pan and tilt mounting brackets are adjusted via M6 bolts with a 10mm spanner or socket. When aligning CableFree FSO head units only ever align one head at a time and one axis at a time, otherwise it may take much longer than necessary.

It is recommended that the FSO head unit is fixed to the pan and tilt adapter before the pan and tilt is mounted on the bracket (wall, plinth, roof mount pole etc.). M6 bolts, washers and spring washers are all provided with the pan and tilt for fixing to the FSO head unit. Ensure not to use bolts which are too long otherwise damage to the FSO head unit may occur.

When fixing the FSO head unit to the pan and tilt adapters for the first time it is recommended to loosen the 6 x M6 side bolts (used for vertical adjustment) as the holes in the base plate will align better.

3.8.2 Aligning the Horizontal axis

The horizontal axis is held by 4 x M6 bolts (See diagram).

1. To align the horizontal axis, loosen the bolts and move the unit in the required direction.

    For speed of installation it is best to tighten only two of the 4 bolts. The front and back bolts are recommended.

2. Once the unit is aligned, tighten bolts firmly. Note ; slight movement is normal when tightening all bolts up, this can be compensated for by either setting unit beyond required position which will then move into the required position as the bolt is tightened. Or by holding the FSO head unit as the bolts are tightened.

3. Repeat steps 1 and 2 until the horizontal axis is aligned correctly.

4. Once aligned correctly, tighten all the bolts firmly, checking that alignment has not changed.

    The best way to check for alignment is to gently press up, down, left & right and check that the remote and local beeps (RSSI) decreases with each movement. Note ; it should take the same
effort to move the unit to the left and cause a certain drop in RSSI as it does to the right (and vice versa for up and down)

3.8.3 Aligning the Vertical axis
The vertical alignment is controlled by three M6 bolts on each side of the pan and tilt unit.

1. To align the vertical axis, loosen off the bolts on both sides of the mounting unit and move the unit in the required direction.

ⓘ For speed of alignment slacken off the two bolts in the “channel” on either side, leave the lower “pivot” bolt quite tight to prevent the FSO head unit from “flopping” too far.

2. Once the unit is aligned then tighten the bolts firmly. Note ; slight movement is normal when tightening all bolts up, this can be compensated for by either setting unit beyond required position which will then move into the required position as the bolt is tightened. Or by holding the FSO head unit as the bolts are tightened.

3. Repeat steps 1 and 2 until the vertical axis is aligned correctly.

4. Once the vertical axis is aligned correctly tighten all bolts firmly, checking that the alignment has not changed.

3.8.4 Fine Adjustments
In the final stages of alignment, only fine adjustments maybe necessary to achieve a maximum signal. The following guidelines give the basic instructions on slight movements, using the pan and tilt unit.

1. Slacken off only slightly the tightened bolts.

2. Apply pressure to the back of the unit in the intended direction. Apply enough pressure so the head unit is facing beyond the intended direction. This will be indicated by the RSSI level rising to its maximum and then dropping away.

3. Whilst still applying pressure retighten the bolts and the unit should spring back to the desired position. If the correct position has been obtained then the signal should be at a maximum.

⚠️ Do not over-tighten the bolts as this may cause the internal threads to be stripped.
3.9 Alignment of CableFree FSO links

Users who are familiar with other types of wireless link (radio, microwave, MMW etc) please note that alignment of FSO is more critical due to the narrower beams used in FSO technology. The reliability of the installed link will be highly dependent on the quality of the installation and precision of alignment. Please note and follow these instructions carefully.

3.9.1 Tools Required for FSO link alignment

The following items are needed to align a CableFree FSO link:

- 2x CableFree Alignment Units (Pair)
- 2x 10mm or adjustable spanners
- 2x Screwdrivers to open rear panels of unit

3.9.2 Summary of FSO alignment process

The alignment procedure of CableFree FSO systems comprises the following stages:

1. Switch the ATPC feature OFF
2. Initial “Coarse” Alignment using the Pan and Tilt Adaptor
3. Link Acquisition and Fine Alignment
4. Checking for maximum signal to ensure the link is correctly aligned
5. Switch the ATPC feature back ON

3.9.2.1 Switch the ATPC feature OFF

It is vitally important to switch OFF the ATPC feature before commencing link alignment. Otherwise, the link will continually alter the transmitted power level in an attempt to optimise the link margin. This will mean the installer cannot find the “centre” of the link and hence the alignment will be incomplete.

3.9.2.2 Initial “Coarse” Alignment & Obtaining FM lock

The main aim of these guidelines are to describe clearly the correct techniques for aligning CableFree links, so that they operate at maximum RSSI, ensuring maximum fade margins, while avoiding saturation. The units must already be mounted and correctly installed with data and power cables in place. CableFree recommend that the data cables should not be connected until the alignment process is completed and the laser heads are returned to “Data” mode. Random noise generated by the laser heads in FM mode can sometimes corrupt IP routing tables in some network equipment.

CableFree units are internally aligned in the factory, to remove “squint”. This means that both the Receive and Transmit elements of the head have been aligned parallel, as well as in focus. These guidelines are for external alignment only and do not require the FSO Head Units to be opened at any point during installation, other than the rear access panel.

1. Align the heads (see Pan and Tilt Alignment Guidelines) so that they are facing each other. Use the bottom left hand edge of the Base plate as a sighting guide, for the 1000, 2000 and 4000 models use the sighting tube attached (located bottom-left of unit).
For longer distance links, where the remote head unit is not directly visible, aim the local head unit in the general direction of the remote head i.e. at the end of a building. The main aim of this initial line up is to establish FM lock via the alignment modules.

2. Undo the M4 screws at the back of the unit and remove the rear Perspex cover.

3. Connect the alignment module to the 15 pin D-type connector.

The link has two modes of operation: FM mode which is used in the alignment process and data mode, which is used to send information once the link has been aligned. The alignment module allows the users to switch between the FM and data modes. During the installation process the FM mode allows the installers to talk to each other over the link, via the headsets.

The alignment module should not be attached whilst the unit is on. If the unit is on, turn the unit off and then attach the module, then reconnect power to the unit.)

4. Connect power via the 8-way orange connector in the unit. Make sure that the connector orientation is correct. Check that the power connector wiring is correct and that the connector orientation is correct for the specific laser head.

5. Turn the unit on via the key switch located on power supply.

The following messages will appear on the LCD display of the alignment module. The L and R stand for the Local and Remote units. The local unit refers to the unit that that alignment module is plugged into.

- **CABLEFREE SOLUTIONS**
  1) Indicates this is a CableFree product.

- **SERIAL L [xxxxxx] NUMBER R [xxxxxx]**
  2) Displays the serial numbers of each Laser head unit

- **EXTFM [xxxxxx] AX00 [xxxxxx]**
  3) Displays local alignment module and backplane firmware version.

- **ODU L [xxxxxx] VOLT R [xxxxxx]**
  4) Displays the unit temperature of both the local and remote heads

- **RSSI L [xxxxxx] LEVEL R [xxxxxx]**
  5) Displays the laser head voltage level

- **UNIT L [xxxxxx] TEMP R [xxxxxx]**
  6) Displays the laser temperature of the units.

- **LASER L [xxxxxx] TEMP R [xxxxxx]**
  7) The Received Signal Strength Indicator (RSSI) indicates the level of received signal.

The LCD display will remain on the RSSI level indicator, which shows both the bar graph reading and the digital equivalent of both the local and remote heads.
8. Switch both alignment modules into FM mode via the “FM ON” button located at the middle right hand side of the alignment module. Check that both units are receiving FM via the FM indicator light located, left hand side of the alignment module. If they are illuminated at both the local and remote ends of the link then voice communication over the link is enabled. For any problems with establishing FM lock consult the following trouble shooting guide.

! If both FM lights are on but you cannot hear the remote end of the link.
Check the following:
I. Both units are switched into FM mode.
II. The volume is turned up on the alignment module. Volume control is located at the bottom right of alignment module.
III. Turn the beeper on located at the top right hand side of the alignment module, you should be able to hear the remote beeps in your headset.

! If one or both of the FM lock lights is not on, either one or both of the units is not receiving an FM signal.
Check the following:
I. That both units are on.
II. That the units are aligned correctly. Try to realign by moving one Laser Head around to try and establish a better signal and obtain FM.
III. Check that the beam is arriving at the unit. Use a strip of Filtron (optical filter plastic used on the A/CF/G 200 and 500 optical front panel) to try and see the beam, although this only possible on the 785nm systems, as the beam is partly visible to the human eye. 980nm beams are invisible. Place the Filtron in front of your eyes and put your head level with the unit, looking towards the remote unit NOT the local unit. If the remote end unit is moved slowly, watch out for the red spot. Move the remote end around until the spot is at its brightest, so that the local unit is receiving the strongest signal or FM lock is established.

! The FM lights are on, but you hear your own voice in the headphones. This is probably due to either a feedback loop in the headset or the unit receiving a reflection of its own beam. Note : if the local unit does not detect the remote signal, a reflection can sometimes be noticed, this is usually caused by the sensitivity of the units rather than a fault

**Feedback loop check:**
I. Check the volume on the alignment module is not set too high.

**Reflections check:**
I. Check the far end of the link for any shiny or reflective surfaces behind the link, either on the building that the unit is mounted to, or on other buildings behind the head.
II. Units that are mounted inside may have reflections from the surface in front of them.
III. If the link is very short then reflections may arise from the laser heads themselves. Offsetting in minor cases or attenuation in severe cases will cure this.
3.9.2.3 Fine Alignment of the FSO link - Maximum RSSI

The following stage outlines the principles and methods for obtaining maximum RSSI. The principles are illustrated by a set of diagrams that show an effective link. The beam patterns of each of the head units is shown along with their respective RSSI. An audio headset is attached to the alignment module, shown on the diagrams to show how the beeps are transmitted over the link.

If FM lock has not been established yet or voice communication over the link is not possible see the previous section before starting this next step.

1. Turn the beeps on at one of the units, the beeper switch is located at the top of the right hand side of the alignment module. The beeps will be heard from the alignment module itself and at the remote unit through the head phones.

   The alignment module enables the local user to hear the local signal strength via the beeper, on the alignment module. The remote user can also hear the same beeps over the headphones. The units should be aligned so that it is the remote beeps that are set to a maximum i.e. listening to the beeps from the headphones. This is because the acceptance angle of the receiver marginally wider than the transmit divergence.

   ![Diagram of Headphones and Head being aligned]

   **Local Head Alignment Vertical Axis**

   2. Align only one of the heads using the beeps in the headphones for maximum RSSI. If both sets of beeps are on, turn the set off that are local to the unit that is being aligned. In the above diagram, the red unit is being aligned to the blues beeps over the headphones. In this case it is the vertical axis that is being aligned first. It can be seen that the red (local) unit must point further downwards to increase the blue (remote) units RSSI. Although when aligning for real, the beam footprint cannot be seen, so a technique for knowing in which direction the local unit must face must be used.

   The technique is as follows:

   i. The pan and tilt bolts should already be done up tight from the initial alignment.
ii. Before undoing the bolts apply pressure to the unit, up and down to check the vertical axis and left and right for the horizontal. It is done this way, so only one axis should be corrected at once. Listen for an increase in the speed and pitch of the beeps. If there is an increase then the unit must face in that direction for a stronger signal. In this case the red unit must face downwards. Finding the correct direction in which to adjust the pan and tilt before undoing the bolts is a quicker and more accurate method. It allows adjustment of only one axis at a time. Trying to adjust both axes at once could be confusing to even the most experienced installers.

iii. Once the unit has been realigned and the pan and tilt bolts are done up, repeat step ii. If there is no increase in beeps in any direction then that unit is aligned correctly.

During alignment, do not lean on the bracket for any reason, as this could cause the link to be misaligned.

3. Now the horizontal axis should be aligned the same as step 2, moving the head to where the signal is the strongest (the speed and pitch of the beeps increase). For hints on how to use the pan and tilt adapter see the section on Pan and Tilt Alignment.

Local Head Alignment Horizontal Axis

4. Repeat steps 2 and 3 until the signal is at its strongest, and then tighten the bolts on the Pan and Tilt Mounting Bracket. It is advisable to roughly align each laser head in turn several times rather than spend a long time trying to get it perfect before the remote unit is assured to be well aligned.

Now there will be two sets of beeps at both ends of the link. There will be the beeps from the local alignment module, and over the headphones will be the remote beeps. Therefore when both alignment modules are on, you can hear the signal strength at your head via local beeps and the remote units signal strength via the headphones. If the beeps are confusing, when aligning, turn off the local beeps at the end that is not being aligned so that the end that is being aligned is only being done so on the remote beeps (via headphones).
Remote Head Alignment Vertical Axis

5. Now repeat steps 1 through 4 for the other laser head.

6. Check both laser heads are perfectly aligned by gently pressing up, down, left and right on the laser head (ensure the pan and tilt bolts are tight). The link should now be aligned for maximum RSSI. The final RSSI will depend on the system being installed, the link length and the weather conditions plus other site specific factors e.g. installation through glass, etc. The figure below shows a perfectly aligned link with 10 on the bar graph.

Aligned Link: Maximum RSSI
All CableFree systems with ATPC should be installed with the highest signal strength possible, as the ATPC should be able to reduce the power levels to be below 10 bars. For systems without ATPC, aim for an RSSI no greater than 9 bars, 160 on the alignment module, otherwise there is a high risk of saturation which causes data errors. If the RSSI is higher than 185 then the link will require attenuating to prevent data loss. As can be seen in the example above this link is in saturation and would not pass data reliably. If this is the case, it is strongly advised to fit appropriate CableFree Optical Attenuator panels to the front of the units. It is strongly advised not to “offset” the links to reduce the signal level, as this technique may cause future loss of signal or saturation if the FSO units move slightly for any reason.

7. When the link has been aligned successfully make one final check to ensure the bolts are all tight then turn the power off.

8. Disconnect the alignment module and plug in the data connector.

9. Install the desiccators and indicator card in the laser head and replace the rear Perspex cover and M4 screws and tighten the screws. Note: ensure you do not lose any of the screws, and ensure that ALL of them are re-inserted to secure the rear Perspex cover, or water may leak in. Make one final check to ensure the units are water proof around the rear cover and the cable entry gland.

10. Turn the units back on again.

3.9.2.4 Checking for Maximum Signal

To check that the unit is right in the middle of the beam footprint the following checks should be carried out and will only require very fine alignment. To check the vertical axis, apply equal pressure up and down on the unit, the same drop in beeps should be heard providing that the receiver is in the centre of the beam footprint. The same drop should also be heard for the horizontal axis when applying pressure to the left and right of the unit.

1. If there is not an equal drop in the frequency of beeps the unit should be re aligned in the direction of the higher frequency of beeps.

2. When pushing in a certain direction and no drop is heard but when pushing in the opposite direction a drop is heard, then the unit should be slightly repositioned in the direction where there was no drop in the frequency of beeps, so that an equal drop is heard.

3.9.2.5 Switch the ATPC feature ON

After alignment is complete, it is important to switch ON the ATPC feature (set to AUTO mode) before commencing link alignment. Otherwise, the link will operate at a fixed output power, and cannot optimise the link margin. This will mean the link will have restricted fade margin and may suffer outage and unavailability in poor weather conditions.
3.10 Troubleshooting an FSO link

CableFree FSO links are designed for long-term unattended operation and when properly installed are extremely reliable, giving customers many years of trouble-free performance. The FSO units feature solid-state electronics and have no moving parts. They have no user-serviceable parts inside.

In most cases, any “Troubleshooting” is encountered during commissioning of the links when they are attached to complex customer networks or third party equipment, or later in service when any major network change has been made. Troubleshooting may also be needed in rare cases where units have been damaged or are faulty.

3.10.1 Interface cards

General Guidelines

If once the link has been aligned and the data leads connected, the link does not appear to pass data, then the following guidelines should be used to correct this problem. They are divided into three main sections; power, interface cards, and alignment. All are dealt with one at a time and should be followed through logically. Each section is labelled with either one or more of the following sub headings:

- **Network**: dealing with switching and network problems,
- **Cabling**: dealing with cables (Power, UTP, FIBRE (SC,ST,)) that run between the network and the CableFree link
- **CableFree**: CableFree equipment.

3.10.1.1 Does the LASER HEAD have power?

Check power indicator on the interface card (depends on card type – normally red LED)

**NO**
- **CableFree**: Check that the power supply LED indicator is on.
  - NOT ON: Check the fuse, and change if necessary and check that the cable is plugged in.
  - ON: **Cabling**: Check that the power cable running to the heads is not damaged and that it is connected properly.
- **CableFree**: Attach alignment module (see ALIGNMENT GUIDELINES section 3) and check the power indicator and the LCD screen, if this is on but the interface card is not on, contact CableFree technical support.

**YES**
- **IS THE INTERFACE CARD LINK LIGHT ON?**
  Check link light on the interface card is on (depends on card type – normally green LED)

**NO**
- **CableFree**: Loop the link back on its self.
  Connect the output to the input. Note some interface cards do not generate idle signal so cannot be used in the loop back mode unless traffic is injected at the remote end and transferred over the link. (SEE TABLE)
• **Cabling:** Run a tester on the cabling, disconnecting it from the network and the CableFree equipment. Test it at the data rate of the link. If there is a problem with the cabling replace if possible, if not check that the network is configured using the following guidelines

For Ethernet check the following cable connections

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Ethernet</th>
<th>Fast Ethernet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link to hub/switch</td>
<td>Crossed</td>
<td>Straight</td>
</tr>
<tr>
<td>Link to PC</td>
<td>Straight</td>
<td>Crossed</td>
</tr>
</tbody>
</table>

**UTP Patch Cord Configuration**

• **Network:** Check the customer network configurations.
  1. Ensure that the switch is switched to full duplex
  2. Auto negotiate is switched off.
  3. Set data rate at the link speed
  4. Change port on the switch to make sure that the switch is operating correctly.
  5. Power cycle switch to ensure the configuration is not corrupted.

For further information on switches consult the relevant manufacturers guidelines or technical support service

**YES**

• **IS THE LINK CORRECTLY ALIGNED?**
  **Cablefree:** Check that the RSSI level ranges from 1 to 9 on the Bar graph, or 20 to 200 on the alignment module.

**NO**

• **SEE ALIGNMENT GUIDELINES**

**YES**

• Contact vendors for technical support.

Note that these are only guidelines to ensure that the link is transmitting and receiving data. For error checking data, an error tester must be run over the system. The commissioning guidelines outline possible tests, depending on the requirements of the end user, to ensure error free data transfer.
3.11 Maintenance of CableFree FSO links

CableFree FSO links are designed for long-term unattended operation and when properly installed are extremely reliable, giving customers many years of trouble-free performance. The FSO units feature solid-state electronics and have no moving parts. They have no user-serviceable parts inside.

General maintenance of CableFree units is minimal, and is somewhat dependent upon the environment under which the units operate. For dirtier environments such as cities and industrial sites it is important to keep the front optical face of the unit clean, as a dirty front face plate can lead to a significant fall in RSSI levels on both units.

The front face plate of a CableFree system should be wiped with a clean, damp lint-free cloth at periodic intervals. In clean environments, this may be once a year, but were dirt or sea salt deposits are likely this should be performed more frequently.

As CableFree systems are precise optical systems containing complex electronics it is important that the inside of these units should be kept dry. This is particularly important in environments were the unit is exposed to a lot of rain or moisture i.e. in humid or wet countries. Moisture can cause faults in the electronics as well as condensation on the lenses that would result in a drop of the RSSI levels.

- Change desiccators when indicator shows or approximately every 6 months.

The most common cause of problems with CableFree links in the alignment. This should be checked at the same time as the desiccators and front screen. Follow alignment guidelines

- Check alignment when the desiccators have been changed, by looking at the RSSI levels.

CableFree FSOmanager software allows remote diagnostics via a PC, connected to the RS232 port or remote access from the NMC (Network Management Centre) via dialup modem or Ethernet connection. This software aids maintenance greatly by providing link statistics such as RSSI of both the local and remote heads. This is very important in links where either one or both of the head units are hard to access. So that a drop in the RSSI level can be seen without actual access required to the head. Other link statistics are provided and can help in the preventative maintenance, such as LASER bias levels, power supply and link interruptions.

3.12 Servicing CableFree FSO units

The FSO units feature solid-state electronics and have no moving parts. They have no user-serviceable parts inside. Modular swap-out of items can be effected as follows:

- A complete FSO unit can be swapped out with a maintenance spare unit.
- The interface module can be replaced, in the rare event that damage to the card has occurred.
- The power supplies (PSU) can be replaced, in the rare event that they are damaged.

A range of advanced replacement and spare unit options are available. Please contact Wireless Excellence for any more information about servicing and support options for CableFree products.
# Appendix

## 4.1 Abbreviations & Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATPC</td>
<td>Automatic Transmit Power Control</td>
</tr>
<tr>
<td>AIS</td>
<td>Alarm Indication Signal</td>
</tr>
<tr>
<td>BER</td>
<td>Bit Error Rate</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>dB</td>
<td>Decibel</td>
</tr>
<tr>
<td>dBm</td>
<td>Decibel relative to 1 mW</td>
</tr>
<tr>
<td>DCE</td>
<td>Data Circuit-Terminating Equipment</td>
</tr>
<tr>
<td>DTE</td>
<td>Data Terminal Equipment</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>LED</td>
<td>Light-emitting diode</td>
</tr>
<tr>
<td>LOS</td>
<td>Line of Sight</td>
</tr>
<tr>
<td>MIB</td>
<td>Management Information Base</td>
</tr>
<tr>
<td>ms</td>
<td>Millisecond</td>
</tr>
<tr>
<td>NMS</td>
<td>Network Management System</td>
</tr>
<tr>
<td>OAM&amp;P</td>
<td>Operations, Administration, Maintenance, and Provisioning</td>
</tr>
<tr>
<td>ODU</td>
<td>Outdoor Unit</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed circuit board</td>
</tr>
<tr>
<td>POP</td>
<td>Point of Presence</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>RSL</td>
<td>Received Signal Level (in dBm)</td>
</tr>
<tr>
<td>RSSI</td>
<td>Received Signal Strength Indicator/Indication</td>
</tr>
<tr>
<td>RX</td>
<td>Receiver</td>
</tr>
<tr>
<td>SDH</td>
<td>Synchronous Digital Hierarchy</td>
</tr>
<tr>
<td>SNMP</td>
<td>Simple Network Management Protocol</td>
</tr>
<tr>
<td>SNR</td>
<td>Signal-to-Noise Ratio</td>
</tr>
<tr>
<td>IDU</td>
<td>Software Defined Indoor Unit (CableFree Solutions trademark)</td>
</tr>
<tr>
<td>STM-1</td>
<td>Synchronous Transport Module 1</td>
</tr>
<tr>
<td>TCP/IP</td>
<td>Transmission Control Protocol/Internet Protocol</td>
</tr>
<tr>
<td>TX</td>
<td>Transmitter</td>
</tr>
</tbody>
</table>
IN CASE OF DIFFICULTY...

Wireless Excellence products are designed for long life and trouble-free operation. However, this equipment, as with all electronic equipment, may have an occasional component failure. The following information will assist you in the event that servicing becomes necessary.

TECHNICAL ASSISTANCE

Technical assistance for Wireless Excellence products is available from our Technical Support Department by phone or email. When calling, please give the complete model number of the radio, along with a description of the trouble/symptom(s) that you are experiencing. In many cases, problems can be resolved over the telephone, without the need for returning the unit to the factory. Please use one of the following means for product assistance:

Phone: +44 (0)870 4959169
E-Mail: support@cablefree.net
FAX: +44 (0)1865 989013
Web: http://www.cablefree.net

For all sales related questions please call your sales representative or for general inquiries please email info@cablefree.net

FACTORY SERVICE

Component level repair of radio equipment is not recommended in the field. Many components are installed using surface mount technology, which requires specialized training and equipment for proper servicing. For this reason, the equipment should be returned to the factory for any PC board repairs. The factory is best equipped to diagnose, repair and align your radio to its proper operating specifications.

If return of the equipment is necessary, you will be issued a Returned Materials Authorisation (RMA) number and return shipping address. The RMA number will help expedite the repair so that the equipment can be repaired and returned to you as quickly as possible. Please be sure to include the RMA number on the outside of the shipping box, and on any correspondence relating to the repair. No equipment will be accepted for repair without an RMA number.

A statement should accompany the radio describing, in detail, the trouble symptom(s), and a description of any associated equipment normally connected to the radio. It is also important to include the name and telephone number of a person in your organization who can be contacted if additional information is required.

The radio must be properly packed for return to the factory. The original shipping container and packaging materials should be used whenever possible.