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LANCOM L-320agn Wireless LANCOM L-321agn Wireless LANCOM L-322agn dual Wireless

- Handbuch
- Manual

LANCOM L-320agn Wireless
LANCOM L-321agn Wireless
LANCOM L-322agn dual Wireless

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Wuerselen, Juli 2011

Preface

Thank you for your confidence in us!

LANCOM L-320agn Wireless, LANCOM L-321agn Wireless and LANCOM L-322agn dual Wireless are professional access points that provide a maximum wireless LAN performance of up to 300 Mbps thanks to the support of the IEEE 802.11n standard. The access points operate either in the 2.4 GHz or in the 5 GHz frequency band. LANCOM L-322agn dual Wireless works with two integrated radio modules (two IEEE 802.11agn), both of which can operate simultaneously in the 2.4- and/or 5 GHz frequency range. The 5 GHz band is not used as much and, offering a larger number of channels, it provides better opportunities to establish non-overlapping wireless cells. The L-32x Access Point series models can operate in stand-alone mode, in managed mode or in client mode. The access point can be used in managed mode with a LANCOM WLAN Controller without any additional software upgrades.

The 802.11n standard includes many new mechanisms—such as the use of MIMO, 40-MHz channels, packet aggregation and block acknowledgment—in order to increase the bandwidth available for user applications significantly. This allows a more than fivefold increase in speed over 802.11a/g networks with physical data rates of up to 300 Mbps.

MIMO (multiple input multiple output) technology allows the L-32x Access Point to transfer several data streams in parallel and thus significantly improve data throughput. MIMO uses several transmit/receive units for both the transmitter and the receiver. The separate data streams are identified by unique characteristics that result from the different paths that the data take. By processing multiple data streams MIMO achieves not just higher data throughput but also better coverage (fewer "radio black spots") and better stability. These are the most important arguments for 802.11n for commercial customers in particular.

Model variants

This documentation is intended for L-32x Access Point users. The following models are available:

- The LANCOM L-320agn Wireless with two integrated antennas.
- The LANCOM L-321agn Wireless with two external antennas.
- The LANCOM L-322agn dual Wireless with two WLAN modules and four external antennas.

Model
restrictions

Passages applying only to certain models are identified either in the text itself or by a comment in the margin.

Otherwise the documentation refers to all models collectively as the L-32x Access Point series.

Security settings

To maximize the security available from your product, we recommend that you undertake all of the security settings (e.g. firewall, encryption, access protection) that were not already activated when you purchased the product. The LANconfig Wizard 'Security Settings' will help you with this task. Further information is also available in the chapter 'Security settings'.

We would additionally like to ask you to refer to our Internet site www.lancom.eu for the latest information about your product and technical developments, and also to download our latest software versions.

Components of the documentation

The documentation of your device consists of the following parts:

- Installation Guide
- User manual
- Menu Reference Guide

You are now reading the user manual. It contains all information you need to put your device into operation. It also contains all of the important technical specifications.

The Reference Manual is to be found as an Acrobat document (PDF file) at www.lancom.eu/download or on the CD supplied. It is designed as a supplement to the user manual and goes into detail on topics that apply to a variety of models. These include, for example:

- The system design of the operating system LCOS
- Configuration
- Management
- Diagnosis
- Security
- Routing and WAN functions
- Firewall
- Quality of Service (QoS)
- Virtual Local Networks (VLAN)

- Wireless networks (WLAN)
- Backup solutions
- Further server services (DHCP, DNS, charge management)

The Menu Reference Guide (also available at www.lancom.eu/download or on the CD supplied) describes all of the parameters in LCOS, the operating system used by LANCOM products. This guide is an aid to users during the configuration of devices by means of WEBconfig or the telnet console.

This documentation was created by ...

... several members of our staff from a variety of departments in order to ensure you the best possible support when using your LANCOM product.

Should you find any errors, or if you would like to suggest improvements, please do not hesitate to send an e-mail directly to:

info@lancom.eu



Our online services www.lancom.eu are available to you around the clock if you have any questions on the content in this manual, or if you require any further support. The area 'Support' will help you with many answers to frequently asked questions (FAQs). Furthermore, the knowledgebase offers you a large reserve of information. The latest drivers, firmware, utilities and documentation are constantly available for download.

In addition, LANCOM Support is available. For telephone numbers and contact addresses for LANCOM Support, please refer to the enclosed leaflet or the LANCOM Systems Web site.

Information symbols



Very important instructions. Failure to observe these may result in damage.



Important instruction that should be observed.



Additional information that may be helpful but is not essential.

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1 Introduction

1.1 What is a wireless LAN?



The following sections describe the functionality of wireless networks in general. You can see from the table 'What your LANCOM can do' further below which functions your device supports. Please refer to the reference manual for further information on this topic.

A wireless LAN connects individual end-user devices (PCs and mobile computers) to form a local network (also called – **Local Area Network**). In contrast to a traditional LAN, communication takes place over a wireless connection and not over network cables. For this reason it is called a **Wireless Local Area Network (WLAN)**.

A wireless LAN provides the same functionality as a cable-based network: Access to files, servers, printers etc. as well as the integration of individual work stations into a corporate mail system or access to the Internet.

There are obvious advantages to wireless LANs: Notebooks and PCs can be installed where they are needed—problems with missing connections or structural changes are a thing of the past with wireless networks.

Apart from that, wireless LANs can also be used for connections over longer distances. Expensive leased lines and the associated construction measures can be saved.



LANCOM Wireless Routers and LANCOM Access Points can be operated either as self-sufficient Access Points with their own configuration (WLAN modules in "Access Point mode") or as components in a WLAN infrastructure, which is controlled from a central WLAN-Controller ("managed mode").

Split management can be used to separate the WLAN configuration from the rest of the router configuration. This allows router settings and VPN settings to be adjusted locally, for example in a branch office or home office installation, and the WLAN configuration is regulated by a LANCOM WLAN Controller at the main office.

Please observe the corresponding notices to this in this documentation or in the LCOS reference manual.

1.1.1 Modes of operation of wireless LANs and access points

Wireless LAN technology and access points in wireless LANs are used in the following modes of operation:

- Simple, direct connection between terminal devices with an access point (ad-hoc mode)
- Extensive wireless LANs, possibly connected to a LAN, with one or more access points (infrastructure network)
- Establishing access to the Internet
- Connecting two LANs over a wireless link (point-to-point mode)
- Connecting devices with an Ethernet interface via an access point (client mode)
- Extending an existing Ethernet network with a wireless LAN (bridge mode)
- WDS (Wireless Distribution Systems)
- Central administration using a LANCOM WLAN Controller

1.2 Wireless LANs in accordance with 802.11n

The new wireless LAN standard IEEE 802.11n—ratified as „WLAN Enhancements for Higher Throughput“ in september 2009—features a number of technical developments that promise up to six-times the performance in wireless LANs.

Some of the improvements refer to the physical layer (PHY), which describes the transmission of individual bits over the physical medium—in this case the air represents the physical medium. Other additions are concerned with the MAC (medium access control) that among other things governs access to the transmission medium. The two areas are treated separately below.



You can find additional information on this subject in the LCOS reference manual or in the technical papers relating to this topic.

1.2.1 Advantages of 802.11n

The new technology includes the following advantages:

■ Higher effective data throughput

The 802.11n standard includes a number of new mechanisms to significantly increase available bandwidth. Current wireless LAN standards based on 802.11a/g enable physical data rates (gross data rates) of up to 54 Mbps, which turn out to be approx. 22 Mbps net. Networks based on

802.11n **currently** achieve a gross data throughput of up to 300 Mbps (in reality approx. 120 to 130 Mbps net) – theoretically the standard defines up to 600 Mbps with four data streams. For the first time, maximum speeds exceed the 100 Mbps of cable-based Fast Ethernet networks, which are currently standard in most workplaces.

■ Improved and more reliable wireless coverage

The new 802.11n technologies do not just increase data throughput but bring about improvements in the range and reduce the wireless dead spots in existing a/b/g installations.

This results in better signal coverage and improved stability for significantly better utilization of wireless networks, in particular for users in professional environments.

■ Greater range

Data throughput generally decreases when the distance between receiver and transmitter increases. The overall improved data throughput allows wireless LANs based on 802.11n to achieve greater ranges, as a significantly stronger wireless signal is received by the Access Point over a given distance than in 802.11a/b/g networks.

1.2.2 Compatibility with other standards

The 802.11n standard is backwardly compatible to previous standards (IEEE 802.11a/b/g). However, some of the advantages of the new technology are only available when, in addition to the access points, the wireless LAN clients are also compatible with 802.11n.

In order to allow the co-existence of wireless LAN clients based on 802.11a/b/g (called "legacy clients") 802.11n access points offer special mechanisms for mixed operation, where performance increases over 802.11a/b/g are not as high. Only in all-802.11n environments is the "greenfield mode" used, which can exploit all the advantages of the new technology. In greenfield mode both access points and wireless LAN clients support the 802.11n standard, and access points reject connections with legacy clients.

1.2.3 The physical layer

The physical layer describes how data must be transformed in order for them to be transmitted as individual bits over the physical medium. In this process the following steps are performed in a wireless LAN device:

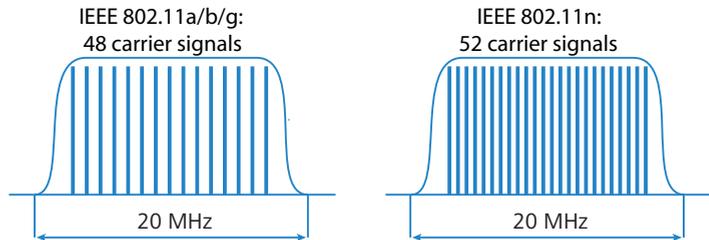
- Modulation of digital data into analog carrier signals
- Modulation of the carrier signal into a radio signal in the selected frequency band, which for a wireless LAN is either 2.4 or 5 GHz.

The second modulation step in IEEE 802.11n occurs in the same way as in conventional wireless LAN standards and is therefore not covered here. However, there are a number of changes in the way digital data are modulated into analog signals in 802.11n.

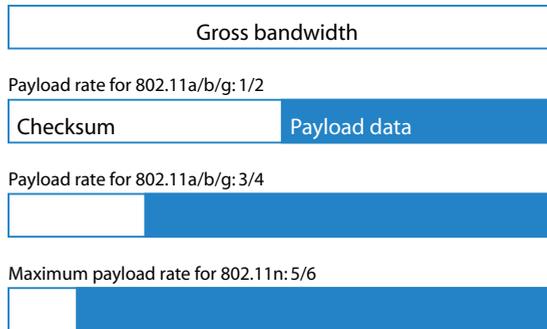
Improved OFDM modulation (MIMO-OFDM)

Like 802.11a/g, 802.11n uses the OFDM scheme (Orthogonal Frequency Division Multiplex) as its method of modulation. This modulates the data signal not on just one carrier signal but in parallel over several. The data throughput that can be achieved with OFDM modulation depends on the following parameters, among other things:

- Number of carrier signals: Whereas 802.11a/g uses 48 carrier signals, 802.11n can use a maximum of 52.



- Payload data rate: Airborne data transmission is fundamentally unreliable. Even small glitches in the WLAN system can result in errors in data transmission. Check sums are used to compensate for these errors, but these take up a part of the available bandwidth. The payload data rate indicates the ratio between theoretically available bandwidth and actual payload. 802.11a/g can operate at payload rates of 1/2 or 3/4 while 802.11n can use up to 5/6 of the theoretically available bandwidth for payload data.

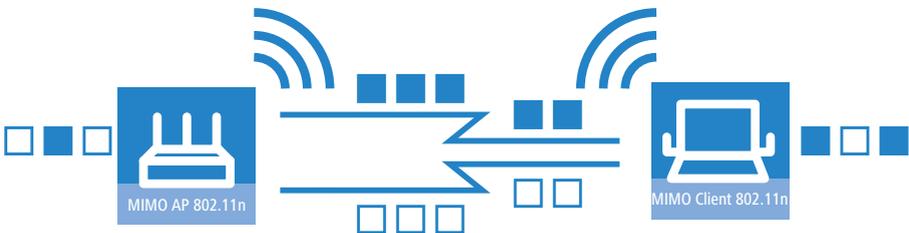


These two features increase the maximum useable bandwidth of 54 Mbps for 802.11a/g to 65 Mbps for 802.11n. This increase is not exactly spectacular, but it can be further improved by using the following features:

MIMO technology

MIMO (multiple input multiple output) is the most important new technology contained in 802.11n. MIMO uses several transmitters and several receivers to transmit up to four parallel data streams on the same transmission channel (currently only two parallel data streams have been implemented). The result is an increase in data throughput and improved wireless coverage.

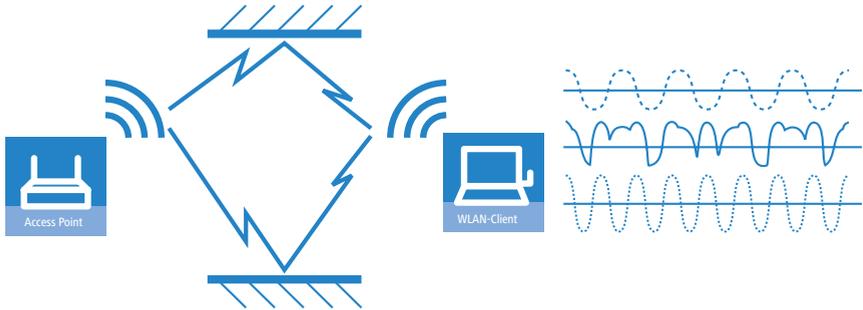
For example, the Access Point splits the data into two groups which are then sent simultaneously via separate antennas to the WLAN client. Data throughput can therefore be doubled using two transmitting and receiving antennas.



But how can several signals be transmitted on a single channel simultaneously? This was considered impossible with previous WLAN applications.

Let us consider how data is transmitted in "normal" wireless LAN networks: Depending on antenna type, an Access Point's antenna broadcasts data in several directions simultaneously. These electromagnetic waves are reflected

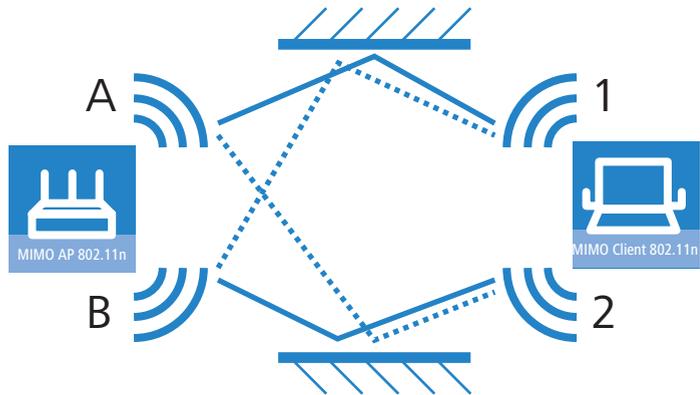
by the surrounding surfaces causing a broadcast signal to reach the WLAN client's antenna over many different paths; this is also referred to as "multipath propagation". Each of these paths has a different length meaning that individual signals reach the client with a different time delay.



These time-delayed signals interfere with each other at the WLAN client and significantly weaken the original signal. For this reason, conventional WLAN networks should always have a direct line of sight (LOS) between transmitter and receiver in order to reduce the influence of reflections.

MIMO technology transforms this weakness in WLAN transmission into a strength that allows an enormous increase in data throughput. As mentioned above, it is virtually impossible to transmit different signals on the same channel simultaneously as the receiver cannot distinguish between them. MIMO uses the reflection of electromagnetic waves and the associated spatial aspect to obtain a third criterion for identifying the signals.

A signal sent by transmitter A and received by receiver 1 follows a different path than a signal from transmitter B to receiver 2. Due to the different reflections and changes in polarization that both signals experience along their paths, each of these paths takes on its own characteristics. When data transmission starts, a training phase records the characteristics of the path by transmitting standardized data. Subsequently, the data received here is used to calculate which data stream the signals belong to. The receiver decides for itself which of the incoming signals is to be processed, thus avoiding loss from interference.



MIMO thus allows the simultaneous transmission of several signals over one shared medium, such as the air. Individual transmitters and receivers must be positioned a minimum distance apart from one another, although this is just a few centimeters. This separation results in differing reflections and signal paths that can be used to separate the signals.

Generally speaking, MIMO can provide up to four parallel data streams, which are also called "spatial streams". However, the current generation of chips can only implement two parallel data streams as the separation of data streams based on characteristic path information demands high levels of computing power, which consumes both time and electricity. The latter tends to be undesirable particularly for WLAN systems, where attempts are often made to achieve independence from power sockets at the WLAN client or when using PoE as the electricity supply for the Access Point.

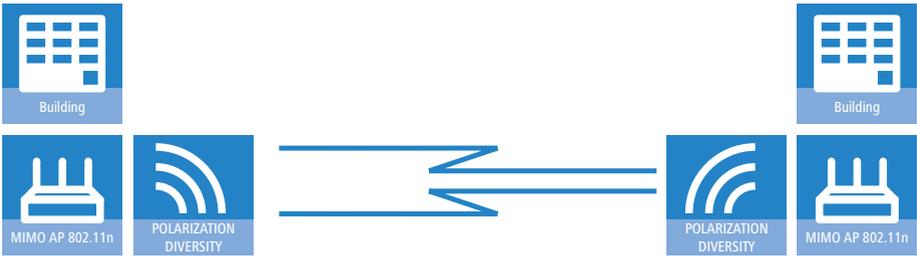
Even if the aim of four spatial streams has not yet been achieved, the use of two separate data connections results in a doubling of data throughput, which represents a true technological leap in the area of WLAN systems. Combined with the improvements in OFDM modulation, the data throughput that can be attained increases to 130 Mbps.

The short description "transmitter x receiver" expresses the actual number of transmitting and receiving antennas. 2x2 MIMO describes two transmitting and two receiving antennas.

MIMO in outdoor use

Outdoor 802.11n applications cannot use natural reflections since signal transmission usually takes place over the direct path between directional

antennas. In order to transmit two data streams in parallel, special antennas are employed that use polarization channels turned through 90° to each other. These so-called "dual-slant" antennas are really two antennas in one housing. Since a third signal does not offer additional reliability, outdoor applications generally use as many antennas (or polarization channels) as there are data streams for transmission.



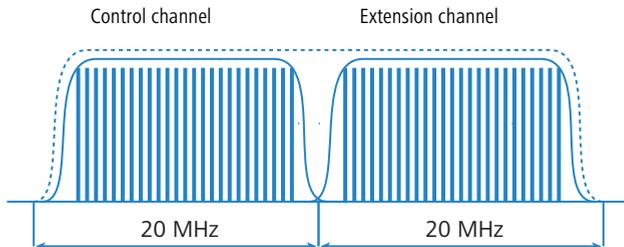
40 MHz channels

As the above explanation of OFDM modulation states, data throughput rises with an increasing number of carrier signals because this allows several signals to be transmitted simultaneously. If a channel with a bandwidth of 20 MHz supports no more than 48 (802.11a/g) or 52 (802.11n) carrier signals, the obvious choice would be to use a second channel with additional carrier signals.

This method was used in the past by a number of manufacturers (including LANCOM Systems) and was referred to as "turbo mode", allowing data rates of up to 108 Mbps. Turbo mode does not form part of the official IEEE standard but is frequently employed on point-to-point connections, for example, because compatibility to other manufacturers tends to play a secondary role.

However, the success of the underlying technology has led to its incorporation into 802.11n. IEEE 802.11n uses the second transmission channel in a way that maintains compatibility to IEEE 802.11a/g devices. 802.11n transmits data over two contiguous channels. One of these assumes the task of a control channel that, among other things, handles the administration of data transmission. Concentrating these basic tasks into the control channel means that devices supporting a transmission at 20 MHz only can also be connected. The second channel is an extension that only comes into effect if the remote client also supports data transmission at 40 MHz. The use of the

second channel remains optional throughout, with transmitter and receiver deciding dynamically whether one or two channels should be employed.

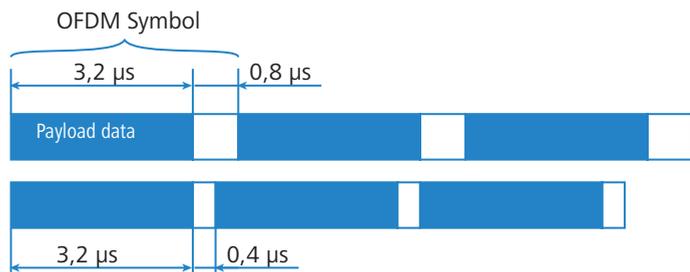


As the implementation of 40 MHz with separate control and extension channels is more efficient in the 802.11n standard than in the conventional turbo mode, more than double the amount of carrier signals can be obtained (108 in total). The maximum data throughput when using improved OFDM modulation and two parallel data streams thus rises to 270 Mbps.

Short guard interval

The final improvement of the 802.11n standard is the improvement in the chronological sequence of data transmission. A signal that is to be transmitted in a WLAN system is not broadcast at a distinct point in time but is "held up" for a certain, constant transmission period. In order to prevent interference at the receiving end, a short break is made following the transmission period before the transmission of the next signal commences. The entire duration of transmission period and break are referred to in WLAN terminology as "symbol length" and the break itself is known as the "guard interval".

IEEE 802.11a/g uses a symbol length of 4 μ s: the information transmitted on the carrier signal changes following transmission of 3.2 μ s and a break of 0.8 μ s. 802.11n reduces the break between transmissions to the so-called "short guard interval" of only 0.4 μ s.



Transmitting data in shorter intervals thus increases the maximum data throughput when using improved OFDM modulation, two parallel data streams and transmission at 40 MHz to 300 Mbps.

1.2.4 The MAC layer

Frame aggregation

The improvements in the physical layer brought about by the new 802.11n initially describe only the theoretical data throughput of the physical medium. However, the share of this theoretical bandwidth that is actually available for payload data is limited by two factors:

- in addition to the actual payload data, each data packet in a wireless LAN system contains additional information such as a preamble and MAC address information.
- Time is lost to the management events that occur when the transmission medium is actually accessed. Thus the transmitter must negotiate access authorization with the other receivers before transmitting each data packet (frame); further delays are caused by data packet collisions and other events.

This loss, referred to as "overhead", can be reduced by combining several data packets together to form one large frame and transmitting them together. In this process, information such as the preamble are only transmitted once for all the combined data packets and delays due to negotiating access to the transmission medium only occur at longer intervals.

The use of this method, known as frame aggregation, is subject to certain restrictions:

- As information such as MAC address only needs to be transmitted once for the aggregated frame, only those data packets intended for the same address can be combined.
- All data packets that are to be combined into a single large frame must be available at the sender at the time of aggregation—as a consequence some data packets may have to wait until enough data packets for the same destination are available with which they can be combined. This aspect may represent a significant limitation for time-critical transmissions such as voice over IP.

Block acknowledgement

Each data packet directed to a specific address (i.e. not broadcast or multicast packets) is acknowledged immediately after receipt. In this way, the transmitter is informed that the packet was received correctly and does not need to be repeated. This principle also applies to aggregated frames in 802.11n.

Two different methods are used for frame aggregation. These are not explained in detail here, but they differ in the way aggregated frames are acknowledged.

- Mac Service Data Units Aggregation (MSDUA) combines several Ethernet packets together to form one common wireless LAN packet. This packet is acknowledged only once and the acknowledgment is valid for all aggregated packets. If there is no acknowledgement the whole block is resent.
- Mac Protocol Data Units Aggregation (MPDUA) combines individual wireless LAN packets together to form one large common wireless LAN packet. In this case, each wireless LAN packet is acknowledged and the acknowledgements are combined and transmitted as a block. In contrast to MSDUA, the sender receives information about the receipt status of every single WLAN packet and can, if necessary, resend only those specific packets that were not successful.

1.3 What can your LANCOM do?

The following table shows the properties and functions of your device.

	LANCOM L-320agn Wireless	LANCOM L-321agn Wireless	LANCOM L-322agn dual Wireless
Applications			
Expansion of the LAN through WLAN (infrastructure mode)	✓	✓	✓
WLAN via point-to-point	✓	✓	✓
Relais mode with two WLAN modules			✓
Relais mode with one WLAN modules (WDS mixed mode)	✓	✓	✓
Internet Access	✓	✓	✓
IP router with Stateful Inspection Firewall	✓	✓	✓

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	LANCOM L-320agn Wireless	LANCOM L-321agn Wireless	LANCOM L-322agn dual Wireless
DHCP and DNS server (for LAN and WLAN)	✓	✓	✓
N:N mapping for routing networks with the same IP-address ranges over VPN	✓	✓	✓
Policy-based routing	✓	✓	✓
Backup solutions and load balancing with VRRP	✓	✓	✓
PPPoE Server	✓	✓	✓
WAN RIP	✓	✓	✓
Spanning Tree protocol	✓	✓	✓
Layer 2 QoS tagging	✓	✓	✓
WLAN			
Wireless transmission by IEEE 802.11g and IEEE 802.11b	✓	✓	✓
Wireless transmission by IEEE 802.11a and IEEE 802.11h	✓	✓	✓
Wireless transmission by IEEE 802.11b/g and IEEE 802.11a/h at the same time			✓
Wireless transmission by IEEE 802.11n (including 40 MHz channels, packet aggregation, block acknowledgement, short guard interval)	✓	✓	✓
Internal antennas	✓		
External antennas and connector for AirLancer Extender-Antennen		2	4
Point-to-point mode (six P2P paths can be defined per WLAN interface)	✓	✓	✓
Access point mode	✓	✓	✓
Client mode	✓	✓	✓
Managed mode for central configuration of WLAN modules by a WLAN Controller	✓	✓	✓
Multi SSID	✓	✓	✓
Roaming function	✓	✓	✓
802.11i / WPA with hardware AES encryption	✓	✓	✓

	LANCOM L-320agn Wireless	LANCOM L-321agn Wireless	LANCOM L-322agn dual Wireless
WEP encryption (up to 128 Bit key length, WEP152)	✓	✓	✓
IEEE 802.1x/EAP	✓	✓	✓
MAC address filter (ACL)	✓	✓	✓
Individual passphrases per MAC address (LEPS)	✓	✓	✓
Closed network function	✓	✓	✓
Integrated RADIUS server	✓	✓	✓
VLAN	✓	✓	✓
Intra-Cell Blocking	✓	✓	✓
WLAN QoS (IEEE 802.11e, WME)	✓	✓	✓
LAN Connection			
Gigabit ethernet connector 10/100/1000 Base-TX, autosensing, auto node-hub, PoE by IEEE 802.3af	1	1	1
Fast Ethernet LAN port (10/100Base-TX), Autosensing, Auto Node-Hub, PoE by IEEE 802.3af			1
Power over Ethernet (PoE)	✓	✓	2x redundant
DHCP and DNS server	✓	✓	✓
WAN Connection			
Connection for DSL or cable modem	✓	✓	✓
Connection for serial modem	✓	✓	✓
Internet access (IP router)			
Stateful-Inspection Firewall	✓	✓	✓
Firewall filters (IP addresses, ports)	✓	✓	✓
IP masquerading (NAT, PAT)	✓	✓	✓
Quality of Service	✓	✓	✓

■ Chapter 1: Introduction

	LANCOM L-320agn Wireless	LANCOM L-321agn Wireless	LANCOM L-322agn dual Wireless
Configuration and firmware			
Configuration with LANconfig or with web browser, additionally terminal mode for Telnet or other terminal programs, SNMP interface and TFTP server function., SSH connection.	✓	✓	✓
Setup wizards	✓	✓	✓
FirmSafe with firmware versions for absolutely secure software upgrades	✓	✓	✓
Monitoring and management of the WLAN with Rogue AP Detection	✓	✓	✓
Optional software extensions			
LANCOM Public Spot Option	✓	✓	✓
LANCOM 2-Year Warranty Extension	✓	✓	✓
LANCOM Next Business Day Service Extension	✓	✓	✓
Optional hardware extensions			
AirLancer Extender antennas for increased range	✓	✓	✓
LANCOM PoE Power Injector (100 MBit/s)	✓	✓	✓
LANCOM PoE Power Injector (1 GBit/s)	✓	✓	✓
LANCOM ES-1108P, 8 port switch with 4 PoE ports (100 MBit/s)	✓	✓	✓
LANCOM ES-2126, managed 24 port switch (100 MBit/s)	✓	✓	✓
LANCOM ES-2126P, managed 24 port switch with 24 PoE-Ports (100 MBit/s)	✓	✓	✓
LANCOM Serial Adapter Kit for connection of analog or GSM modems to the serial interface	✓	✓	✓

2 Installation

This chapter will assist you to quickly install hardware and software. First, check the package contents and system requirements. The device can be installed and configured quickly and easily if all prerequisites are fulfilled.

2.1 Package contents

Please check the package contents for completeness before starting the installation. In addition to the LANCOM Wireless Router itself, the package should contain the following accessories:

	LANCOM L-320agn Wireless	LANCOM L-320agn Wireless	LANCOM L-322agn dual Wireless
12V DC Power adapter	✓	✓	✓
Ethernet LAN connector cable (green plugs)	✓	✓	✓
LANCOM CD	✓	✓	✓

If anything is missing, please contact your retailer or the address stated on the delivery slip of the unit.

2.2 System requirements

2.2.1 Configuring the LANCOM devices

Computers that connect to a LANCOM must meet the following minimum requirements:

- Operating system with TCP/IP support, such as Windows, Linux, BSD Unix, Apple Mac OS, OS/2.
- Access to the LAN via the TCP/IP protocol.
- Wireless LAN adapter or LAN access (if the access point is to be connected to the LAN).



The LANtools also require a Windows operating system. A web browser under any operating system provides access to WEBconfig.

2.2.2 Operating access points in managed mode

LANCOM Wireless Routers and LANCOM Access Points can be operated either as self-sufficient Access Points with their own configuration ("Access Point mode") or as components in a WLAN infrastructure, which is controlled from a central WLAN-Controller ("managed mode").

2.3 Status displays and interfaces

Meanings of the LEDs

In the following sections we will use different terms to describe the behaviour of the LEDs:

- **Blinking** means, that the LED is switched on or off at regular intervals in the respective indicated colour.
- **Flashing** means, that the LED lights up very briefly in the respective colour and stay then clearly longer (approximately 10x longer) switched off.
- **Inverse flashing** means the opposite. The LED lights permanently in the respective colour and is only briefly interrupted.
- **Flickering** means, that the LED is switched on and off in irregular intervals.

2.4 Front side

The L-32x Access Points have status displays on the front panel.

Example:
LANCOM L-320agn
Wireless



Top

The two top-mounted LEDs enable the main function status to be assessed even if the device is positioned vertically.



Power

This LED provides information on the device's operating state.

Off		Device switched off
Green	blinking	Self-test after power-up
Green	On (permanently)	Device operational
Red/green	Blinking alternately	Device insecure: Configuration password not set
Orange/green	In the housing cover; blinking alternately with the online LED	At least one WLAN module is in managed mode and has not found a WLAN Controller yet. The corresponding WLAN module(s) is/are switched off until a WLAN Controller is found to supply a configuration, or until being switched manually into another operating mode.
Orange /red	In the housing cover; blinking alternately with the online LED	At least one WLAN module is in managed mode and has found a WLAN Controller. However, the WLAN Controller cannot assign a configuration because the firmware and/or the device's loader version is not compatible with the WLAN Controller.



The power LED blinks alternately in red/green until a configuration password has been set. Without a configuration password, the configuration data in the LANCOM is unprotected. Normally you would set a configuration password during the basic configuration (instructions in the following chapter). Information about setting a configuration password at a later time is available in the section 'The Security Wizard'.

The power LED is blinking and no connection can be made?

If the power LED blinks red and no WAN connections can be established, there is no cause for concern. This merely means that a pre-set charge or time limit has been reached.



Signal that a charge or time limit has been reached

There are three ways to remove the lock:

- Reset the toll protection.
- Increase the limit.
- Deactivate the lock completely (set limit to '0').

LANmonitor shows you when a charge or time limit has been reached. To reset the toll protection, activate the context menu (right-mouse click) **Reset charge and time limits**. The charge settings are defined in LANconfig under **Management ▶ Costs** (these settings are only available if the 'Complete configuration display' is activated under **Tools ▶ Options**).

With WEBconfig, charge protection and all parameters are to be found under **LCOS menu tree ▶ Setup ▶ Charges ▶ Reset budgets**.

- 1 WLAN Link
(nur LANCOM
L-320agn
Wireless und
LANCOM
L-321agn
Wireless)

Provides information about the WLAN connections via the internal WLAN module.

The following can be displayed for WLAN link:

Off		No WLAN network defined or WLAN module deactivated. The WLAN module is not transmitting beacons.
Green		At least one WLAN network is defined and WLAN module activated. The WLAN module is transmitting beacons.
Green	Inverse flashing	Number of flashes = number of connected WLAN stations and P2P wireless connections, followed by a pause (default). Alternatively, the frequency of the flashed can indicate the received signal strength of a P2P link or the received signal strength from an access point, to which this device is connected in client mode.
Green	Blinking	DFS scanning or other scan procedure.
Red	Blinking	Hardware error in the WLAN module

- 2 WLAN Data

Provides information about the data traffic at the internal WLAN module.

The following can be displayed for WLAN data:

Green	Flickering	TX data traffic.
Red	Flickering	Error in wireless LAN (TX error, e.g. transmission error due to a poor connection)
Red	Blinking	Hardware error in the WLAN module

3 ETH

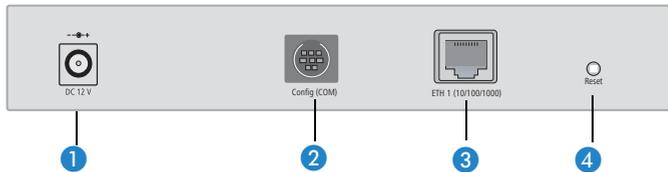
LAN connector status:

Off		No networking device attached
Green	On (permanently)	Connection to network device operational, not data traffic
Green	Flickering	Data traffic

2.5 Device connectors

The connections and switches of the router are located on the back panel:

Model example:
LANCOM L-320agn
Wireless



- 1 Connection for the included power adapter
- 2 Serial configuration port
- 3 Ethernet plug 10/100/1000Base-Tx for LAN connections

The used transfer speed will automatically be identified (autosensing).

The LAN connector of the LANCOM Access Point supports the Power-over-Ethernet standard (PoE). You find further information about operating with PoE in the info box 'Power-over-Ethernet – elegant power supply through the LAN wiring'.

By activated DSLoL option, the LAN connector can also be used for connecting the LANCOM Access Point to a broadband modem.

- 4 Reset switch

Model example:
LANCOM L-321agn
Wireless

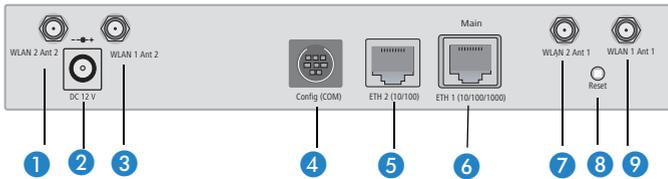
LANCOM L-321agn Wireless additionally provides two connectors for external antennas:



- 1 Connector for the 2nd external antenna
- 2 Connector for the 1st external antenna

LANCOM L-322agn
dual Wireless

The LANCOM L-322agn dual Wireless provides the following connectors:



- 1 Connector for antenna 2 at the 2nd WLAN module.
- 2 Connection for the included power adapter
- 3 Connector for antenna 2 at the 1st WLAN module.
- 4 Serial configuration port
- 5 Second ethernet plug 10/100Base-Tx for LAN connections

The used transfer speed will automatically be identified (autosensing).

The LAN connector of the LANCOM Access Point supports the Power-over-Ethernet standard (PoE). You find further information about operating with PoE in the info box 'Power-over-Ethernet – elegant power supply through the LAN wiring'.

By activated DSLoL option, the LAN connector can also be used for connecting the LANCOM Access Point to a broadband modem.

- 6 First ethernet plug 10/100/1000Base-Tx for LAN connections
- 7 Connector for antenna 1 at the 2nd WLAN module.

- 8 Reset switch
- 9 Connector for antenna 1 at the 1st WLAN module.

Reset button functions

The reset button offers two basic functions—boot (restart) and reset (to the factory settings)—which are called by pressing the button for different lengths of time.

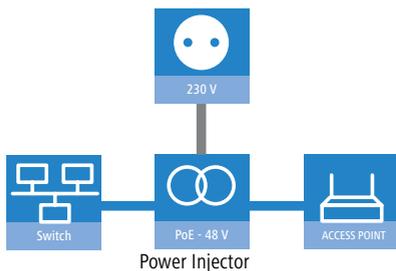
It is not always possible to install a device under lock and key. There is consequently a risk that the configuration will be deleted by mistake if a co-worker

Power-over-Ethernet – elegant power supply through the LAN wiring

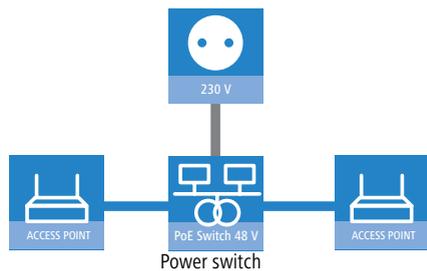
LANCOM Access Points are prepared for the PoE power supply (Power-over-Ethernet), corresponding to the 802.3af standard. PoE-enabled network devices can be comfortably supplied with power feeding through the LAN wiring. A separate external power supply for each base station is unnecessary, which reduces the installation complexity considerably.

The power feeding into the LAN happens at a central position, either via a PoE power injector, or via a so-called powerhub/powerswitch. For the LAN wiring is to note that all 8 wires must be available by the cabling. PoE feeds the power over those four wires, which are normally not used for data transfer.

Installation of single devices



Installation of several devices



The PoE supply works only in such network segments, in which exclusively PoE-capable devices are operating. The protection of network devices without PoE support is guaranteed by an intelligent mechanism, that tests the network segment for devices without PoE support before starting the PoE power feeding. The power is only switched onto the segment, if only devices with PoE support were detected.



In a PoE installation use exclusively devices which correspond to the 802.3af standard! For damages caused by inadmissible devices no warranty may be claimed.

presses the reset button too long. You can define the behavior of the reset button with a setting in WEBconfig (LCOS menu tree ► Setup ► Config):

■ Reset button

This option controls the behavior of the reset button when it is pressed:

- Ignore: The button is ignored.
- Boot only: With a suitable setting, the behavior of the reset button can be controlled; the button is then ignored or a press of the button prompts a re-start only, however long it is held down.



Please observe the following notice: The settings 'Ignore' or 'Boot only' makes it impossible to reset the configuration to the factory settings. If the password is lost for a device with this setting, there is no way to access the configuration! In this case the serial communications interface can be used to upload a new firmware version to the device—this resets the device to its factory settings, which results in the deletion of the former configuration. Instructions on firmware uploads via the serial configuration interface are available in the LCOS reference manual.

- Reset-or-boot (standard setting): Press the button briefly to re-start the device. Pressing the button for 5 seconds or longer restarts the device and resets the configuration to its factory settings.

All LEDs on the device light up continuously.

Once the switch is released the device will restart with the restored factory settings.



After resetting, the device starts completely unconfigured and **all** settings are lost. If possible be sure to backup the current device configuration **before** resetting.



After resetting, the LANCOM Access Point returns to managed mode, in which case the configuration cannot be directly accessed via the WLAN interface!

2.6 Hardware installation

Installation of the L-32x Access Point devices involves the following steps:

LANCOM L-321agn
Wireless and
LANCOM L-322agn
dual Wireless only

- ① **Antennas** – screw the antennas supplied to the back of the L-32x Access Point. Depending on how the antennas are to be used, the 'Antenna Grouping' parameter may need to be configured in order provide the desired MIMO behavior (→'Advanced Wireless LAN Configuration').



Antennas are only to be attached or changed when the device is switched off. Mounting or demounting antennas while the device switched on may cause the destruction of the WLAN module!



When assembling separately purchased antennas please note that the maximum allowed transmission power of the wireless LAN according to EIRP in the country in question may not be exceeded. The system operator is responsible for adhering to the threshold values.

- ② **LAN** – You can first connect the L-32x Access Point to your LAN. Plug in one end of the supplied network cable (green connectors) to the LAN connector on the device ③ and the other end into an available network connector socket in your local network or on a hub or switch. Alternatively you can connect a single PC.

The LAN connector automatically recognizes the wiring (Auto MDI/X) and the transfer rate (10/100/1000 Mbit with LANCOM L-320agn Wireless and LANCOM L-321agn Wireless, 10/100 Mbit with LANCOM L-322agn dual Wireless) by autosensing.

Information about the installation of PoE can be found in the information box →'Power over Ethernet—elegant power supply over LAN cabling'.

- ③ **DSLol** – if you wish to operate the access point in DSLol mode you can either connect the device directly to the DSL modem (exclusive mode) or via a hub or switch in the wired LAN (automatic mode).
 - In exclusive mode, plug one end of the network cable supplied (green connectors) into the LAN port of device ③ and plug the other end into the corresponding port on the DSL modem.
 - In automatic mode, plug one end of the supplied network cable (green connectors) to the LAN port on device ③ and the other end into an available network connector socket in your local network (or a free socket on a switch or hub).
- ④ **Power supply** – socket ② is for connecting the power supply unit provided.

LAN interface: Can be used exclusively or in parallel for DSLoL.

There are basically two possibilities for using the access point for DSLoL operation. Use exclusive mode when you wish to connect the device directly to the DSL modem. Use automatic mode when you wish to connect it to a hub or switch on a wired LAN and the hub (or switch) is connected to the DSL modem. If the access point is advertised as a gateway via DHCP, computers in the LAN and wireless LAN can access the Internet via one physical port **simultaneously**. You can set the desired mode in LANconfig in the interface settings of the DSLoL interface.



DSLoL supports all PPPoE-based Internet connections (such as T-DSL) as well as Internet connections that have been implemented with static IP addresses via a router (for example CompanyConnect or various SDSL connections for business customers).

Alternatively you can use the PoE facility for the power supply (please refer to →'Power over Ethernet—elegant power supply over LAN cabling').



Please make sure to use only the power adapter listed in the technical specifications. The use of the wrong power adapter can be of danger to the device or persons.

- ⑤ **Ready for operation?** – After a brief self-test the power LED lights up permanently in green or it blinks alternately in red and green until a configuration password is set.

2.7 Software installation

The following section describes the installation of the Windows-compatible system software LANtools, as supplied.



You may skip this section if you use your L-32x Access Point exclusively with computers running operating systems other than Windows.

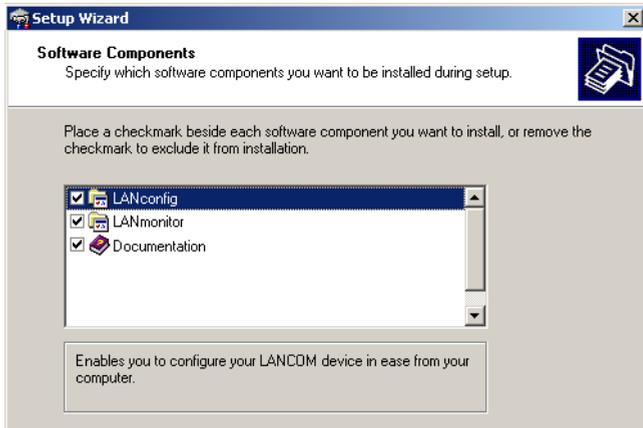
2.7.1 Starting the software setup

Place the product CD into your drive. The setup program will start automatically.



If the setup does not start automatically, run AUTORUN.EXE in the root directory of the LANCOM CD.

In Setup, select **Install software**. The following selection menus will appear on screen:



2.7.2 Which software should I install?

- **LANconfig** is the Windows configuration program for all LANCOM routers and LANCOM access points. WEBconfig can be used alternatively or in addition via a web browser.
- With **LANmonitor** you can use a Windows computer to monitor all of your LANCOM routers and LANCOM access points.
- **WLANmonitor** enables the observation and surveillance of wireless LAN networks. Clients connected to the access points are shown, and even non-authenticated access points and clients can be displayed as well (rogue AP detection and rogue client detection).
- With **Documentation** you copy the documentation files onto your PC.

Select the appropriate software options and confirm your choice with **Next**. The software is installed automatically.

3 Basic configuration

The basic configuration is conducted with a convenient Setup Wizard that provides step-by-step guidance through the configuration and that requests any necessary information.



Unconfigured LANCOM Access Points with standard factory settings cannot be commissioned by means of the WLAN interface.

First of all this chapter presents the information that has to be entered for the basic configuration. This first section will help you to gather up all of the necessary data before you start the Wizard.

You subsequently enter this information into the Setup Wizard. Starting the program and the following procedure are described step by step. LANconfig and WEBconfig each have their own description. With all of the necessary information collected in advance, this basic configuration can now take place quickly and in ease.

At the end of this chapter we show you the necessary settings for the workplace computers in the LAN so that they can access the device without problem.

For LANCOM Access Points that are unconfigured and in their factory settings, the WLAN modules are switched off and set to the "Managed" operating mode. The WLAN modules search the LAN for a LANCOM WLAN Controller from which they can receive their WLAN-interface configuration profiles.

Once executed, the Basic Settings Wizard automatically resets the WLAN-module operating mode to "Access Point". The WLAN interface then has to be configured manually.



Only activate the Basic Settings Wizard if the Access Point is not to be configured from a WLAN-Controller. Subsequently execute the WLAN Wizard → WLAN Configuration.

3.1 Details you will need

The Basic Settings Wizard is used to set the L-32x Access Points basic TCP/IP parameters and to protect the device with a configuration password. The following description of the information required by the wizard is divided into the following configuration sections:

- TCP/IP settings

- Protecting the configuration
- Wireless LAN details
- Security settings

3.1.1 TCP/IP settings

TCP/IP configuration can be performed in two different ways: Either fully automatically or manually. No user input is required if TCP/IP configuration is performed automatically. All parameters are set by the Setup Wizard on its own. When manual TCP/IP configuration is performed the wizard prompts for the usual TCP/IP parameters: IP address, network mask etc. (more on this later)

The fully automatic TCP/IP configuration is only possible in certain network environments. For this reason the Setup Wizard analyses the connected LAN to see whether fully automatic configuration is possible or not.

New LAN – fully automatic configuration possible

The setup wizard offers to configure TCP/IP fully automatically if no network devices connected have yet been configured. This usually happens in the following situations:

- Only a single PC is going to be attached to the L-32x Access Point
- Setting up a new network

Fully automatic TCP/IP configuration will not be offered if you are integrating the L-32x Access Point into an existing TCP/IP LAN. In this case please continue with the section 'Required information for manual TCP/IP configuration'.

The result of fully automatic TCP/IP configuration is as follows: The L-32x Access Point is assigned the IP address '172.23.56.254' (network mask '255.255.255.0'). The integrated DHCP server is also activated so that the L-32x Access Point can assign the devices in the LAN IP addresses automatically.

Should you still configure manually?

Fully automatic TCP/IP configuration is optional. Instead of this you can select manual configuration. Make this selection after considering the following:

- Select automatic configuration if you are **not** familiar with networks and IP addresses.
- Select the manual TCP/IP configuration if you are familiar with networking and IP addresses, and you would like to specify the IP address for the router yourself (from one of the address ranges reserved for private use,

for example '10.0.0.1' with a network mask of '255.255.255.0'). If you do this you simultaneously specify the address range that the DHCP server will subsequently use for the other devices in the network (provided the DHCP server is activated).

Required information for manual TCP/IP configuration

When performing manual TCP/IP configuration the Setup Wizard prompts you for the following information:

■ DHCP mode of operation

- Off: The IP addresses required must be entered manually.
- Server: The L-32x Access Point operates as DHCP server in the network; as a minimum its own IP address and the network mask must be assigned.
- Client: The L-32x Access Point obtains its address information from another DHCP server; no address information is required.

■ IP address and network mask for the L-32x Access Point

Assign the L-32x Access Point a free IP address from your LAN's address range and enter the network mask.

■ Gateway address

Enter the gateway's IP address if you have selected 'Off' as the DHCP mode of operation or if another network device is assuming the role of gateway in the 'Server' mode of operation.

■ DNS server

Enter the IP address of a DNS server to resolve domain names if you have selected 'Off' as the DHCP mode of operation or if another network device is assuming the role of DNS server in the 'Server' mode of operation.

3.1.2 Configuration protection

Using a password secures access to the L-32x Access Point's configuration and thus prevents unauthorized modification. The device's configuration contains a great deal of sensitive data such as data for Internet access and should be protected by a password in all cases.



Multiple administrators can be set up in the configuration of the LANCOM, each with different access rights. Up to 16 different administrators can be set up for a L-32x Access Point. Further information can be found in the LCOS reference manual under "Managing rights for different administrators".



In the managed mode the LANCOM Wireless Routers and LANCOM Access Points automatically receive the same root password as the WLAN-Controller, assuming that no root password has been set in the device itself.

3.1.3 Settings for the wireless LAN

There is a handy installation wizard to help you with the LANCOM Access Point's wireless LAN configuration. After performing the basic configuration please execute the wizard to configure the wireless LAN interface (→'WLAN configuration with the wizards in LANconfig').

3.2 Instructions for LANconfig

- ① Start LANconfig with **Start ► Programs ► LANCOM ► LANconfig**. LANconfig automatically detects new LANCOM devices in the TCP/IP network.
- ② If the search detects an unconfigured device, the Setup Wizard launches to help you with its basic settings, or indeed to handle the entire process on your behalf (assuming that the appropriate networking environment exists).



If the Setup Wizard does not start automatically, you can manually search for new devices at all interfaces (if the L-32x Access Point is connected via the serial configuration interface) or in the network (**File ► Find devices**).



If you cannot access an unconfigured L-32x Access Point, the problem may be the LAN netmask: In case there are less than 254 potential hosts available (netmask >'255.255.255.0'), you must ensure that the IP address 'x.x.x.254' is available in your subnet.

If you choose automatic TCP/IP configuration, you can continue with step ⑤.

- ③ Give the LANCOM an address from the applicable IP address range. Confirm with **Next**.
- ④ In the window that follows, you first set the password to the configuration. Entries are case sensitive and should be at least 6 characters long.

You also define whether the device can be configured from the local network only, or if remote configuration via WAN (i.e.. from a remote network) is to be permitted.

 Be aware that releasing this option also allows remote configuration over the Internet. Whichever option you select, make sure that configuration access is password protected.

- ⑤ Charge protection is a function which can place a limit on the costs from WAN connections. Accept your entries with **Next**.

- ⑥ Close the configuration with **Finish**.

 See the section 'TCP/IP settings for PC workstations' for information on the settings that are required for computers in the LAN.

3.3 Instructions for WEBconfig

Device settings can be configured from any Web browser. WEBconfig configuration software is an integral component of the LANCOM. A Web browser is all that is required to access WEBconfig. WEBconfig offers similar Setup Wizards to LANconfig and hence provides the perfect conditions for easy configuration of the LANCOM – although, unlike LANconfig, it runs under any operating system with a Web browser.

Secure with HTTPS

WEBconfig offers secure (remote) configuration by encrypting the configuration data with HTTPS.

```
https://<IP address or device name>
```

 Always use the latest version of your browser to ensure maximum security.

Accessing the device with WEBconfig

To carry out a configuration with WEBconfig, you need to know how to contact the device. Device behavior and accessibility for configuration via a Web browser depend on whether the DHCP server and DNS server are active in the LAN already, and whether these two server processes share the assignment in the LAN of IP addresses to symbolic names. WEBconfig accesses the LANCOM either via its IP address, the device name (if configured), or by means of any name if the device has not yet been configured.

Following power-on, unconfigured LANCOM devices first check whether a DHCP server is already active in the LAN. Depending on the situation, the device can either enable its own DHCP server or enable DHCP client mode. In the second operating mode, the device can retrieve an IP address for itself from a DHCP server in the LAN.



If a LANCOM Wireless Router or LANCOM Access Point is centrally managed from a LANCOM WLAN Controller, the DHCP mode is switched from auto-mode to client mode upon provision of the WLAN configuration.

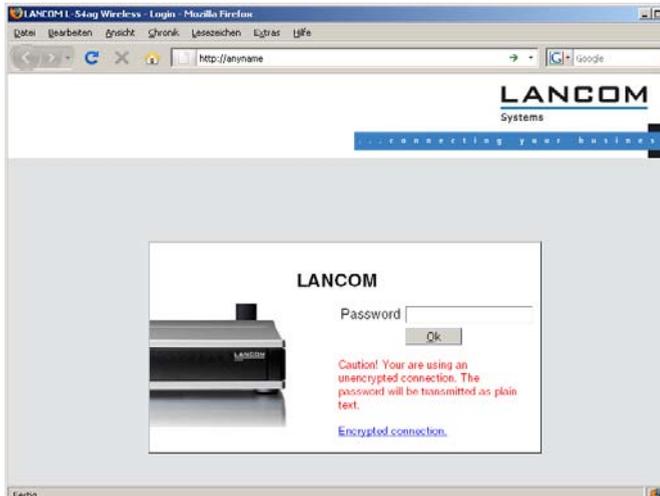
Network without a DHCP server

Not for centrally managed LANCOM Wireless Routers or LANCOM Access Points

In a network without a DHCP server, unconfigured LANCOM devices enable their own DHCP server service when switched on and assign IP addresses, information on gateways, etc. to other computers in the LAN (provided they are set to automatic retrieval of IP addresses – auto DHCP). In this constellation, the device can be accessed by every computer with the auto DHCP function enabled with a Web browser under IP address **172.23.56.254**.



With the factory settings and an activated DHCP server, the device forwards all incoming DNS requests to the internal Web server. This means that a connection can easily be made to set up an unconfigured LANCOM by entering any name into a Web browser.



If the configuration computer does not retrieve its IP address from the LANCOM DHCP server, it determines the current IP address of the computer (with **Start ▶ Run ▶ cmd** and command **ipconfig** at the prompt under Windows 2000 or Windows XP or Windows Vista, with **Start ▶ Run ▶ cmd** and command **winipcfg** at the prompt under Windows Me or Windows 9x, or with command **ifconfig** in the console under Linux). In this case, the LANCOM can be accessed with address **x.x.x.254** (the “x”s stand for the first three blocks in the IP address of the configuration computer).

Network with DHCP server

If a DHCP server for the assignment of IP addresses is active in the LAN, an unconfigured LANCOM device disables its own DHCP server, switches to DHCP client mode and retrieves an IP address from the DHCP server in the LAN. However, this IP address is initially unknown and accessing the device depends on the name resolution:

- If the LAN also has a DNS server for name resolution and this communicates the IP address/name assignment to the DHCP server, the device can

be reached under name "LANCOM-<MAC address>", e.g. "LANCOM-00a057xxxxx".



The MAC address on a sticker on the base of the device.

- If there is no DNS server in the LAN, or if it is not coupled to the DHCP server, the device cannot be reached via the name. In this case the following options remain:
 - Under LANconfig use the function "Find devices", or under WEBconfig use the "search for other devices" option from any other networked LANCOM.
 - Use suitable tools to find out the IP address assigned to the LANCOM by DHCP and access the device directly using this IP address.
 - Use the serial configuration interface to connect a computer running a terminal program to the device.

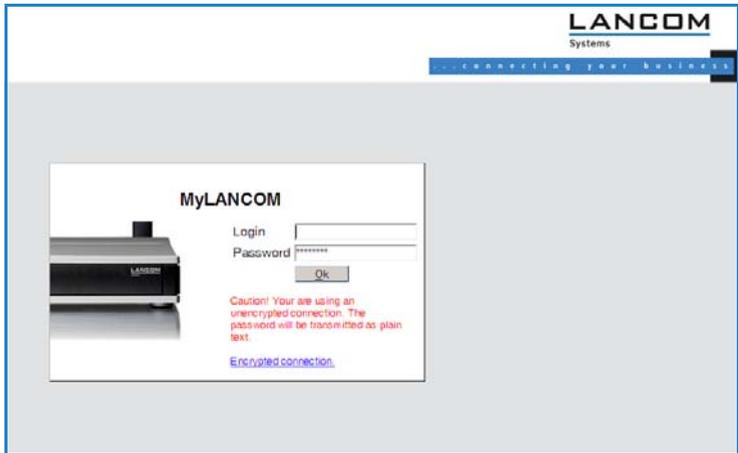
Login

When prompted for user name and password when accessing the device, enter your personal data in the appropriate fields. Observe the use of upper and lower case.

If you used the general configuration access, only enter the corresponding password. The user name field remains blank in this case.

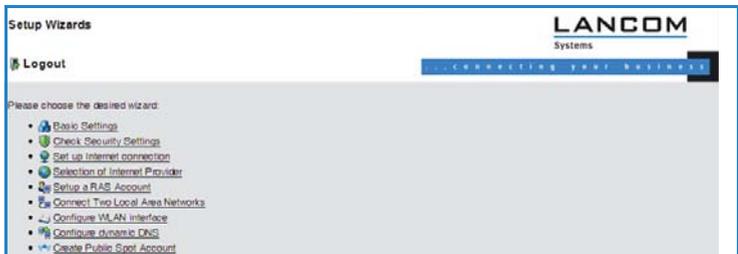


As an alternative, the login dialog provides a link for an encrypted connection over HTTPS. Always use the HTTPS connection for increased security whenever possible.



Setup Wizards

The setup Wizards allow quick and easy configuration of the most common device settings. Select the Wizard and enter the appropriate data on the following screens.



The settings are not stored in the device until inputs are confirmed on the last screen of the Wizard.

3.4 TCP/IP settings for PC workstations

It is extremely important to assign the correct addresses to all of the devices in the LAN. Also, all of these computers must know the IP addresses of two central stations in the LAN:

- Standard gateway – receives all packets which are not addressed to computers in the local network

- DNS server – translates network and computer names into their actual IP addresses.

The L-32x Access Point can fulfill the functions of a standard gateway and also of a DNS server. It can also operate as a DHCP server, which automatically assigns IP addresses to all of the computers in the LAN.

The correct TCP/IP configuration of a PC in the LAN depends essentially on the method used for assigning IP addresses in the LAN:

- **IP address allocation by a LANCOM**

In this operating mode, a LANCOM uses DHCP to allocate not only an IP address to each PC in the LAN and WLAN (for devices with a radio module), but it also communicates its own IP address as the standard gateway and DNS server. For this reason, the PCs have to be set up to automatically retrieve their own IP address and those of the standard gateway and DNS server via DHCP.

- **IP address allocation by a separate DHCP server**

For this reason, the workstation PCs have to be set up to automatically retrieve their own IP address and those of the standard gateway and DNS server via DHCP. The DHCP server is to be programmed such that the IP address of the LANCOM is communicated to the PCs in the LAN as the standard gateway. The DHCP server should also communicate that the LANCOM is the DNS server.

- **Manual IP address assignment**

If IP addresses in a network are statically assigned, then the IP address of the LANCOM is to be set as the standard gateway and DNS server in the TCP/IP configuration of each PC in the LAN.



Further information and help on the TCP/IP settings for your L-32x Access Point is available in the Reference Manual. For information on the network configuration of workstation PCs, refer to the documentation for the installed operating system.

4 Security settings

Your LANCOM features numerous security functions. This chapter provides you with all of the information you need to optimally protect your device.



You can carry out the configuration of security settings very quickly and conveniently with the Security Wizards in LANconfig and WEBconfig.

4.1 Security in the wireless LAN

Wireless LANs are potentially a significant security risk. It is a common assumption that it is simple to misuse data transferred by wireless.

Wireless LAN devices from LANCOM Systems enable the latest security technologies to be used.

- Encrypted data transfer with WPA2 and AES encryption
- 802.1x / EAP
- LANCOM Enhanced Passphrase Security (LEPS)
- Access control by MAC address
- Optional IPSec-over-WLAN VPN

4.1.1 Encrypted data transfer

Encryption takes on a special role in the transfer of data in wireless LANs. Wireless communication with IEEE 802.11 is supplemented with the encryption standards 802.11i/WPA and WEP. The aim of the encryption methods is to provide wireless LAN with levels of security equivalent to those in cabled LANs.



LANCOM Systems's recommendation for the most secure passphrase variant is to employ 802.11i (WPA2) in combination with AES. The key should be randomly selected from the largest possible range of numbers and should be as long as possible (32 to 63 characters). This prevents dictionary attacks.

- Use encryption on the data transferred in the WLAN. Activate the strongest possible encryption method available to you (802.11i with AES, TKIP or WEP) and enter the appropriate keys or passphrases into the access point and the WLAN clients.

- The passphrases for 802.11i or WPA do not have to be changed quite so regularly as new keys are generated for each connection anyway. This is not the only reason that the encryption with 802.11i/AES or WPA/TKIP is so much more secure than the now obsolete WEP method. If you use WEP encryption to maintain compatibility with older WLAN clients, regularly change the WEP key in your access point.
- If the data is of a high security nature, further improvements include additionally authenticating the client with the 802.1x method ('802.1x / EAP' →page 46) or activate an additional encryption of the WLAN connection as used for VPN tunnels ('IPSec over WLAN' →page 47). In special cases, a combination of these two mechanisms is possible.



Detailed information about WLAN security and the various encryption methods are to be found in the LCOS reference manual.

4.1.2 802.1x / EAP

The international industry standard IEEE 802.1x and the **Extensible Authentication Protocol (EAP)** enable access points to carry out reliable and secure access checks. The access data can be managed centrally on a RADIUS server (integrated RADIUS/EAP server in the L-32x Access Point or external RADIUS/EAP server) and accessed by the access point when required. The dynamically generated and cryptographically secure key material for 802.11i (WPA1/2) replaces the manual key management.

The IEEE-802.1x technology has already been fully integrated since Windows XP. Client software exists for other operating systems. The drivers for the LANCOM AirLancer wireless cards feature an integrated 802.1x client.

4.1.3 LANCOM Enhanced Passphrase Security

With LEPS (**LANCOM Enhanced Passphrase Security**), LANCOM Systems has developed an efficient method that makes use of the simple configuration of IEEE 802.11i with passphrase, but that avoids the potential error sources in passphrase distribution. LEPS uses an additional column in the ACL to assign an individual passphrase consisting of any 4 to 64 ASCII characters to each MAC address. The connection to the access point and the subsequent encryption with IEEE 802.11i or WPA is only possible with the right combination of passphrase and MAC address.

LEPS can be used locally in the device and can also be centrally managed with the help of a RADIUS server, and it works with all WLAN client adapters currently available on the market without modification. Full compatibility to

third-party products is assured as LEPS only involves configuration in the access point.

An additional security aspect: LEPS can also be used to secure single point-to-point (P2P) connections with an individual passphrase. Even if an access point in a P2P installation is stolen and the passphrase and MAC address become known, all other WLAN connections secured by LEPS remain protected, particularly when the ACL is stored on a RADIUS server.



Guest access with LEPS: LEPS can also be set up to allow access to guests. To this end, all users of the internal WLAN network are given individual passphrases. Guests can make use of their own dedicated SSID and a global passphrase. To avoid abuse, the this global passphrase can be changed on a regular basis—every few days, for example.

4.1.4 Access control by MAC address

Every network device has a unique identification number. This identification number is known as the MAC address (**M**edia **A**ccess **C**ontrol) and it is unique worldwide.

The MAC address is programmed into the hardware. Wireless LAN devices from LANCOM Systems display their MAC number on the housing.

Access to an infrastructure network can be limited to certain wireless LAN devices by defining MAC addresses. The access points have filter lists in (ACL – access control list) for storing authorized MAC addresses.

4.1.5 IPSec over WLAN

With the help of the IPSec-over-WLAN technology in addition to the security measures described already, a wireless network for the exchange of especially sensitive data can be optimally secured. Required for this is a base station with VPN support and the LANCOM Advanced VPN Client that operates under Windows 2000, XP and Windows Vista™. Client software from third parties is available for other operating systems.

4.2 Tips for the proper treatment of keys and passphrases

By observing a few vital rules on the treatment of keys you can significantly increase the security of encryption techniques.

- **Keep your keys as secret as possible.**

Never write down a key. Popular but completely unsuitable are, for example: Notebooks, wallets and text files on the computer. Do not pass on a key unless it is absolutely necessary.

- **Choose a random key.**

Use long random strings that combine letters and numbers (at least 32 to a maximum of 63 characters). Keys that are normal words are not secure.

- **If you suspect anything, change the key immediately.**

When an employee with access to a key leaves the company, then it is high time to change the wireless LAN key. Even if there is the slightest suspicion of a leak, renew the key.

- **LEPS avoids the global distribution of passphrases.**

Activate LEPS to enable the use of individual passphrases.

4.3 Security settings Wizard

Access to the configuration of a device allows access to more than just critical information (e. g. WPA key, Internet password). Far more critical is that settings for security functions (e.g. the firewall) can be altered. Unauthorized access is not just a risk for the device itself, but for the entire network.

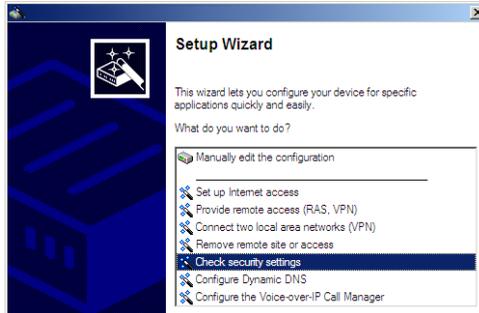
Your LANCOM offers password-protected access to its configuration. This is activated during the initial basic configuration simply by entering a password.

If the wrong password is entered a certain number of times, the device automatically blocks access to the configuration for a fixed period. You can modify the critical number of attempts and also the duration of the lock. By default, the device locks for five minutes after five incorrect entries of the password.

Along with these basic settings, you can use the Security settings Wizard to check the settings of your wireless network (if so equipped).

4.3.1 LANconfig Wizard

- 1 Mark your LANCOM in the selection window. From the command line, select **Extras ▶ Setup Wizard**.



- 2 In the selection menu, select the Setup Wizard, **Check security settings** and confirm the selection with **Next**.
- 3 In the dialogs that follow you can set the password and select the protocols to be available for accessing the configuration from local and remote networks.
- 4 In a subsequent step, you can set parameters for locking the configuration such as the number of incorrect password entries and the duration of the lock.
- 5 For devices with a WLAN interface, you have the option of specifying the security parameters of the wireless network. This includes the name of the wireless network, the closed-network function, and encryption by 802.11i/WPA or WEP. For devices with an optional second WLAN interface, you can set the parameters for both wireless networks separately.
- 6 For the WLAN interface, you can subsequently define the access control lists (ACL) and the protocols. This allows you to place limitations on the data exchange between the wireless network and the LAN.
- 7 For the firewall, you can activate stateful inspection, ping blocking, and the stealth mode.
- 8 The Wizard will inform you as soon as the entries are complete. Close the configuration with **Finish**.

4.3.2 WEBconfig Wizard

With WEBconfig you have the option to launch the **Check security settings** Wizard to check and change any settings. The following values are edited:

- Device password
- The protocols to be available for accessing the configuration from local and remote networks
- The parameters for locking the configuration (the number of incorrect password entries and the duration of the lock)
- Security parameters such as WLAN name, closed-network function, WPA passphrase, WEP key, ACL lists, and protocol filters

4.4 The security checklist

The following checklists provide an overview of all security settings that are important to professionals. Most of the points in this checklist are uncritical for simple configurations. In these cases, the security settings in the basic configuration or that were set with the Security Wizard are sufficient.



Detailed information about the security settings mentioned here are to be found in the reference manual.

■ Have you secured your wireless network with encryption and access control lists?

With the help of 802.11i, WPA or WEP, you can encrypt the data in your wireless network with different encryption methods such as AES, TKIP or WEP. LANCOM Systems recommends the strongest possible encryption with 802.11i and AES. If the WLAN client adapters do not support these, then you should use TKIP or at least WEP. Make sure that the encryption function in your device is activated, and that at least one passphrase or WEP key has been entered and selected for application.



For security reasons, LANCOM Systems strongly advises you not to use WEP! You should only ever use WEP under exceptional circumstances. When using WEP encryption, use additional security mechanisms additionally.

To check encryption settings, open LANconfig, go to the configuration area and select 'Wireless LAN' on the '802.11i/WEP' tab to view the settings for the logical WLAN interfaces.

With the access control list (ACL) you can permit or prevent individual clients accessing your wireless LAN. The decision is based on the MAC address that is permanently programmed into wireless network adapters. To check the access-control list, go to the configuration area in LANconfig and select 'WLAN security' on the 'Stations' tab.

The LANCOM Enhanced Passphrase Security (LEPS) uses an additional column in the ACL to assign an individual passphrase consisting of any 4 to 64 ASCII characters to each MAC address. The connection to the access point and the subsequent encryption with IEEE 802.11i or WPA is only possible with the right combination of passphrase and MAC address.

■ **Have you protected the configuration with a password?**

The simplest way of protecting the configuration is to agree upon a password. If no password has been agreed for the device, the configuration is open to be changed by anybody. The field for entering the password is to be found in LANconfig in the 'Management' configuration area on the 'Security' tab. It is absolutely imperative to assign a password to the configuration if you want to enable remote configuration!

■ **Have you permitted remote configuration?**

If you do not require remote configuration, please ensure to switch it off. If you need to make use of remote configuration, ensure that you do not fail to password-protect the configuration (see the section above). The field for disabling remote configuration is to be found in LANconfig in the 'Management' configuration area on the 'Security' tab. Under 'Access rights – From remote networks' select the option 'denied' for all methods of configuration.

■ **Have you allowed configuration from the wireless LAN?**

If you do not need to configure the device from the wireless LAN, switch this function off. The field for disabling configuration from the wireless LAN is to be found in LANconfig in the 'Management' configuration area on the 'Admin' tab. Under 'Access rights – From the wireless LAN' select the option 'denied' for all methods of configuration.

■ **Have you password-protected the SNMP configuration?**

Protect the SNMP configuration with a password too. The field for password-protecting the SNMP configuration is also to be found in LANconfig in the 'Management' configuration area on the 'Security' tab.

■ Have you activated the firewall?

The stateful inspection firewall of LANCOM devices ensures that your local network cannot be attacked from the outside. Activate the firewall in LANconfig under 'Firewall/QoS' on the 'General' tab.



Note that firewall security mechanisms (incl. IP masquerading, port filters, access lists) are active only for data connections that are transmitted via the IP router. Direct data connections via the bridge are not protected by the firewall!

■ Are you using a 'deny all' firewall strategy?

Maximum security and control is initially achieved by denying all data traffic from passing the firewall. The only connections to be accepted by the firewall are those that are to be explicitly permitted. This ensures that Trojan horses and certain types of e-mail virus are denied communication to the outside. Activate the firewall rules in LANconfig under 'Firewall/QoS' on the 'Rules' tab. Instructions on this are to be found in the reference manual.

■ Have you activated IP masquerading?

IP masquerading refers to the concealment of local computers while they access the Internet. All that is revealed to the Internet is the IP number of the router module of the device. The IP address can be fixed or dynamically assigned by the provider. The computers in the LAN then use the router as a gateway and are not visible themselves. The router separates the Internet from the intranet like a wall. The application of IP masquerading is set in the routing table for every route individually. The routing table can be found in the LANconfig in the configuration area 'IP router' on the 'Routing' tab.

■ Have you used filters to close critical ports?

The firewall filters in LANCOM devices offer filter functions for individual computers or entire networks. It is possible to set up source and destination filters for individual ports or port ranges. Furthermore, filters can be set for individual protocols or any combination of protocols (TCP/UDP/ICMP). It is especially convenient to set up the filters with the aid of LANconfig. Under 'Firewall/QoS', the 'Rules' tab contains the functions for defining and editing filter rules.

■ Have you excluded certain stations from accessing the device?

A special filter list can be used to limit access to the device's internal functions via TCP/IP. The phrase "internal functions" refers to configuration sessions via LANconfig, WEBconfig, Telnet or TFTP. As standard this table contains no entries, meaning that computers with any IP address can use TCP/IP and Telnet or TFTP to commence accessing the device. The first time an IP address is entered with its associated netmask, the filter is activated and only the IP addresses contained in this entry are entitled to make use of internal functions. Further entries can be used to extend the circle of authorized parties. The filter entries can describe individual computers or even entire networks. The access list can be found in the LANconfig in the configuration area 'TCP/IP' on the 'General' tab.

■ Do you store your saved LANCOM configuration to a safe location?

Protect your saved configurations in a location that is safe from unauthorized access. Otherwise, by way of example, an unauthorized person may load your stored configuration file into another device and they can access the Internet at your expense.

■ Concerning the exchange of your particularly sensitive data via wireless LAN; have you set up the functions offered by IEEE 802.1x?

If you move especially sensitive data via wireless LAN you can provide even stronger security by using the IEEE 802.1x technology. To check or activate the IEEE 802.1x settings in LANconfig select the configuration area '802.1x'.

■ Have you activated the protection of your WAN access in case the device is stolen?

After being stolen, the device can theoretically be operated at another location by unauthorized persons. Password-protected device configurations do not stop third parties from operating RAS access, LAN connectivity or VPN connections that are set up in the device: A thief could gain access to a protected network.

The device's operation can be protected by various means; for example, it will cease to function if there is an interruption to the power supply, or if the device is switched on in another location.

The scripting function can store the entire configuration in RAM only so that restarting the device will cause the configuration to be deleted. The configuration is not written to the non-volatile flash memory. A loss of

power because the device has been relocated will cause the entire configuration to be deleted (for further information see the reference manual).

■ **Have you ensured that the reset button is safe from accidental configuration resets?**

Some devices simply cannot be installed under lock and key. There is consequently a risk that the configuration will be deleted by mistake if a co-worker presses the reset button too long. The behavior of the reset button can be set so that a press is either ignored or it causes a re-start, depending on the time for which it is held pressed.

5 Advanced wireless LAN configuration

The configuration of the LANCOM Access Points for your wireless LAN is conducted with the aid of highly convenient installation wizards.

The settings include the general, far-reaching parameters and also the individual settings for one or more logical wireless LAN networks (WLAN radio cells or SSIDs).

5.1 WLAN configuration with the wizards in LANconfig

Highly convenient installation wizards are available to help you with the configuration of LANCOM Access Points for your wireless LAN.

The settings include the general shared parameters and also the individual settings for one or more logical wireless LAN networks (WLAN radio cells or SSIDs).

- ① Mark your LANCOM Access Point in the selection window in LANconfig. From the command line, select **Extras ▶ Setup Wizard**.



- ② In the selection menu, select the Setup Wizard, **Configure WLAN interface** and confirm the selection with **Continue**.
- ③ Make the settings as requested by the wizard and as described as follows.

Country settings

Regulations for the operation of WLAN cards differ from country to country. The use of some radio channels is prohibited in certain countries. To operate the LANCOM Access Points while observing the regulations in various countries, all physical WLAN interfaces can be set up for the country where they are operated.

WLAN module operation

The WLAN modules can be operated in various operating modes:

- As a base station (Access Point mode), the device makes the link between WLAN clients and the cabled LAN. Parallel to this, point-to-point connections are possible as well.
- In Managed Mode the Access Points also accept WLAN clients into the network, although the clients then join a WLAN infrastructure that is configured by a central WLAN-Controller. In this operating mode, no further WLAN configuration is necessary as all WLAN parameters are provided by the WLAN-Controller.
- In client mode, the device itself locates the connection to another Access Point and attempts to register with a wireless network. In this case the device serves, for example, to link a cabled network device to an Access Point over a wireless connection. In this operating mode, parallel point-to-point connections are **not** possible.

For further information please refer to section →Client Mode.

Physical WLAN settings

Along with the radio channels, the physical WLAN settings can also be used to activate options such as the bundeling of WLAN packets (TX Burst), hardware compression, or the use of QoS compliant with 802.11e. You also control the settings for the diversity behavior here.

Logical WLAN networks

Each WLAN module can support up to eight logical WLAN networks for mobile WLAN clients to register with. The following parameters have to be set when configuring a logical WLAN network:

- The network name (SSID)
- Open or closed radio LAN
- Encryption settings
- MAC filter
- Client-bridge operation
- Filter settings

Point-to-point settings

The configuration of P2P connections involves setting not only the operating mode but also the station name that the Access Point can connect to. Also, the role as "Master" or "Slave" is set here.

Along with the settings for the Access Point itself, also to be defined is the remote site that the Access Point can contact via the P2P connection.

For further information please refer to section →Point-to-point connections.

5.2 Special wireless LAN parameters for 802.11n

You can use special parameters to adjust the operation of the 802.11n Access Point to match the application in question. Some of the parameters are concerned with compatibility to the conventional wireless LAN standard, others with transmission performance.

5.2.1 Compatibility

In principle, 802.11n is backwardly compatible to the previous IEEE 802.11a/b/g wireless LAN standards even though not all 802.11n functions are supported in this mode. Compatibility can be allowed or restricted by selecting the operating mode in the relevant frequency band (2.4 or 5 GHz). In this way you can allow the corresponding wireless LAN clients to register with the Access Point.

- In the 2.4 GHz band you can allow operation in accordance with 802.11b/g/n either exclusively or in various mixed modes. When 802.11b is supported you can also select whether only 11 Mbps mode or the older 2 Mbps are to be supported.
- In the 5 GHz band you can choose to allow either greenfield mode (802.11n only) or mixed operation with 802.11a.



Compatibility is always achieved at the expense of performance. It is therefore recommended to allow only those modes of operation that are absolutely necessary for the wireless LAN clients in use.

5.2.2 Performance settings for the wireless LAN module

802.11n provides a number of functions intended to improve wireless LAN performance, some of which apply to the entire wireless LAN module.

■ Double bandwidth (40 MHz channels)

A wireless LAN module normally uses a frequency range of 20 MHz in which data to be transmitted is modulated to the carrier signals. 802.11a/b/g use 48 carrier signals in a 20 MHz channel. The use of double the frequency range of 40 MHz means that 96 carrier signals can be used, resulting in a doubling of the data throughput.

802.11n can use 52 carrier signals in one 20 MHz channel for modulation and up to 108 in a 40 MHz channel. The use of the 40 MHz option for 802.11n therefore means a performance gain of more than double.

■ Antenna grouping

The L-32x Access Points use two antennas for transmitting and receiving data. Using several antennas with 802.11n can have different purposes:

- Improved data throughput: Using "spatial multiplexing" allows parallel data streams to be implemented to transmit double the amount of data.
- Improving wireless coverage: Cyclic shift diversity (CSD) can be used to transmit a radio signal in different phases. This reduces the risk of the signal being erased at certain points in the radio cell.

Depending on the application the use of the antennas can be set:

- When using the device in Access Point mode to connect wireless LAN clients it is necessary to use all antennas in parallel in order to profit from the MIMO effect and to achieve good network coverage.
- For applications with only one antenna (for example an outdoor application with just one antenna) the antenna is connected to port 1 and port 2 should be deactivated



The "Auto" setting means that all available antennas are used.

5.2.3 Performance settings for wireless LAN networks

Some performance settings can be configured separately for each logical wireless LAN network (i.e. for each SSID).

■ Number of spatial streams

The spatial multiplexing function allows several separate data streams to be transmitted over separate antennas in order to increase data throughput. When using external antennas, please observe that the number of spatial streams can be transmitted by the antenna system (e.g. two with

polarization-diversity antennas and one with normal outdoor antennas with a single antenna connector).



With the 'Auto' setting all spatial streams that are supported by the wireless LAN module in question are used.

■ Modulation Coding Scheme (MCS)

A specific MCS number denotes a unique combination from the modulation of the individual carriers (BPSK, QPSK, 16QAM, 64QAM), coding rate (i. e. proportion of error correction bits in the raw data and number of spatial streams. 802.11n uses this term instead of the term "data rate" used in older wireless LAN standards because data rate is no longer an unequivocal description.

MCS index	Data streams	Modulation	Coding rate	Data throughput (GI=0.4 μ s, 40 MHz)
0	1	BPSK	1/2	15
1	1	QPSK	1/2	30
2	1	QPSK	3/4	45
3	1	16QAM	1/2	60
4	1	16QAM	3/4	90
5	1	64QAM	1/2	120
6	1	64QAM	3/4	135
7	1	64QAM	5/6	150
8	2	BPSK	1/2	30
9	2	QPSK	1/2	60
10	2	QPSK	3/4	90
11	2	16QAM	1/2	120
12	2	16QAM	3/4	180
13	2	64QAM	1/2	240
14	2	64QAM	3/4	270
15	2	64QAM	5/6	300

The MCS selection therefore indicates the type and minimum or maximum number of modulation parameters that should be used for one or two spatial data streams. Within these limits, the appropriate MCS is selected

when the connection is established depending on the current conditions and may be adapted during the connection if required. This also defines the maximum attainable data throughput, indicated in the last column of the table (here for the short guard interval $GI = 0.4 \mu s$ using the 40 MHz channel).

■ Short guard interval

This option is used to reduce the transmission pause between two signals from $0.8 \mu s$ (default) to $0.4 \mu s$ (short guard interval). This increases the effective time available for data transmission and thus the data throughput. However, the wireless LAN system becomes more liable to disruption that can be caused by interference between two consecutive signals.

The short guard interval is activated in automatic mode provided the remote station supports this operating mode. Alternatively the short guard mode can be switched off.

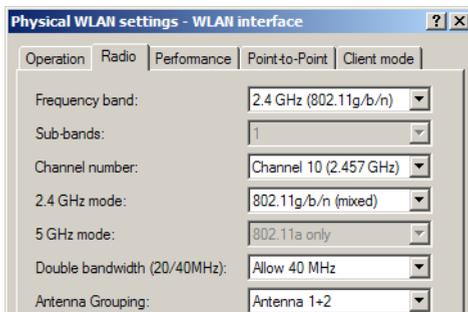
■ Frame aggregation

Frame aggregation is used to combine several data packets (frames) into one large packet and transmit them together. This method serves to reduce the packet overhead, and the data throughput increases.

Frame aggregation is not particularly suited to time critical data transmission such as voice over IP.

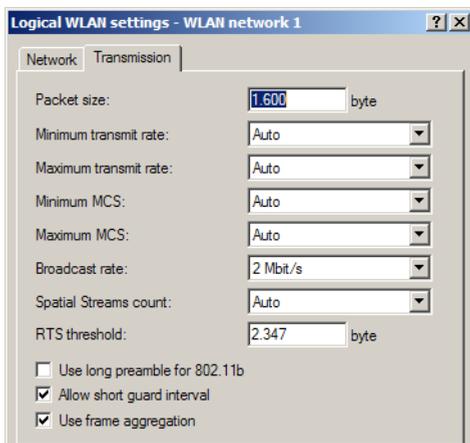
5.2.4 Configuring 802.11n parameters

You can find 802.11n parameter configuration for the wireless LAN module in LANconfig under **Wireless LAN ► General ► Physical WLAN Settings ► Radio**.



You can find these parameters in WEBconfig or Telnet under **LCOS Menu Tree ► Setup ► Interfaces ► WLAN ► Radio Settings**.

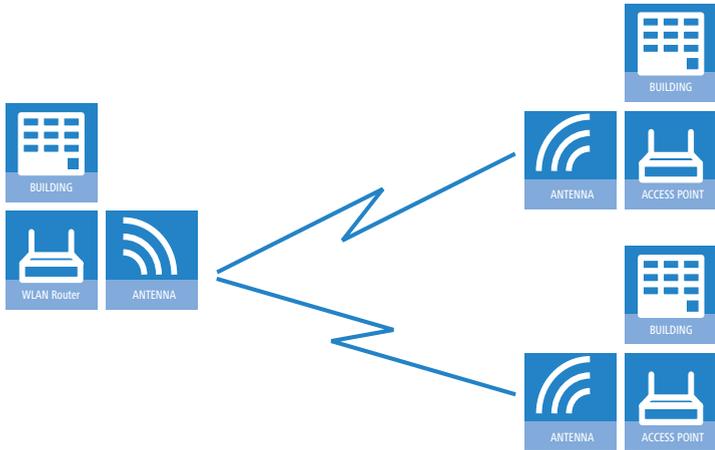
You can find 802.11n parameter configuration for individual wireless LAN networks in LANconfig under **Wireless LAN ▶ General ▶ Logical WLAN Settings ▶ Transmission**.



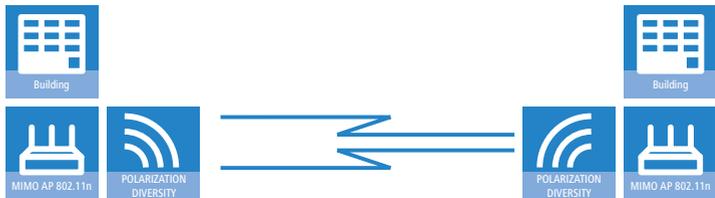
You can find these parameters in WEBconfig or telnet under **LCOS Menu Tree ▶ Setup ▶ Interfaces ▶ WLAN ▶ Transmission**.

5.3 Point-to-point connections

LANCOM Access Points can serve not only as central stations in a wireless network, they can also operate in point-to-point mode to bridge longer distances. For example, they can provide a secure connection between two networks that are several kilometers apart — without direct cabling or expensive leased lines.



When using Access Points and appropriately polarized antennas in accordance with IEEE 802.11n two wireless links can be established simultaneously between the end points of a point-to-point connection. This allows higher data throughput to be achieved or greater distances to be covered than when using other standards.



This chapter introduces the basic principles involved in designing point-to-point links and provides tips on aligning the antennas.

5.3.1 Geometric dimensioning of outdoor wireless network links

The following basic questions must be answered when designing wireless links:

- Which antennas are necessary for the desired application?
- How do the antennas have to be positioned to ensure problem-free connections?
- What performance characteristics do the antennas need to ensure sufficient data throughput within the legal limits?

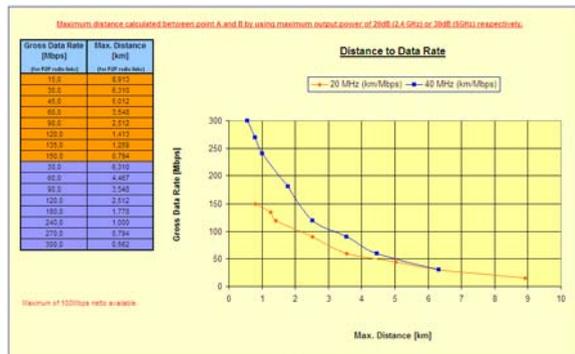
Selection of antennas using the LANCOM Antenna Calculator

You can use the LANCOM Antenna Calculator to calculate the output power of the access points as well as for a first estimation of the achievable distances and data rates. The program can be downloaded from our Web site at www.lancom.eu.

After selecting your components (access points, antennas, lightning protection and cable) the calculator works out the data rates, ranges, and the antenna gain settings that have to be entered into the access point.



Please note that when using 5 GHz antennas additional technologies such as dynamic frequency selection (DFS) may be stipulated depending on the country of use. The operator of the wireless LAN system is responsible for ensuring that local regulations are met.



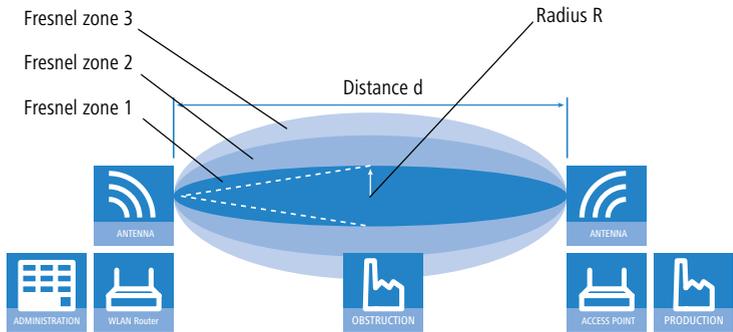
Positioning the antennas

Antennas do not broadcast their signals linearly, but within an angle that depends on the model in question. The spherical expansion of the signal waves produces amplification or interference of the effective power output at certain distances along the connection between the transmitter and receiver. The areas where the waves amplify or cancel themselves out are known as Fresnel zones.



Protecting the components employed from the consequences of lightning strikes and other electrostatic influences is one of the most important aspects to be considered when designing and installing wireless LAN systems for outdoor use. Please refer to the appropriate notes on 'Lightning and surge protection' as otherwise LANCOM Systems cannot provide any guarantee for damage to LANCOM and AirLancer components.

Information on the installation of WLAN systems for outdoor deployment is available in the 'LANCOM Outdoor Wireless Guide'.



The Fresnel zone 1 must remain free from obstruction in order to ensure that the maximum level of output from the transmitting antenna reaches the receiving antenna. Any obstructing element protruding into this zone will significantly impair the effective signal power. The object not only screens off a portion of the Fresnel zone, but the resulting reflections also lead to a significant reduction in signal reception.

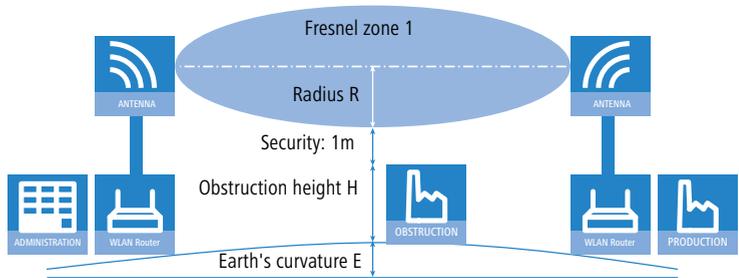
The radius (R) of Fresnel zone 1 is calculated with the following formula assuming that the signal wavelength (λ) and the distance between transmitter and receiver (d) are known.

$$R = 0.5 * \sqrt{\lambda * d}$$

The wavelength in the 2.4 GHz band is approx. 0.125 m, in the 5 GHz band approx. 0.05 m.

Example: With a separating distance of 4 km between the two antennae, the radius of Fresnel zone 1 in the 2.4-GHz band is **11 m**, in the 5-GHz band **7 m**.

To ensure that the Fresnel zone 1 remains unobstructed, the height of the antennas must exceed that of the highest obstruction by this radius. The full height of the antenna mast (M) should be as depicted:



$$M = R + 1\text{m} + H + E \text{ (earth's curvature)}$$

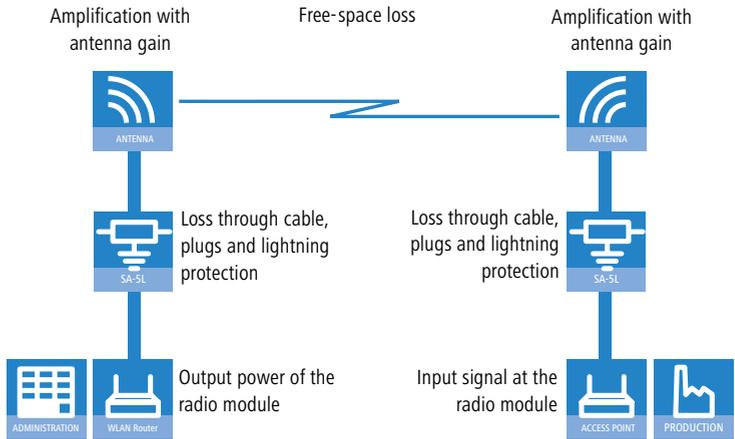
The allowance for the curvature of the earth (E) can be calculated at a distance (d) as $E = d^2 * 0.0147$ – i.e. at a distance of 8 km this is almost 1m

Example: With a distance of 8 km between the antennae, the result in the 2.4-GHz band is a mast height above the level of the highest obstruction of approx. **13 m**, in the 5-GHz band **9 m**.

Antenna power

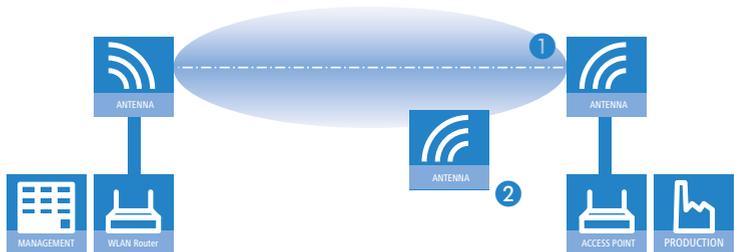
The power of the antennas must be high enough to ensure acceptable data transfer rates. On the other hand, the country-specific legal regulations regarding maximum transmission power should not be exceeded.

The calculation of effective power considers everything from the radio module in the transmitting access point to the radio module in the receiving access point. In between there are attenuating elements such as the cable, plug connections or simply the air transmitting the signals and amplifying elements such as the external antennas.



5.3.2 Antenna alignment for P2P operations

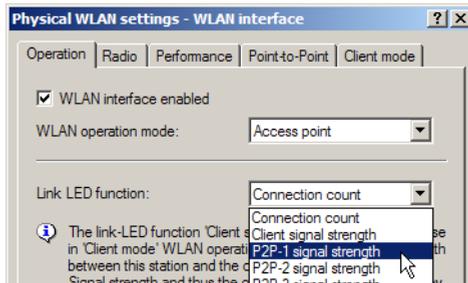
The precise alignment of the antennas is of considerable importance in establishing P2P connections. The more central the receiving antenna is located in the "ideal line" of the transmitting antenna, the better are the actual performance and the effective bandwidth **1**. If the receiving antenna is outside of this ideal area, however, significant losses in performance will be the result **2**.



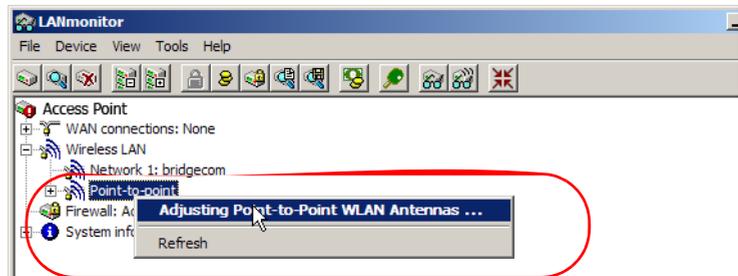
i You can find further information on the geometrical design of wireless paths and the alignment of antennas with the help of LANCOM software in the LCOSreference manual.

The current signal quality over a P2P connection can be displayed on the device's LEDs or in the LANmonitor in order to help find the best possible alignment for the antennas.

The display of signal quality on the LEDs must be activated for the wireless LAN interface (LANconfig: **Wireless LAN ▶ General ▶ Physical WLAN settings ▶ Operation**). The faster the LED blinks the better the connection (a blinking frequency of 1 Hz represents a signal quality of 10 dB, double the frequency indicates that the signal strength is twice as high).



In LANmonitor the connection quality display is opened with the context menu. Right-clicking with the mouse on 'Point-to-point' activates the option 'Adjusting Point-to-Point WLAN Antennas...'



i The 'Point-to-point' entry is only visible in the LANmonitor if the monitored device has at least one base station defined as a remote site for a P2P connection (LANconfig: **Wireless LAN ▶ General ▶ Physical WLAN settings ▶ Point-to-Point**).

In the dialog for setting up point-to-point connections, LANmonitor prompts for the information required to establish the P2P connection:

- Is the P2P connection configured at both ends (remote base station defined with MAC address or station name)?
- Is the point-to-point mode of operation activated?
- Which access point is to be monitored? All of the base stations defined as P2P remote sites in the device concerned can be selected here.

- Are both antennas approximately aligned? The basic P2P connection has to be working before fine-tuning can be performed with the aid of LANmonitor.

Once signal monitoring has commenced, the P2P dialog displays the absolute values for the current signal strength and the maximum value since starting the measurement. The development of the signal strength over time and the maximum value are displayed in a diagram, too.



Initially only one of the two antennas should be adjusted until a maximum value is achieved. This first antenna is then fixed and the second antenna is then adjusted to attain the best signal quality.

5.3.3 Measuring wireless bridges

After planning and installation, the wireless bridge can be analyzed to determine the actual data throughput. Further information about the available tools and taking measurements can be found in the LANCOM Techpaper "The performance of outdoor P2P connections", available as a download from www.lancom.eu.

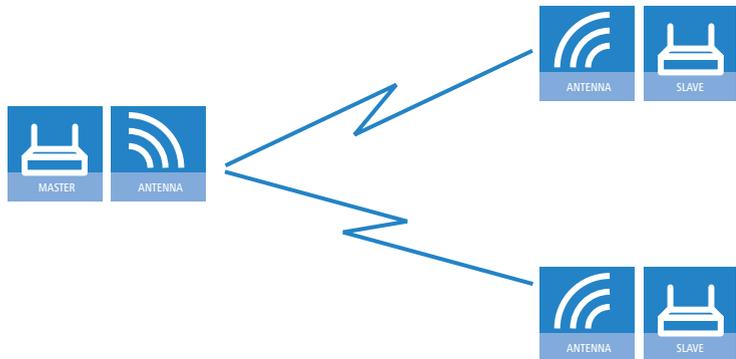
5.3.4 Activating the point-to-point operation mode

The behavior of an access point when exchanging data with other access points is defined in the "Point-to-point operation mode".

- **Off:** The access point only communicates with mobile clients
- **To:** The access point can communicate with other access points and with mobile clients
- **Exclusive:** The access point only communicates with other base stations

In the 5 -GHz band, the automatic search for vacant WLAN channels can lead to several simultaneous test transmissions from multiple access points, with the result that they do not find each other. This stalemate situation can be avoided with the appropriate "Channel selection scheme":

- **Master:** This access point takes over the leadership when selecting a free WLAN channel.
- **Slave:** All other access points will search for a channel until they have found a transmitting Master.



Thus it is recommended for the 5 GHz band that one central access point should be configured as 'Master' and all other point-to-point partners should be configured as 'Slave'. In the 2.4 GHz band, too, this setting simplifies the establishment of point-to-point connections if the automatic channel search is activated.



It is imperative that the channel selection scheme is configured correctly if the point-to-point connections are to be encrypted with 802.11i/WPA (a master as authentication server and a slave as client).

5.3.5 Configuration of P2P connections

In the configuration of point-to-point connections, entries have to be made for the point-to-point operation mode and the channel selection scheme, along with the MAC addresses or station names of the remote sites.

Configuration with
LANconfig

For configuration with LANconfig you will find the settings for P2P connections under the configuration area 'Interfaces' on the 'Wireless LAN' tab.

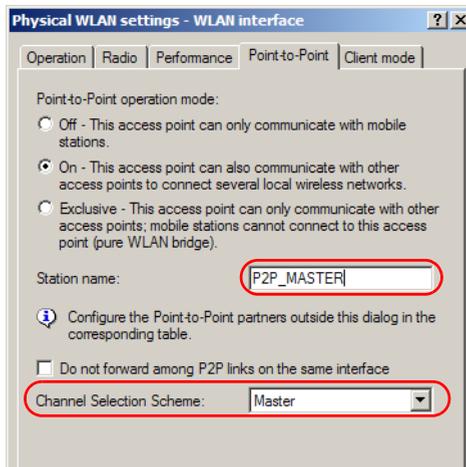


The configuration of the P2P connections can also be carried out with the WLAN Wizards in LANconfig.

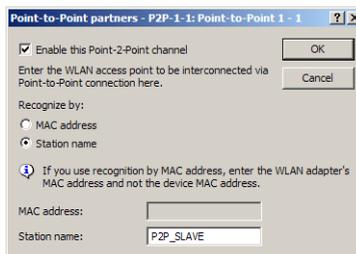
- ① Click on the button **Physical WLAN settings** to open the corresponding WLAN interface and select the tab for 'Point-to-Point'.
- ② Activate the suitable point-to-point operation mode here and set the channel selection scheme to either 'Master' or 'Slave'. If the peers of the P2P connections are to be identified via their station names, then enter a unique name for this WLAN station.



For models with multiple WLAN modules, the station name can be entered separately for each physical WLAN interface.



- ③ Close the physical WLAN settings and open the list of **Point-to-point partners**. For each of the maximum of six P2P connections, enter either the MAC address of the WLAN card at the remote station or enter the WLAN station's name (depending on the chosen method of identification).





Please observe that only the MAC addresses of the WLAN cards at the other end of the connections are to be entered here! Not the access point's own MAC address, and not the MAC addresses from any other interfaces that may be present in the access points.

You will find the WLAN MAC address on a sticker located under each of the antenna connectors. Only use the string that is marked as the "WLAN MAC" or "MAC-ID". The other addresses that may be found are not the WLAN MAC address but the LAN MAC address.

Connecting point-to-point remote stations by station name

When configuring point-to-point connections, an alternative to the MAC addresses is to use the station names of the remote stations.

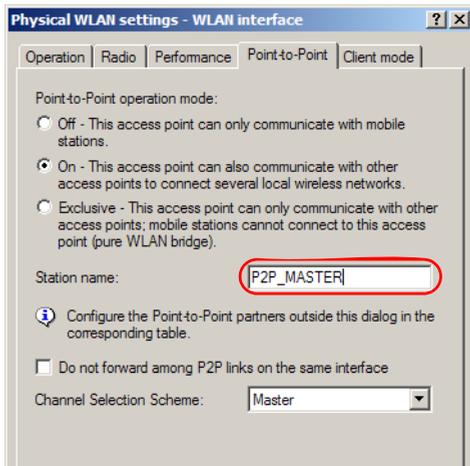
First of all the station name is entered into the point-to-point settings in the Wireless Routers or Access Points.

■ LANconfig: **Wireless LAN** ▶ **General** ▶ **Physical WLAN settings** ▶ **Point to point**

■ WEBconfig: **Setup** ▶ **Interfaces** ▶ **WLAN interpoint settings**

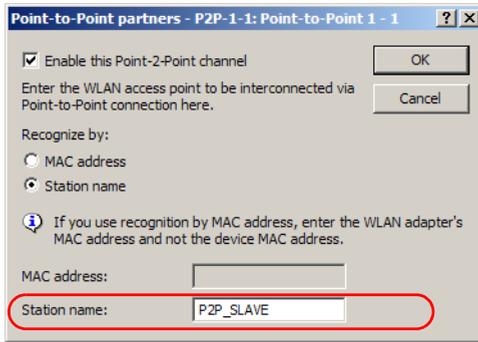


For models with multiple WLAN modules, the station name can be entered separately for each physical WLAN interface.



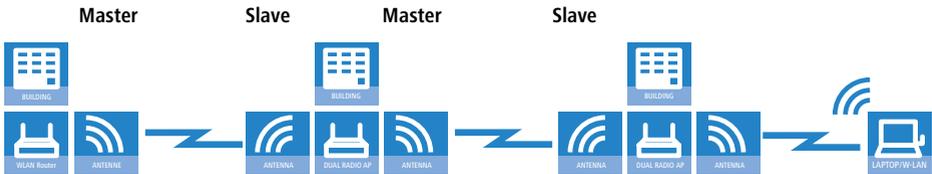
In the point-to-point configuration, select the identification by station name and enter the name of the corresponding station.

- LANconfig: **Wireless LAN ▶ General ▶ Point to point partners**
- WEBconfig: **Setup ▶ Interfaces ▶ WLAN interpoint peers**



5.3.6 Access points in relay mode

Access points equipped with two wireless modules can be used to establish wireless bridges across multiple stations. Each wireless module is configured as a 'Master' and then 'Slave' in turn.



The use of relay stations each equipped with two WLAN modules simultaneously solves the problem of the "hidden station", by which the MAC addresses of the WLAN clients are not transferred over multiple stations.

5.3.7 Security for point-to-point connections

IEEE 802.11i can be used to attain a significant increase in the security of WLAN point-to-point connections. All of the advantages of 802.11i such as the simple configuration and the powerful encryption with AES are thus available for P2P mode, as are the improved security of the passphrase from the LANCOM Enhance Passphrase Security (LEPS).

Encryption with 802.11i/WPA

To activate the 802.11i encryption for a correctly configured P2P connection, adjust the settings for the first logical WLAN network in the appropriate WLAN interface (i.e. WLAN-1 if you are using the first WLAN module for the P2P connection, WLAN-2 if you are using the second module, e.g. as with an access point with two WLAN modules).

- Activate the 802.11i encryption.
- Select the method '802.11i (WPA)-PSK'.
- Enter the passphrase to be used.



The passphrases should consist of a random string of at least 22 characters long, corresponding to a cryptographic strength of 128 bits.

When set as P2P Master, the passphrase entered here will be used to check the Slave's authorization to access. When set as P2P Slave, the access point transfers this information to register with the remote site.

For configuration with LANconfig you will find the encryption settings under the configuration area 'Wireless LAN' on the '802.11i/WEP' tab.

The screenshot shows the 'WPA or Private WEP settings' window in the LANCOM configuration software. The window is divided into two main sections: a table of WLAN interfaces and a detailed configuration panel for the selected interface (WLAN-1).

Interface	Encryption	Method / Key 1	Key 1/passphrase
WLAN-1: Wireless Network 1	Off	WEP64 (40 bit)	0x000000000000
WLAN-1-2: Wireless Network 2	Off	WEP64 (40 bit)	0x000000000000
WLAN-1-3: Wireless Net			
WLAN-1-4: Wireless Net			
WLAN-1-5: Wireless Net			
WLAN-1-6: Wireless Net			
WLAN-1-7: Wireless Net			

The detailed configuration panel for WLAN-1 shows the following settings:

- Interface: WLAN-1: Wireless
- Activate 802.11i Enhanced Security with Advanced Encryption Standard (WPA/AES) or Standard Wired Equivalent Privacy (WEP)
- Method / Key 1 length: 802.11i (WPA)-PSK
- Key 1/passphrase: HgtruHU5786Jt8llk)X(8
- WPA Session Key Type: TKIP/AES

LEPS for P2P connections

A further gain in security can be attained by additionally using LANCOM Enhanced Passphrase Security (LEPS) which involves the matching of MAC address and passphrase.

LEPS can be used to secure single point-to-point (P2P) connections with an individual passphrase. Even if an access point in a P2P installation is stolen

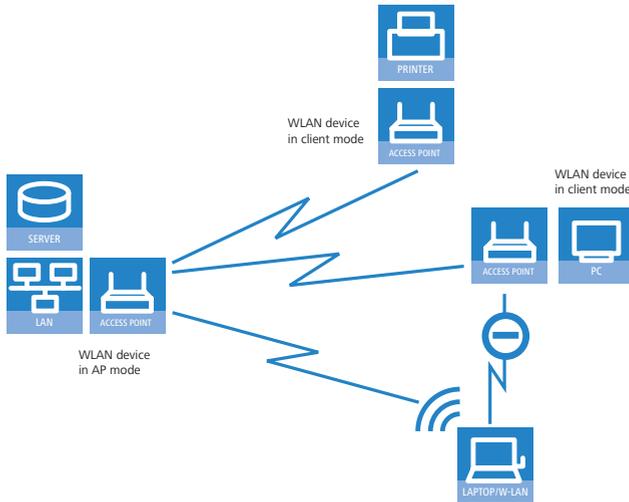
and the passphrase and MAC address become known, all other WLAN connections secured by LEPS remain secure.

When using LANconfig for the configuration, you enter the passphrases of the stations approved for the WLAN in the configuration area 'Wireless LAN' on the 'Stations' tab under the button **Stations**.



5.4 Client mode

To connect individual devices with an Ethernet interface into a wireless LAN, LANCOM devices with a WLAN module can be switched to "client mode", whereupon they act as conventional wireless LAN adapters and not as access points (AP). The use of client mode therefore allows devices fitted with only an Ethernet interface, such as PCs and printers, to be integrated into a wireless LAN.



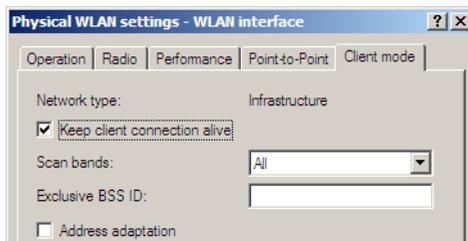
Multiple WLAN clients can register with a WLAN device in AP mode, which is not the case for a WLAN device in client mode.

5.4.1 Client settings

For LANCOM Access Points and LANCOM Wireless Routers in client mode, further settings/client behavior can be configured from the 'Client mode' tab under the settings for the physical interfaces.



The configuration of the client settings can also be carried out with the WLAN Wizards in LANconfig.



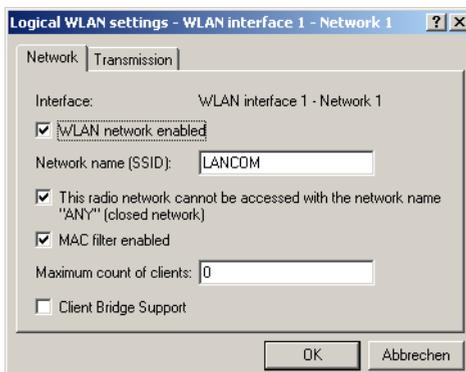
- ① To edit the settings for client mode in LANconfig, go to the 'Client mode' tab under the physical WLAN settings for the desired WLAN interface.

- ② In 'Scan bands', define whether the client station scans just the 2.4 GHz, just the 5 GHz, or all of the available bands to locate an access point.

5.4.2 Set the SSID of the available networks

In the WLAN clients, the SSIDs of the networks to which the client stations are to connect must be entered.

- ① To enter the SSIDs, change to the 'General' tab under LANconfig in the 'Wireless LAN' configuration area. In the 'Interfaces' section, select the **first** WLAN interface from the list of logical WLAN settings.



- ② Enable the WLAN network and enter the SSID of the network the client station should log onto.

5.4.3 Encryption settings

For access to a WLAN, the appropriate encryption methods and key must be set in the client station.

- ① To enter the key, change to the '802.11i/WEP' tab under LANconfig in the 'Wireless LAN' configuration area. From 'WPA / private WEP settings', select the **first** WLAN interface from the list of logical WLAN settings.

- ② Enable encryption and match the encryption method to the settings for the access point.
- ③ In WLAN client operating mode, the LANCOM Access Points and LANCOM Wireless Routers can authenticate themselves to another access point using EAP/802.1X. For this, select the desired client EAP method here. Note that the selected client EAP method must match the settings of the access point that the device is attempting to log onto.



Depending on the EAP method, the appropriate certificates must be stored in the device.

- For TTLS and PEAP - the EAP/TLS root certificate only; the key is entered as a combination username:password.
- For TLS in addition; the EAP/TLS device certificate including the private key.

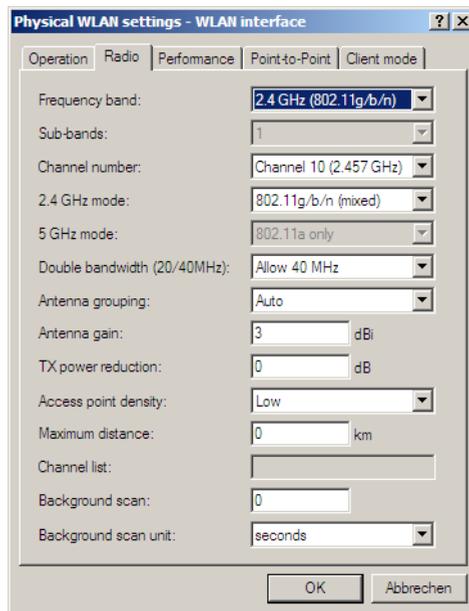
5.4.4 Roaming

Roaming is defined as the transfer of a WLAN client to another access point once the connection to the access point used so far can no longer be kept alive. To allow roaming, at least one additional access point must be within range of the client, it must provide a network with an identical SSID and matching radio and encryption settings.

Under normal circumstances the WLAN client would only log onto another access point if the connection to the access point used up to that point was lost completely (hard roaming). Soft roaming on the other hand enables the client to use scan information to roam to the strongest access point. With the background scanning function, the LANCOM Wireless Router in client mode

can gather information on other available access points prior to the connection being lost. In this case the client is not switched to another access point once the existing connection has been lost completely, but rather when another access point within its range has a stronger signal.

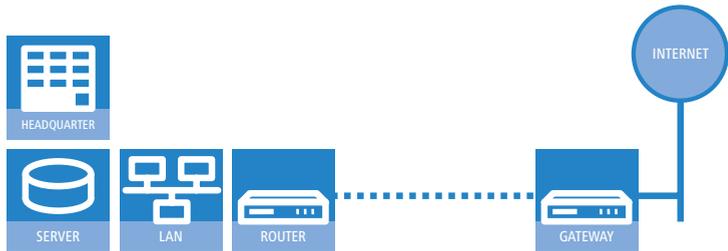
- ① To enable soft roaming in WEBconfig or telnet, change to Setup > Interfaces > WLAN > Roaming and select the physical WLAN interface.
- ② Enable soft roaming and, if required, set the other parameters (such as threshold levels and signal level).
- ③ To configure background scanning in LANconfig, go to the 'Radio' tab under the physical WLAN settings for the desired WLAN interface.



- ④ Enter the background scan interval as the time in which the LANCOM Wireless Router cyclically searches the currently unused frequencies of the active band for available access points. To achieve fast roaming the scan time is set, for example, to 260 seconds (2.4 GHz) or 720 seconds (5 GHz).

6 Setting up Internet access

The LANCOM provides a central point of Internet access for all of the computers in the LAN. For models not equipped with a WAN connector, a LAN interface is configured as a DSL/L connector and is connected to a compatible ADSL modem.



Does the Setup Wizard know your Internet provider?

The Wizard is preset with access data for the principal Internet providers in your country and offers you a selection list. If you find your Internet provider in this list, then you generally do not have to enter any additional parameters to set up your Internet access. All that is required is the authentication data as supplied to you by your Internet provider.

Internet provider unknown

If the list in the Setup Wizard does not contain your provider, you will be asked step-by-step for all of the necessary data. This access data will have been supplied to you by your Internet provider.

Other connection options

In addition you can use the Wizard to activate or deactivate additional options (if supported by your Internet provider):

- Billing by time or flatrate – select the method by which you are billed by your Internet provider.
 - In case of billing by time, you can set the LANCOM to cut connections automatically if no data flows for a certain time (the hold time).
You can also set up line polling that detects inactive remote sites very quickly and, in such cases, can close the connection before the hold time expires.

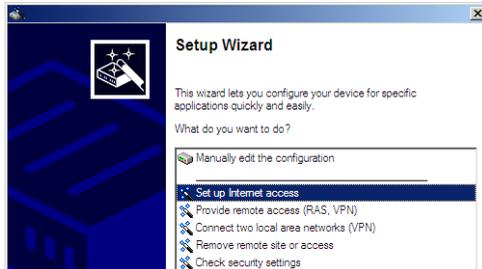
- In case of flatrate billing you can also set up line polling to monitor the function of the remote site.

Apart from that you can opt to keep flatrate connections permanently active ("keep-alive"). In case a connection should fail, it is re-established automatically.

6.1 The Internet Connection Wizard

6.1.1 Instructions for LANconfig

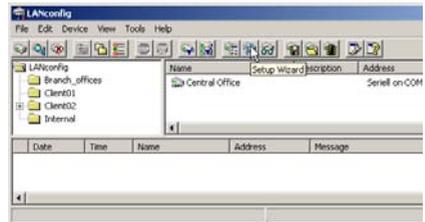
- ① Mark your device in the selection window. From the command line, select **Extras ▶ Setup Wizard**.



- ② In the selection menu, select the Setup Wizard, **Set up Internet connection** and confirm the selection with **Next**.
- ③ In the following windows you select your country, your Internet provider if possible, and you enter your access data.
- ④ Depending on availability the Wizard provides further options for your Internet connection.
- ⑤ The Wizard will inform you as soon as the entries are complete. Close the configuration with **Finish**.

LANconfig: Fast starting of the Setup Wizards

The fastest way of starting the Setup Wizards under LANconfig is to use the command button in the button bar.



6.1.2 Instructions for WEBconfig

- ① Select the entry **Set up Internet connection** from the main menu.
- ② In the following windows you select your country, your Internet provider if possible, and you enter your access data.
- ③ Depending on availability the Wizard provides further options for your Internet connection.
- ④ The wizard will inform you as soon as the entries are complete. Close the configuration with **Finish**.

7 Options and accessories

Your LANCOM device has numerous extensibilities and the possibility to use a broad choice of LANCOM accessories. You find in this chapter information about the available accessories and how to use them with your base station.

- The range of the base station can be increased by optional antennas of the AirLancer series and can be adapted to special conditions of environs.
- With the LANCOM Public Spot Option option it is possible to extend the LANCOM for additional billing and accounting functions in order to upgrade it to a Wireless Public Spot.

7.1 Optional AirLancer Extender antennas

AirLancer Extender antennas are capable of extending the operating range of the devices, or of adapting access point coverage to local conditions. An overview of the supported antennas is available from the LANCOM Web site under www.lancom.eu.



You will also find further information on calculating the best configuration for AirLancer Extender antennas and third-party antennas that you wish to connect to the device in the LANCOM Antenna Calculator, which can be downloaded from our Web site at www.lancom.eu.



When assembling separately purchased mobile radio antennas please note that the maximum allowed transmission power of the wireless LAN according to EIRP in the country in question may not be exceeded. The system operator is responsible for adhering to the threshold values.



For internal lightning protection, the surge adapter AirLancer Extender SA-5L is **always necessary**—the AirLancer Extender SA-5L is mounted between the Access Point and the antenna, as close to the antenna as is possible.



Antennas are only to be attached or changed when the device is switched off. Mounting or demounting antennas while the device switched on may cause the destruction of the WLAN module!

7.1.1 Antenna diversity

The transmission of radio signals can suffer from significant signal losses because of reflection and scatter, among other reasons. In some areas, the interaction with the reflected radio waves can cause a drop in signal strength, or even cause it to be cancelled out completely. Transmission quality can be improved with so-called "diversity" methods. The principle of "diversity" methods relies on the fact that a transmitted signal is often received multiple times (generally twice).

Each wireless LAN module is equipped with two send/receive units, each of which can be connected to an antenna. In the case of antenna diversity, the WLAN module checks which send/receive unit (antenna) is receiving the strongest signal from a client. Only the stronger signal is used. The Access Point stores the information on which send/receive unit was used to receive

data and proceeds to use the same unit for the transmission to the client. Antenna diversity ensures that the various clients associated with the Access Point always use the send/receive unit with the best signal.

7.1.2 Polarization diversity

Other diversity techniques process the two signals and combine them into a single signal. The most common methods are space diversity and polarization diversity. LANCOM Systems supplies various polarization diversity antennas for connection to LANCOM devices. With these models, two orthogonally polarized signals are received at a transmitter/receiver unit and combined to form a single signal which is stronger than the two individual signals. This improvement is the polarization gain.

7.1.3 MIMO

MIMO also uses polarization antennas which can process two orthogonally polarized signals. Different to polarization diversity, MIMO uses each of these signal to transport a separate data stream and achieve twice the data throughput.

7.1.4 Installing the AirLancer Extender antennas

Not for LANCOM L-320agn Wireless

The following diversity antennas are available as accessories for the L-32x Access Points:

- AirLancer Extender O-D80g (2.4 GHz band), item no. 61221
- AirLancer Extender O-D60a (5 GHz), item no. 61222
- AirLancer Extender O-D9a (5 GHz), item no. 61224



Before mounting external antennas, please observe the information on lightning protection in the LANCOM Outdoor Wireless Guide (supplied or available as a download from www.lancom.eu). Mounting antennas without adequate lightning protection could lead to serious damage to the access point and the network infrastructure connected to it.

To install an optional AirLancer antenna, switch the device off by unplugging the power cable. Now carefully unplug the three diversity antennas from the back by unscrewing them. Connect the AirLancer antennas to the antenna connectors marked 'ANT 1' and 'ANT 2'. With a LANCOM L-322agn dual

Wireless, 1 + 3 are always used. External antennas cannot be connected to Antenna 2.



Please note the following when connecting antennas:

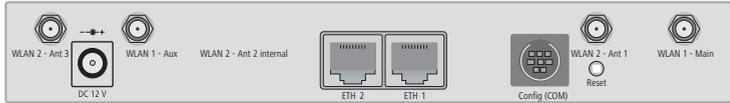
Antenna connector 1 must always be used. Depending on the model, mounting and cabling, the second antenna may be connected either to connector 2 or connector 3.

The configuration of the device software must agree with the actual antenna connections.

LANCOM L-321agn Wireless



LANCOM L-322agn dual Wireless



7.2 LANCOM Public Spot Option

Wireless Public Spots are publicly accessible areas where users can use their own mobile computers to access a wireless network (such as a company network or the Internet).



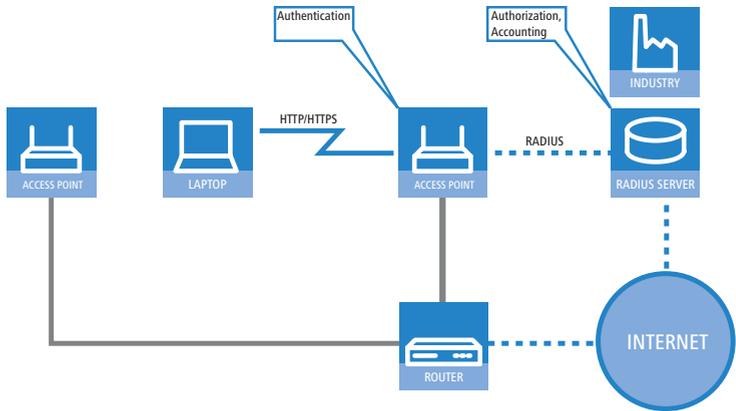
Please note that operating a L-32x Access Point with the LANCOM Public Spot Option (also referred to as a HotSpot) can be subject to legal regulation in your country. Before installing a L-32x Access Point, please inform yourself about any applicable regulations.

Wireless LAN technology is ideal for offering wireless Internet services to the public in locations such as airports, railway stations, restaurants or cafes via so-called HotSpots. The LANCOM Public Spot Option is intended for operators of public wireless networks. It enables the easy installation and maintenance of public HotSpots by providing LANCOM Access Points and LANCOM Routers with additional functions for authentication and billing for public Internet services.

Authentication and billing for individual users is implemented with user-friendly Web pages, enabling client PCs with a WiFi-certified wireless card (el.g. AirLancer) and standard Internet browser to go directly online.

The LANCOM Public Spot Option is the ideal solution for public wireless LAN. Wireless LAN are very well suited for company networks and for wireless networking in the home. However, for public access services the standard setup lacks important mechanisms for authentication and billing of individual users (AAA — authentication, authorization, accounting). This is remedied by the LANCOM Systems Open User Authentication (OUA), the core component of the LANCOM Public Spot Option. OUA implements the authentication of all wireless clients by user name and password. It checks the authorization of each user with a RADIUS server. Accounting data (online time, volumes) on a per user and per session basis can be passed on to the central RADIUS server. All the client PC needs is a wireless card (el.g. AirLancer), TCP/IP, and an Internet browser. No further software is required. The Public Spot Option is optimally suited for setting up wireless Internet access services in hotels,

restaurants, cafes, airports, railway stations, exhibition grounds or universities.



The LANCOM Public Spot Option equips an access point with these functions and upgrades it to a wireless Public Spot.

8 Advice & assistance

See this chapter for first-aid assistance if some of the typical problems should occur.

8.1 No WAN connection can be established

After starting, the router attempts automatically to connect to the Internet provider. During this phase, the Internet-connection status LED blinks green. If successful, this LED switches to constant green. If contact cannot be made, the WAN LED does not illuminate. This is generally due to one of the following causes:

Problems with the cabling?

For the DSL connection, use only the connector cable supplied. This cable must be connected to the Ethernet connector of the DSL modem. The LED for the WAN connection must illuminate in green to show that it is physically connected.

Is the correct transmission protocol selected?

The transmission protocol is defined with the basic settings. The Basic Settings Wizard actually sets the correct protocol for a wide variety of DSL providers. If your DSL provider is unknown to the Wizard you have to set the protocol yourself. The protocol specified by your DSL provider should work without problem.

You can check and adjust your protocol settings under:

LANconfig: Communication ► General ► Communication layers

WEBconfig: LCOS Menu Tree ► Setup ► WAN module ► Layer list

8.2 Slow DSL transmission

The speed of data transmission over an (Internet) DSL connection depends on a number of factors, most of which are beyond the influence of normal users. Along with bandwidth of your provider's connection, of decisive importance is the provider's Internet connection and the load on the target Web page. Several other factors in the Internet itself can also influence the transmission speeds.

Increasing the TCP/IP window size under Windows

If the actual transmission speed over a DSL connection is significantly lower than the maximum specified by the DSL provider, there are very few potential error sources with your own equipment.

A typical problem arises when a Windows PC simultaneously sends and receives large quantities of data over an asynchronous connection. This situation can severely impact download speeds. The cause of this is the RCP/IP receive windows size as defined in the Windows operating system. The default value is too small for asynchronous connections.

Instructions for increasing the windows size are available in the Knowledge-Base in the Support area of the LANCOM Systems Web site (www.lancom.eu).

8.3 Unwanted connections under Windows XP

When booting, Windows XP computers attempt to update the time by accessing a time server in the Internet. For this reason, Windows XP computers booting in the WLAN cause the LANCOM to connect to the Internet.

To prevent Windows XP computers from automatically synchronising the time, **right-click on the time ► Change time/date ► Internet time off.**

9 Appendix

9.1 Performance and characteristics

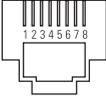
		LANCOM L-320agn Wireless	LANCOM L-321agn Wireless	LANCOM L-322agn dual Wireless
Frequency band		WLAN module with 2400-2483.5 MHz (ISM) or 5150-5750 MHz or 5725-5825 MHz (UK only)		Two WLAN modules each with 2400 - 2483.5 MHz (ISM) or 5150 - 5750 MHz
Connections	ETH1	10/100/1000Base-TX, Autosensing		10/100/1000Base-TX, autosensing
	ETH2			10/100Base-TX, auto-sensing
	WLAN1	2 internal antennas IEEE 802.11agbn	2 external antenna connectors (reverse SMA sockets) IEEE 802.11agbn	2 external antenna connectors (reverse SMA sockets) IEEE 802.11agbn
	WLAN2			2 external antenna connectors (reverse SMA sockets) IEEE 802.11agbn
Power supply		12V DC via external power supply, or IEEE 802.3af-compliant Power over Ethernet. Approved power supply unit: NEST 12V/1A DC/S Hohlstkr 2.1/5.5mm (RoHS) LANCOMItem no. 110524 Type designation on the power supply unit "Type: 15.2230S"		
Antennas		2 internal antennas.	Two dualband dipole antennas (supplied).	Four dualband dipole antennas (supplied).
		Please respect the restrictions which apply in your country when setting up an antenna system. For information about calculating the correct antenna setup, please refer to www.lancom.eu .		
Housing		Dimensions 210 mm x 143 mm x 45 mm (B x H x T), robust plastic housing, stackable, prepared for wall mounting		
Conformity		CE conform with EN 301 489-1, EN 301 489-17, EN 60950-1 Approved for radio operation in all EU countries and Switzerland		
Notifications		Certifications notified in Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Great Britain, Hungary, Ireland, Italy, Lapland, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Rumania, Slovakia, Slovenia, Spain, Sweden, Switzerland		
Environment/Temperature		0 °C to +45 °C at 95 % max. humidity (non condensing)		
Service		3-year warranty		

	LANCOM L-320agn Wireless	LANCOM L-321agn Wireless	LANCOM L-322agn dual Wireless
Support	Via hotline and Internet		
Accessories	<ul style="list-style-type: none"> ■ LANCOM Serial adapter kit for connecting modems (analog or GSM) to the serial configuration interface (item no. 61500) ■ LANCOM Rack Mount Option (item no. 61501) ■ LANCOM LCOS Reference Manual (DE) (item no. 61700) ■ LANCOM PoE Power Injector, item no. 61502 ■ LANCOM ES-1108P, 8-port switch with 4 PoE ports, item no. 61450 ■ LANCOM ES-2126, 24-port switch, item no. 61452 ■ LANCOM ES-2126P, 24-port switch with 24 PoE ports, item no. 61451 		
			<ul style="list-style-type: none"> ■ AirLancer Extender O-D9a 2.4/5 GHz outdoor antenna, item no. 61224 ■ AirLancer Extender O-D60a, 5 GHz outdoor antenna, item no. 61222 ■ AirLancer Extender O-D80g 2.4 GHz outdoor antenna, item no. 61221 ■ AirLancer cable NJ-NP 3m antenna-cable extension, item no. 61230 ■ AirLancer cable NJ-NP 6m antenna-cable extension, item no. 61231 ■ AirLancer cable NJ-NP 9m antenna-cable extension, item no. 61232 ■ AirLancer Extender SA-5L lightning protection (2.4 and 5 GHz), item no. 61553 ■ AirLancer Extender SA-LAN lightning protection LAN cable, item no. 61213
Options	<ul style="list-style-type: none"> ■ LANCOM Next Business Day Service Extension item no. 61411 ■ LANCOM 2-Year Warranty Extension item no. 61414 ■ LANCOM Public Spot Option (authentication and accounting software for hotspots) (item no. 60642) 		

9.2 Connector wiring

9.2.1 Ethernet interface 10/100Base-TX

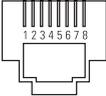
8-pin RJ45 sockets (ISO 8877, EN 60603-7)

Connector	Pin	Line
	1	T+
	2	T-
	3	R+
	4	PoE/G
	5	PoE/G
	6	R-
	7	PoE/ -48 V
	8	PoE/ -48 V

9.2.2 Ethernet interface 10/100/1000Base-TX, DSL interface

LANCOM L-320agn
Wireless and
LANCOM L-321agn
Wireless only

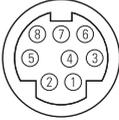
8-pin RJ45 sockets (ISO 8877, EN 60603-7)

Connector	Pin	Fast Ethernet	Gigabit Ethernet
	1	T+	BI_DA+*
	2	T-	BI_DA-
	3	R+	BI_DB+
	4	PoE/G	BI_DC+
	5	PoE/G	BI_DC-
	6	R-	BI_DB-
	7	PoE/ -48 V	BI_DD+
	8	PoE/ -48 V	BI_DD-

*BI_DA+ stands for "bi-directional pair +A"

9.2.3 Configuration interface (outband)

8-pin Mini DIN socket

Connector	Pin	Line
	1	CTS
	2	RTS
	3	RxD
	4	RI
	5	TxD
	6	DSR
	7	DCD
	8	DTR
	U	GND

EN

9.3 CE-declarations of conformity



LANCOM Systems herewith declares that the devices of the type described in this documentation are in agreement with the basic requirements and other relevant regulations of the 1995/5/EC directive.

The CE declarations of conformity for your device can be found on the relevant product page on the LANCOM Web site (www.lancom.eu).

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