Handbook

1 History

Version	Date	Changes	Status
V1.00	02.29.12	Developed	Release
V1.10	07.06.12	Various Modifications	Release
V1.11	29.08.12	Various Corrections Chapter 7 and 8 revision adjustment for LabCon® Version 1.05.02 compatibility	Release
V1.12	23.11.12	Revision of Chapters: Standalone ↔ System operations under Nagios	Release
V1.13	21.01.13	Chapter 12 revisions	Release
V1.14	08.04.13	An SW-Version 2.01.01 adjustments: - Ch. 6.3.1 Addition of alert communities - Ch. 6.3.2 Addition of warning ID - Ch. 6.3.2 CSV further definition additions - Ch. 6.4.3 additions - Ch. 6.6 CSV Push additions - Ch. 7.2.2 Added - Ch. 7.2.4.4.1 Flags adjustment - Ch. 7.3 newly generated - Ch 12.4 extended configuration - Ch. 12.5.1 Addition of timing intervals	Release
V1.15	13.04.17	Ch. 15 outsourced to (“Nagios Installation / LabCon Integration”)	Release

2 Legal

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3 Table of Contents

4 General

This manual describes the integration of LabCon ® into a Nagios environment.

A Debian 6.0 Squeeze system platform has been selected for the installation of Nagios LabCon®.

4.1 Target Group

This document is intended for system administrators integrating LabCon® in Nagios.

4.2 Criteria

- the ZBG-100 gateway must be accessible (section 6.2)
- Linux and the Bash shell experience.

4.3 Definition of Symbols

	The attention symbol refers to actions, which can cause damage to material or equipment.

	The notice indicates necessary conditions for error-free operation. It picks out important details, makes the job easier, and gives tips and advice on the optimal use of hardware and software.

5 LabCon® Overview

LabCon® is a wireless system for the convenient and efficient real-time monitoring and control system of various parameters. It is based primarily on the communication via SNMP, so it is very easy to integrate with other existing monitoring systems such as HP OpenView, Tivoli, etc.

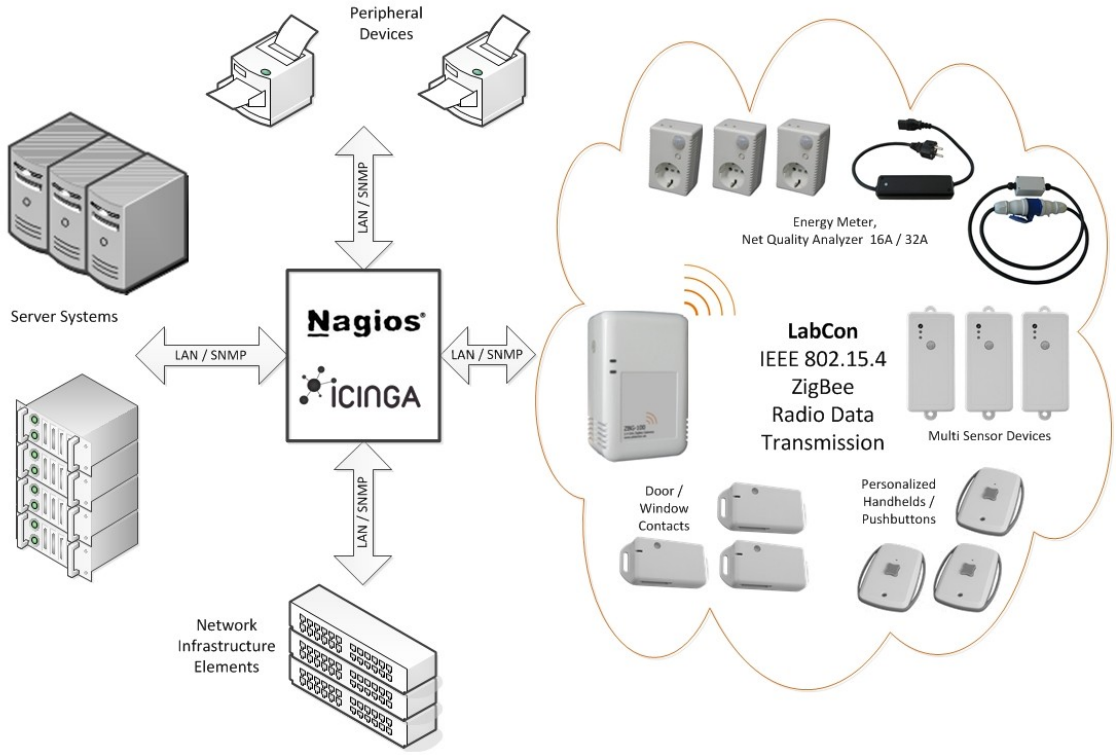


Figure 1: LabCon® & Intreface Overview

ZBG-100-Gateway is the link to the outside world for devices, such as sensors and actuators. It collects all the data from the connected ZigBee devices and makes them available via SNMP. This means that for the integration only one host in Nagios must be configured. The resulting services on the host then display the individual functions / sensors devices.

LabCon® has multi-host capability. This means that the central installation of Nagios further systems and sites can be run.

5.1 ZigBee Wireless Standard

Zigbee is based on IEEE802.15.4 standards and acts as WLAN and Bluetooth in the so-called ISM band (2.4 GHz). The use is royalty-free and available worldwide.

A theoretical maximum bandwidth of 250 kbit/s is sufficient for sensing and managing applications. With an optional 128-bit AES encryption and further security features, it is sufficiently secured against various attacks.

The strengths of ZigBee lie heavily in the meshing and routing. Thus, the network set-up is transparent and independent, without affecting the user. Additional infrastructure, such as repeaters or separate routers, are not necessary.

In the event of router-failure, the network will repair itself (spacial expansion and wireless reception permitting). New routes will be established automatically.

This mechanism may take a few minutes during both the initial network setup and the reorganization.

There are three different types of ZigBee devices:

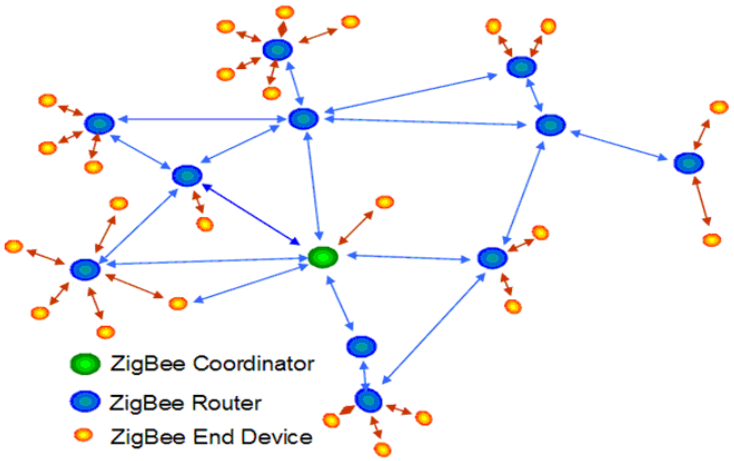


Figure 2: ZigBee Overview

5.1.1 Coordinator

The Coordinator is the center (the so-called master) of the wireless network. It includes two main functions:

a. accessions of routers and end-devices to the network, including key management.

b. gateway to the outside world.

The coordinator is able to communicate with any number of routers and up to 20 end-devices. Other end-devices may require an additional router.

Both the coordinator and the routers require a permanent power supply. ZBG-100 supplies the LabCon® system.

5.1.2 Router

The router's network continues to span the geographic scope. It saves notifications delivered to the connected end-device, in case they are in sleep-mode and therefore unable to accept incoming notifications. Devices with a permanent power supply are generally ideal as routers. (ie. gadgets with energy-saving functions or including a remote switch.)

ZBS-110V2/-111/-112 are the devises used in LabCon® system.

5.1.3 End-Device

End-devices are usually battery-powered and are rarely active if:

a. your configured sleep-time expires (default 28 seconds). Then inquire through the router to which you are registered, whether you have received any messages.

b. there are a local events are active. (eg. Pressing a key)

c. a previously defined measurement-interval (“MSI”) requests sensors, and at least one threshold violation exists.

d. a transmission interval of a previously defined transmission interval ("TXT") forces the device to retrieve all local sensors and send the sensor data to the coordinator.

ZBS-121/-130/-132/-140 are the devices used in LabCon System.

Battery-operated devices are constantly monitored on your battery voltage. If the

battery is empty, it is shown early enough to change the battery before the unit is no longer available.

5.2 Device Overview

5.2.1 ZigBee-Gateway ZBG-100

The freely programmable ZigBee gateway ZBG-100 includes one GHz class ARM-based CPU core with powerful peripherals (such as Gigabit Ethernet), an SD card slot, and a USB port. The USB port can be used- for example- as a memory for data logs or applications can use and a 2.4 GHz ZigBee coordinator module.

A 230V power supply is built in, so that the ZBG-100 unit must only be plugged into a power supply and can be started immediately.

A web front-end is available for a quick and easy start. Through this web-front, all ZigBee devices can be managed easily and reliably.

The ZBG has two LEDs, one blue and one red, which can be addressed via the software. LabCon® uses this to indicate traffic on the ZigBee wireless link.

Figure 3: ZBG-100

Both the USB port and the SD card slot can be used to expand the internal memory. However, you can also launch a Linux operating system from these interfaces.

Additional information is available in the data sheet. You can find this under the following link:

http://www.pikkerton.de/zigbee/ZBG-100_ZigBee_Gateway.html

5.2.2 ZigBee Sensors & Actuators in the ZBS- family

This chapter lists the main equipment of the ZBS family. Further information can be found under:

http://www.pikkerton.de/zigbee/ZigBee.html

5.2.2.1 Smart Energy Meter

The following group of devices are used to measure and partially to switch currents:

- ZBS-110V2,
- ZBS-111
- ZBS-112.

Figure 4: ZBS-112

Switchable devices, such as ZBS-110 and ZBS-111, include the pikkerton SART technology. These enhance the service life of the relay contacts.

Figure 5: ZBS-110V2

The devices ZBS-110, ZBS-111 and ZBS-112 have the **/NQ**-Option. This is a high-precision measuring unit including voltage, which detects and reports fluctuations and spikes.

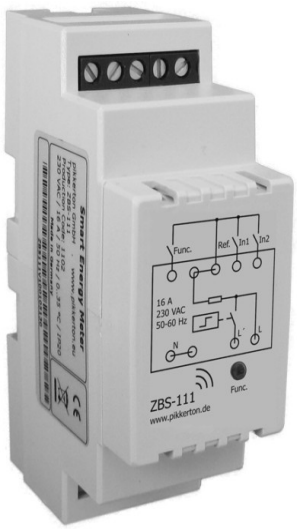


Figure 6: ZBS-111

An automatic measurement is taken at approximately 14.000x per second. This is then delivered to and integrated into an evaluation algorithm supported by DSP and Controller.

5.2.2.2 ZigBee Multi-sensor

ZigBee multi-sensors (ZBS-12x) are available in a variety of configurations. Supported sensor types are currently:

- Temperature
- Brightness
- Air Pressure
- Humidity
- Motion

Figure 7: ZBS-121 (indoor)

Although the unit carries out measurements in narrow intervals, a mere handful of rich µA (a thousandths of a milliamperes) is needed to ensure year-round reliability and efficiency.

After each measurement, all on-board sensors must be turned off completely and the unit switched into deep sleep mode. However, it will continue to detect and report the exceeding of threshold values.

This approach combines the fastest response times with the longest battery life.

5.2.2.3 Additional ZBS-Devices

The ZigBee hand-held ZBS-130 has a button which, when activated, sends a wireless message to the coordinator. Typical applications for this actuator are:

- Entry Control
- Home Automation
- Patient Emergency Call

Figure 8: ZBS-130

The ZigBee contact-monitoring ZBS-132 is used for monitoring doors and windows. Overall, ZBS-132 can monitor up to three doors / windows.

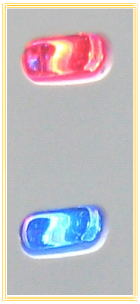
Figure 9: ZBS-132

5.2.3 Initial operation of the equipment and network design

5.2.3.1 Gateway

Once the gateway is plugged in, the wireless module operates independently of the boot / OS. It gives existing terminals, or routers the option to join a wireless network. By default, the wireless traffic is unencrypted, and the coordinator / gateway configured without further restrictions. Therefore, the devices should now find each other automatically.

Wireless traffic is displayed using the two LEDs:



Here, the red LED indicates when messages are received.

The blue LED shows when messages are sent from the gateway.

5.2.3.2 Terminals

Depending on the terminal / router, the respective operating status is displayed on the device-specific LEDs:

- 2 independent LEDs (green / orange)
- 1 multi-color LED or 2 LEDs in a window / plunger button (green / orange)
- 1 RGB-LED red/green)

In the following, both the orange and the red LED are collectively referred to as "red".

After starting a router or terminal, an automatic network scan is initiated, which searches for complementing and open coordinators. Success / failure is indicated by the LED flashing:

- 3x green: The device has logged in to the coordinator / gateway successfully.
- 3x red: The unit has not found a coordinator / gateway or can not log in (Possible reasons for this: connected encryption, outside of the wireless range, closed network, etc.)

The devices are configured so that this network login is cyclically repeated, if the network scan was not successful. In the case of battery-operated devices, this scan cycle will be extended only gradually to conserve battery. For the initial pairing of devices, it may be helpful to reset the devices by rebooting them. The network scan will begin again, and be immediately initiated. For this, press the key until the LED responds (usually 5-10 seconds). The respective LED color varies from device to device.

If you are unsure whether a device has been added to the wireless network or not, you can send a message to the gateway with a mere touch of the button. Whether the message has been delivered successfully is also indicated by:

- 1x green: The message has been successfully delivered.
- 1x red: The message has not been delivered successfully.

The device specifics are described in their respective manuals and in the "CSE Manual".

5.2.4 Timing of Devices

This chapter provides an overview of the most important, internal intervals.

5.2.4.1 Internal Configurable Intervals in the Terminals.

All ZBS devices can be set to certain time intervals.

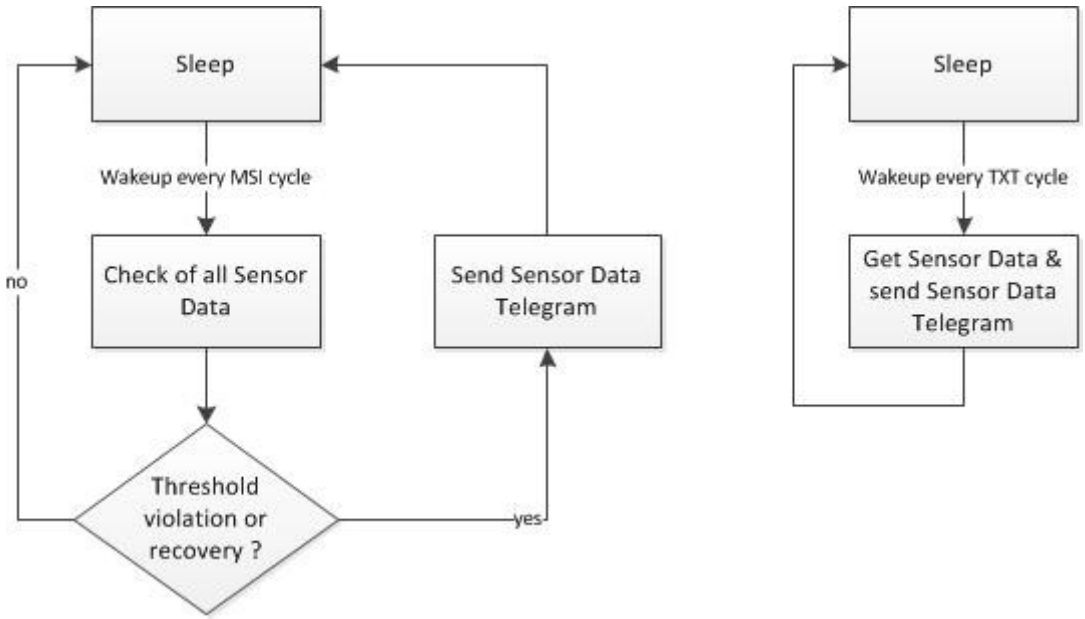


Figure 10: MSI and TXT-Interval Overview

MSI –Measurement Interval

The MSI is the length of the pause between two measurements. Measurements usually mean less power consumption than sending wireless messages. Therefore, it is advisable to send a message only if it is really necessary.

TXT – Transmit Interval

The TXT is the interval between two packets with service / readings.

5.2.3.3 Timeliness of the Measured Values (cyclic)

The ZigBee network works in relation to the data autonomously, and so is completely asynchronous to Nagios or SNMP requests. This is especially due to the battery-operated devices. These are usually in sleep mode and resume only after certain intervals (MSI or TXT), then take measurements and data transmissions to minimize the power consumption. The data transferred over the TXT interval data is stored in a central data structure in order to answer SNMP requests quickly and without risk of timeouts. The data requested by SNMP data may therefore have limited relevance and must be considered accordingly. The timeliness of the data can be easily adjusted for devices with permanent power supply via TXT closer intervals.

Alarm messages can also be set (see next section) and then transferred directly.

6 ZBG-100 Gateways Stand-alone Operation

6.1 Criteria

The operation is web-based. The operation of the front-end has been tested with the following browsers respective current versions:

- Firefox
- Chrome
- Internet Explorer

	The browsers must have Javascript / DOM installed and activated.

6.2 Delivery Status

ZBG-100 is delivered with the following configuration.

IP	192.168.0.100
Subnet	255.255.255.0
Gateway	192.168.0.1
Hostname	ZBG-100
root-Password	rootroot
Web-User	admin
Web-Password	admin
SNMP v1 und v2c Authentifizierung	
Read-Community	public
Write-Community	private
SNMP v3 Authentifizierung	
Passwort	rootroot
Process	md5
Status	off
SNMP v3 Verschlüsselung	
Password	rootroot
Process	sha
Status	off

Table 1: ZBG-100 State of delivery

6.3 Setting the ZBG-100

The web interface of ZBG-100 allows you to make all necessary adjustments. Once ZBG-10's homepage is open, select `Settings` from the left margin to manage the settings. Optionally, this can also be changed via SNMP.

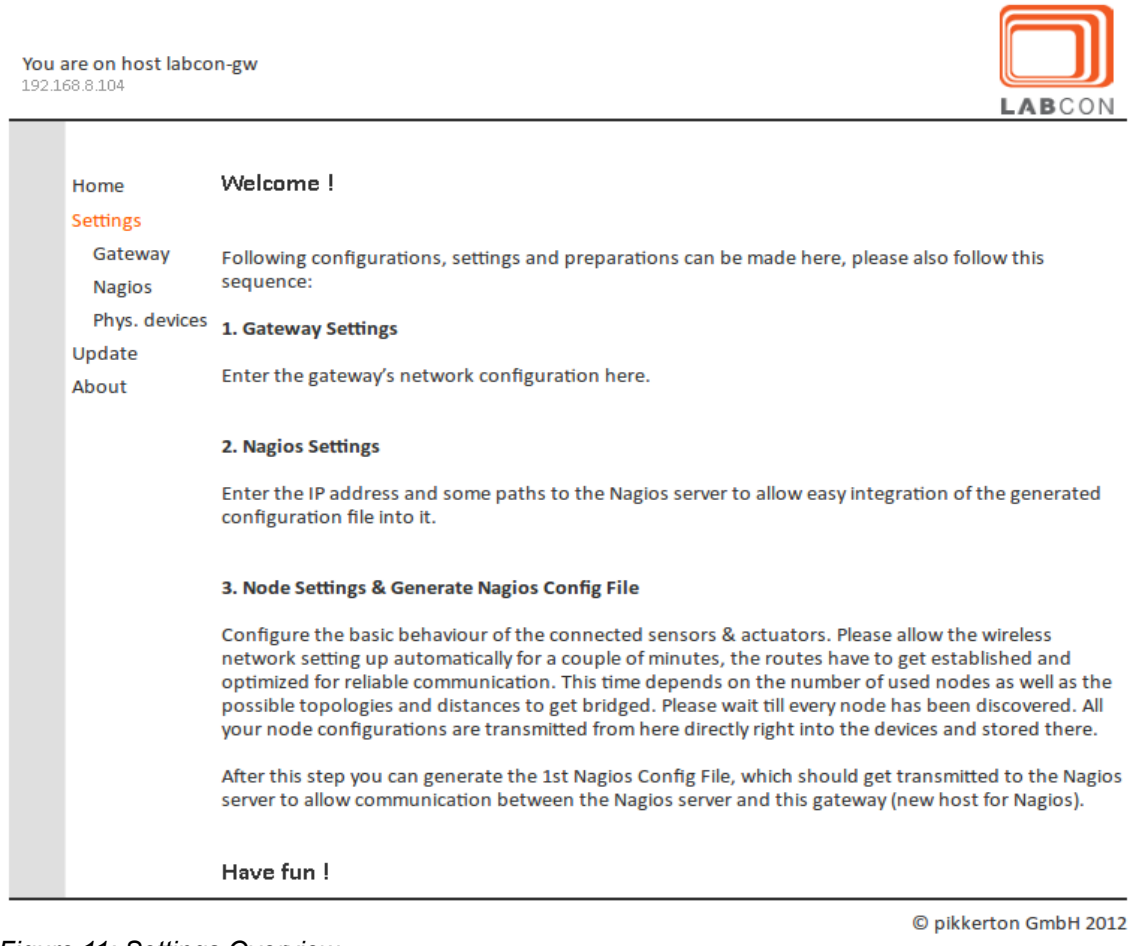


Figure 11: Settings Overview

There are three points under “Settings”:

1. **Gateway**
   Here you can control the settings that affect the ZigBee gateway. (ei. the IP address or host name.)
2. Nagios
   Nagios installations can vary depending on the Linux distributor. In order for LabCon® to work properly, some archive locations must be known. These paths can be chosen freely, but must be considered when installing and configuring Nagios. (Ch. 12 - Apendix: Nagios Installation)
3. **Phys. Devices**
   Here, you can search other ZBS-family units, read their values, as well as configure their thresholds and intervals.

6.3.1 Settings/Gateway

You can manage all settings affecting the ZBG device.
`IP Settings` configures network settings.

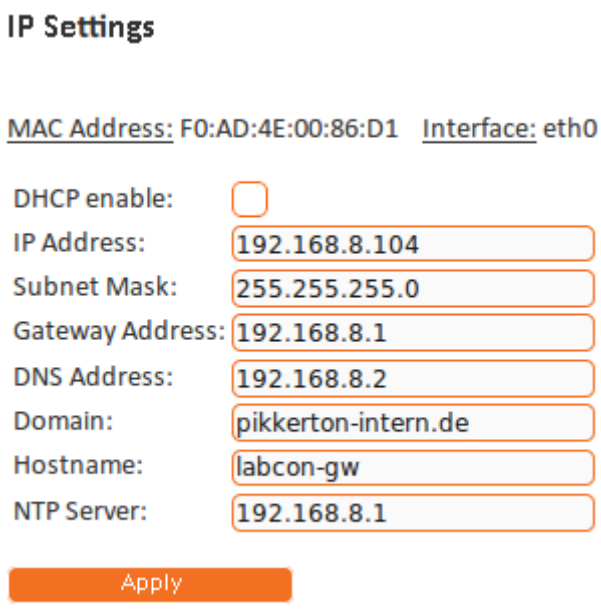


Figure 12: Settings / Gateway / IP Settings

The device can be uniquely identified, once you have adjusted the hostname. You must choose an IP address that allows the Nagios server to reach the ZBG-100 gateway.

A device-restart is not necessary, as the settings are applied immediately by pressing the "Apply" button.

Your web password can be changed under `Password Settings`

	The password change affects only the web password. The root password, which- for example- is needed in ssh, will not be altered.

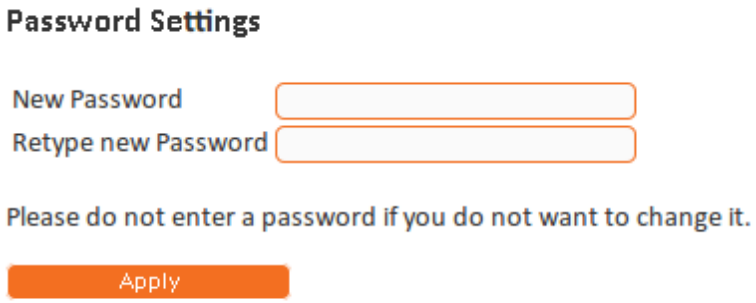


Figure 13: Settings / Gateway / Password Settings

Under `SNMP Settings`, you can manage communities and password settings. Here you can also switch Traps on and off.

	For safety reasons, the three communities must differ from each other.

Currently, only one trap destination is supported, which you can also enter here.

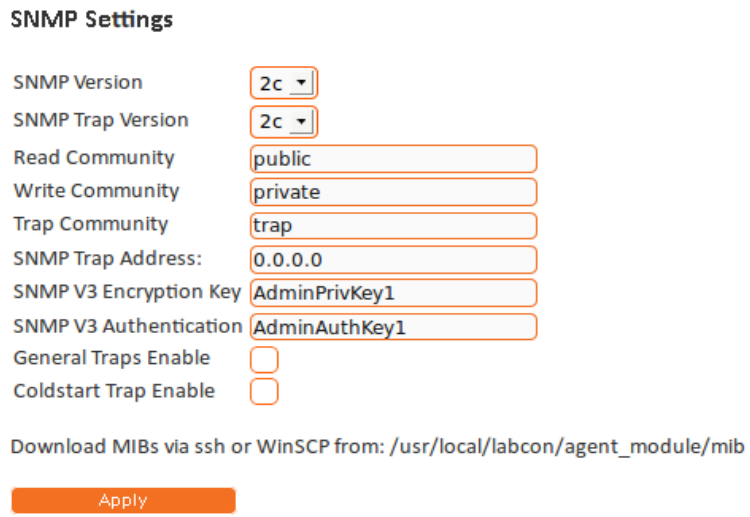


Figure 14: Settings / Gateway / SNMP Settings

A so called `Lost Message Counter` (LMC) counts seemingly lost wireless messages – this is similar to the "packet loss" during a "ping". Normally, there are no higher values. The LMC is calculated internally by the system and is based on ZigBee internal event counters that are transferred. These, however, are rarely sent. (ie. Heartbeat packets, which are set in low-level configuration in ZBS devices.) These are largely switched off due to a massive battery saving program. This allows for the next LMC interval value to be requested solely by the device. It is important to note that data telegrams are also requested, which in consequently cause additional power consumption.

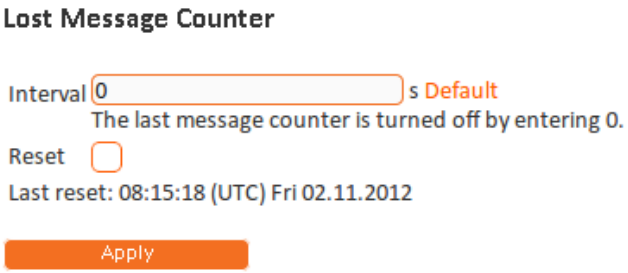


Figure 15: Settings / Gateway / Lost Message Counter

The last two points explain how to restart the entire ZBG or save and restore its configurations.

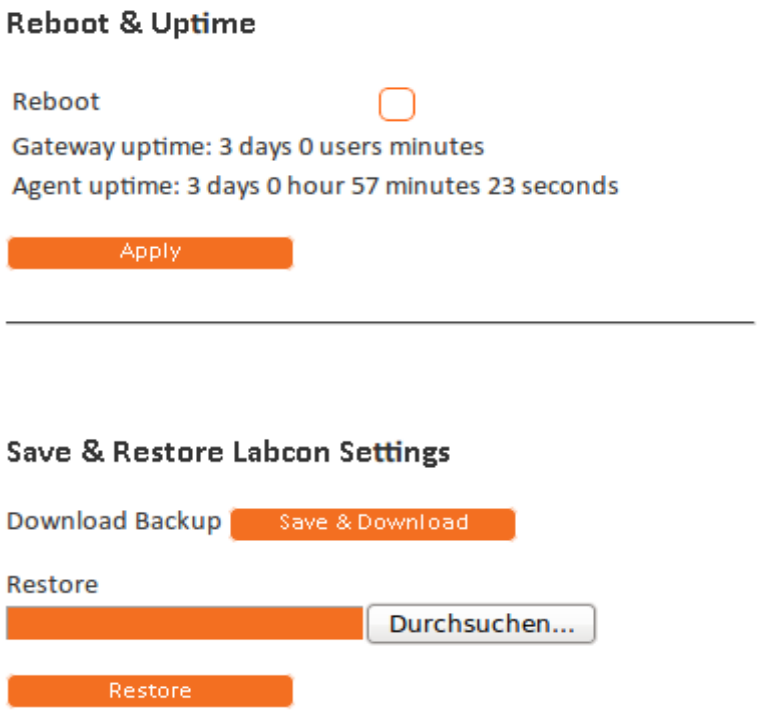


Figure 16: Settings / Gateway / Reboot & Save

6.3.2 Settings / Phys. devices

This page is used to display and configure ZigBee devices found in the ZBS family. After a (re)start of ZBG-100, the ZBS device will need some time to log into the ZigBee Gateway. This may take up to several minutes. Depending on the number of devices in the ZigBee network, times may vary. You can speed up the process by triggering Node Discover (ND). A wireless message is then sent, which forces all devices to log into the network.

If not all devices are shown, the display can be updated by hitting `Refresh`.

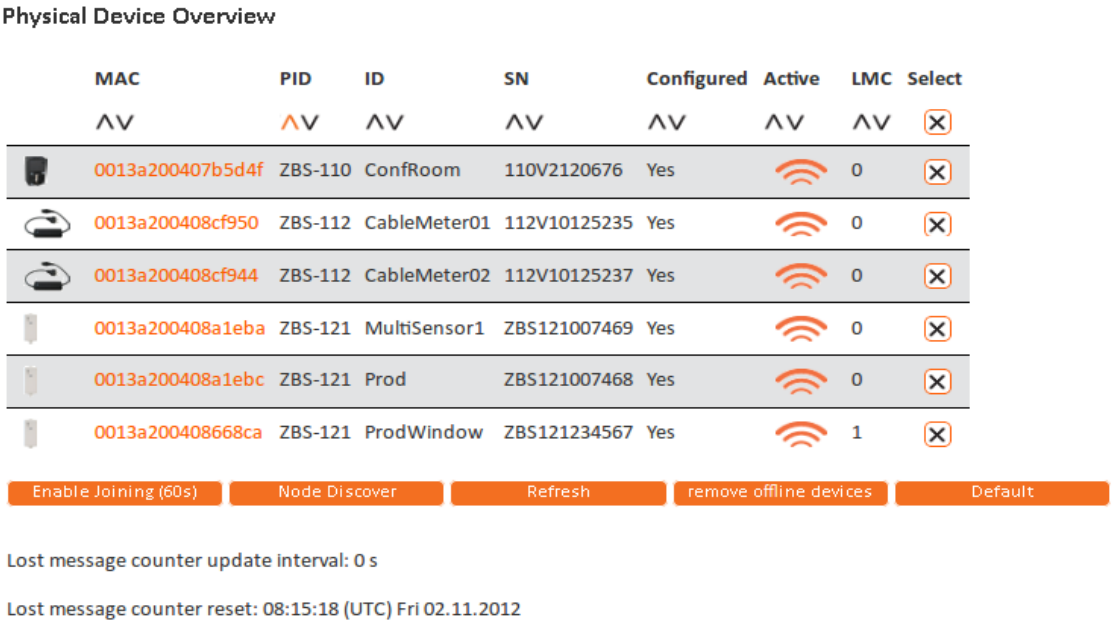


Figure 17: Settings / Phys. devices / Overview

MAC

The ZigBee module has a specific MAC address located on the individual devices. This allows each device to be clearly identified. To get to the respective sensor's page, click on the MAC address link found behind the address. You can then find the current measured values, adjust threshold values and intervals (TXT and MSI), as well as control the device (ei. relay or LED status change).

PID

The PID is the relevant type of ZBS-family.

ID

The ID is the same as the serial number during delivery. You can choose any ID, which is then used to simplify each device's identification and description. (ie. ID = ID = Dataroom4 or Rack5a). It can be up to 12 characters long, but for compatibility reasons, no symbols or spaces are allowed.

	As soon as Nagios/Icinga is activated, no ID may be used more than once.

Active

Here, you can see if the device is currently in the network.

Checkbox

Only devices with an activated checkbox can generate configuration files for Nagios under "Generate".

It is also possible to enter clear text commands under "Command" and then send them to the selected device using "Send Command". These commands go automatically to all devices where the checkbox has been activated. Since the device's response time can take up to 30s when running on battery, the latest device response can be retrieved manually at any time under "Collect Answers".

Please see the relevant manuals for details. (Ch. 10 - Additional Information)

Enable Joining

To allow new ZBS-devices to log in, all routers and the coordinator must be "open".

Node Discover

When a Node Discover is run, all devices currently logged into the network report to the system.

Refresh

Updates the device list.

Remove Offline Devices

Deletes all devices from the list, which are marked as offline.

Default

By activating the default setting sends a `defaults` notification and restores all highlighted devices back to their default settings. You can see which settings are affected by in the respective ICD.

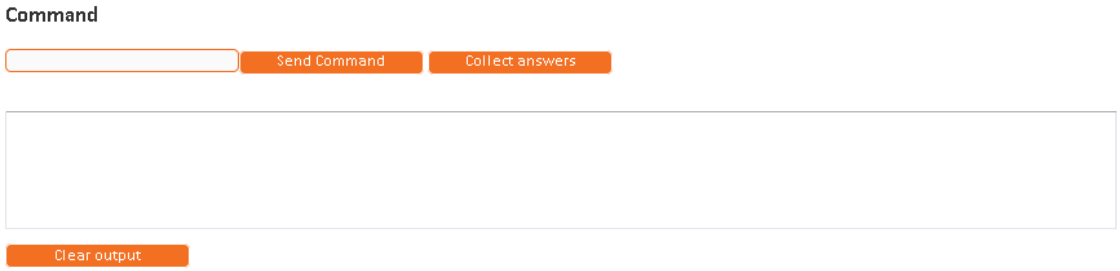


Figure 18: Settings / Phys. devices / Command

Send Command

Sends the command recorded in the right text field to all selected devices.

Collect Answers

Collects all responses from the devices.

	The responses are the last received data from the devices. It may, depending on your network settings, take up to 30 seconds until the requested information is received.

Clear Output

Clears output window of all responses.

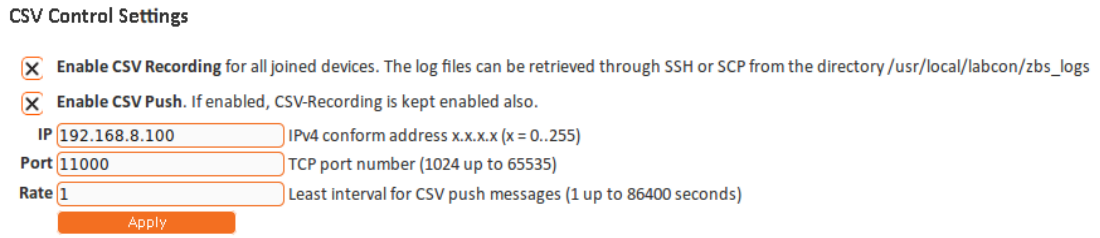


Figure 19: Settings / Phys. devices / CSV Control Settings

CSV Control settings

ZBG-100 provides the ability to store all incoming wireless readings as CSV files and to then send them per TCP connection in clear text. For each device, a separate file is used. The file name is also the MAC-Address of the ZBS-Device. The recording of the sensor values will be discussed further in Section 6.6. The following settings can be made here:

- **Enable CSV Recording**
  Activates back-up, saving the data in the CSV files.
- **Enable CSV Push**
  Activates transmission of the data via TCP. This option turns on the "Enable CSV Recording" field.
- **IP**
  The IP address to which the data is sent.
- **Port**
  The TCP-Port to which the data is sent.
- **Rate**
  Time interval in seconds, in which the "push service" checks for new data.

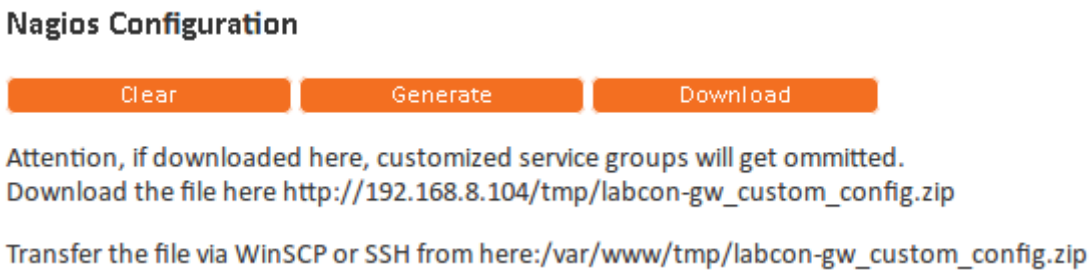


Figure 20: Settings / Phys. devices / Nagios Configuration

Under “Nagios Configuration”, you can create the basic configurations for Nagios. The button “Generate” creates the archive `<zbg_hostname>_custom_config.zip`. This archive contains all the configuration and script files that are needed for a LabCon® installation in Nagios / Icinga. In addition, the needed MIBs for a SNMP are also located in this zip file.

As shown in the Figure 20, this file can be downloaded easily via http or scp.

6.4 Security

6.4.1 Admin-Login / https

To access ZBG-100's website, enter the username and password. During the state of delivery, these are: `admin`. You find the password file (`pw.inc`) in the root-directory of the web server (`/var/www`).

The connection to ZBG-100's website can also be established via the https default port 443 with encrypted SSL.

6.4.2 Communication via SNMP V3

Encrypted and authentisized SNMPv3 packets allow for communication between LabCon® and ZBG-100. For more information, please see Chapter 6.5.1.2 - SNMPv3.

6.4.3 ZigBee Wireless Security via AES

The ZigBee wireless network can be encrypted via AES-128.

	Once the encryption has been activated in the ZigBee coordinator (ZBG-100), only ZigBee routers and end-devices with activated encryption and the same network key can be connected.

The encryption can be set via `Settings → ZigBee Net` . This page allows the coordinator to be set in two different modes: Encrypted (`Encrypted Network`) and unencrypted (`Open Network`) communication.

Please note that the router and end-devices can only show the operation mode in which they are currently.

To encrypt a wireless network, please do the following:

1. Choose a network-key
   - max. 32 signs
   - Hexadecimal (without leading 0x)
   - eg. 3ac56d

2. Configure a Device to a secure network
   `Add to Secure Network.`
3. Reconfigure a coordinator into an encrypted network
   click on Encrypted Network.
4. Wait for the device to log in.
   The settings are now automatically saved on the device.
5. To add further devices, you must configure the Coordinator for the encrypted network. (`Open Network`) Steps 2 – 4 must be repeated.

6.5 SNMP

The LabCon® scripts on the Nagios server and the ZBG-100 communicate via SNMP. According to its terminology, Nagios® LabCon have the following meanings:

1. First, ZBG-100 collects sensor data and makes it available, now becoming the SNMP-Agent. Moreover, agents can send warning messages (so called Traps) to instantly inform the previously configured SNMP-Manager.
2. The LabCon® scripts on the Nagios server, Nagios itself, and the pnp4nagos plugin, represent the SNMP-Manager. This collects the information from the agent at regular intervals and processes them. In addition, the manager "listens" for incoming Traps.

Other LabCon® managers can also be used to control ZBG. These are introduced in ch. 6.5.2- SNMP Manager.

The organization of the variables in SNMP is displayed as a tree structure. Each node has its own number. To retrieve a variable, the path is specified from the root. For example, you can find the ZBG product name under the node:

```
.1.3.6.1.4.1.23596.10.1.0
```

To make things easier, there is the ”Management Information Base (MIB)” which converts this numeric string into a name for the manager and vice-versa. Scalars[1] always end on zero, while tables always have an index.

ZBS family sensors are tabulated. The index serves as your MAC address.

1 A Skalar is a mathmatic size which is characterized solely by the indicated number value. (Consequently, in Physics by Unit.)

6.5.1 Authorization Management

The ZBG-100 supports the protocols SNMPv1, SNMPv2c and SNMPv3. Unlike version 3, versions 1 and 2c are unencrypted.

6.5.1.1 SNMPv1 and v2c

This version is supported by most SNMP managers. The user authentication is done via the so-called "community". These are standard for reading `public` and for writing `private`. These can be changed by preference. (ch. 6.3.1)

6.5.1.2 SNMPv3

SNMPv3 provides two security features:

1. Password-protected user authentication
2. Encryption of raw data in the data packet

You can assign individual passwords for authentication and encryption. These an be switched on independently of one another.

	If it is specified in the configuration that at least one security feature of SNMPv3 is to be used, SNMP versions 1 and 2c are switched off automatically.

6.5.2 SNMP Manager

The company, iReasoning, offers the SNMP Manager "MIB Browser" as a free version. This is Java based, so it can be used on Windows, Mac OS, Linux or other Unix platforms. Among other things, this version has the following features:

- SNMP Walk, Get, Set
- Tabular MIB view
- Trap Receiver / Transmitter
- SNMP v1 and v2c
- can resolve up to 10 MIBs

The paid version has more features, such as SNMPv3.

There are also many other managers, HP OpenView and Net-SNMP being the best known. This manual only briefly touches on iReasoning's MIB Browser. After the first start-up, you will see:

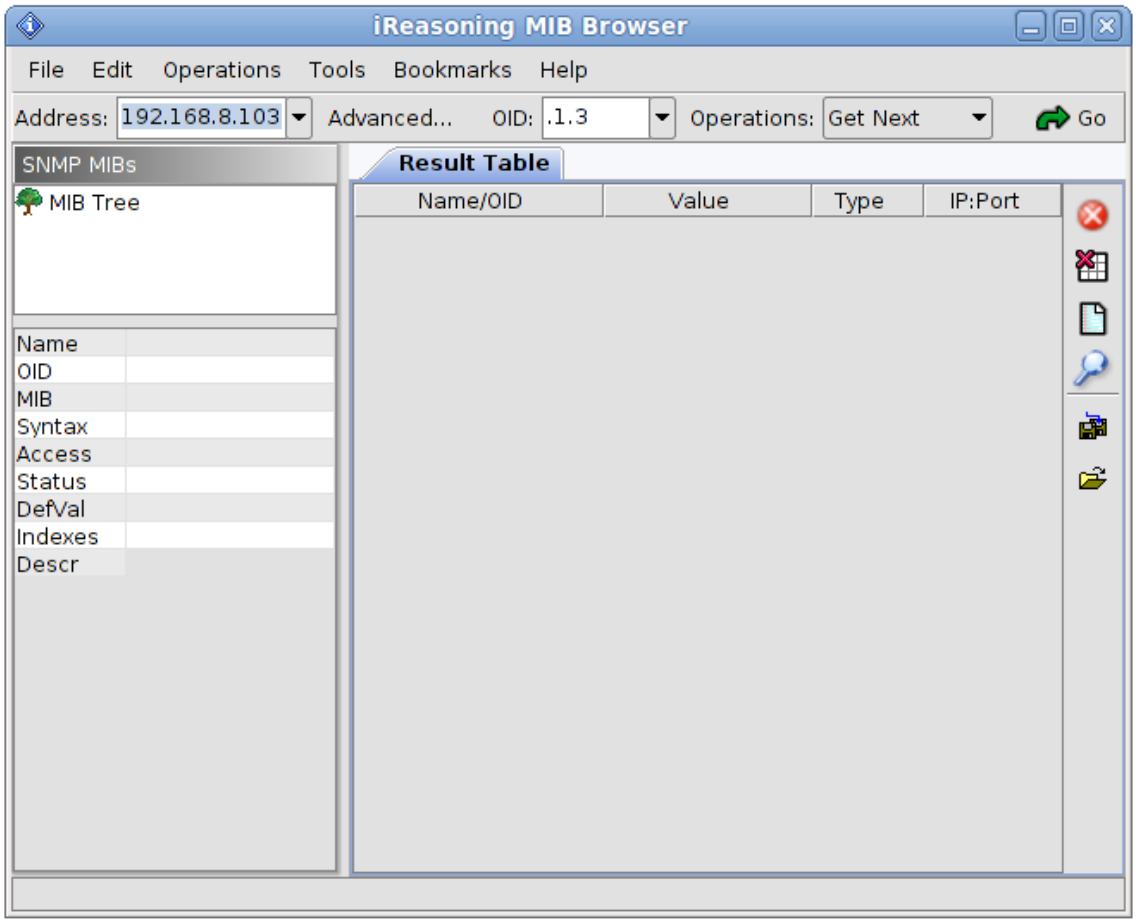


Figure 21: iReasoning MIB Browser

Now load MIBs onto the browser from ZBG-100. You can find these in the archive `<zbg_hostname>_custom_config.zip`. Chapter 6.3.2, pg. 30 explains how to create and download these.

The MIB text files can then be loaded via the menu `File->Load MIBs` .

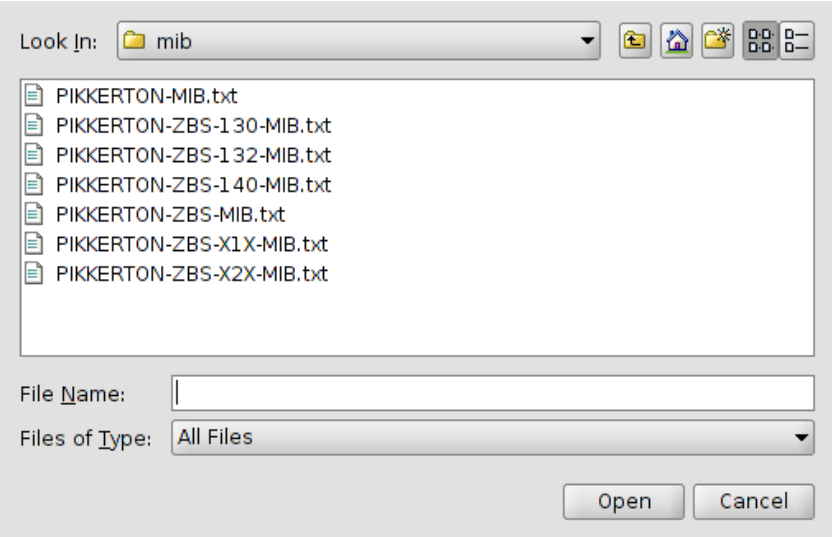


Figure 22: MIB Browser - Load MIBs Dialog

Register the IP address of the BG-100 under `Address`. The `Communities` (Ch. 6.5.1.1) can then be changed in the dialog box `Tools->Options->Agents`.

6.5.3 Traps

When status changes have occurred in which a manager must be notified immediately, ZBG-100 automatically will send Traps. This could be due to exceeded alarm thresholds, or even a device of ZBS-family, which has just re-registered on ZBG.

Traps are also SNMPv3 encrypted and authenticated when sent, however, only if v3 has been previously enabled on the ZBG-100 configuration page.

6.6 CSV-Recording / Pushing

CSV-Recording provides the ability to store all incoming readings via ZigBee. The values are tabulated in a .csv file which is located in the directory `/usr/local/labcon/zbs_logs`.

These files are named according to the type and the MAC address of each ZigBee sensor. For each log file, there is a another containing the sensor data details. This ends with the designation `_header.csv`. The header file of a ZBS-121 (`ZBS-121_0013a200408a1eba_header.csv`) can look like this:

```
YEAR,MON,DAY,HOUR,MIN,SEC,BRI - lx,TEM - °C,BAT,UBAT – V,
```

The first four columns in the csv file are for the data time-stamp, which are followed by the brightness in [lx], the temperature in [°C], the battery state (OK or LOW), and the battery power in volts. The identifiers of the sensor data is consistent with the "Interface Control Document" of the respective sensor.

This excerpt from the csv file shows the structure of the data:

```
2012,11,11,14,5,27,6,21.8,OK,4.19,
2012,11,11,14,5,37,4,21.7,OK,4.22,
2012,11,11,14,5,47,6,21.7,OK,4.22,
```

Here, we see that the data is received every 10s. The first record bears the time-stamp 11.11.2012 - 14:05:27.

Tc prevent the csv files from taking up all the space on the partition, they are monitored by the Linux log rotation service. The log rotation settings can be changed in the file `/etc/logrotate.d/labcon_csv_log_rotation` or via the Webmin interface (ch. 6.8).

These files can also be monitored with the CVS push service, which checks adjustable intervals (ch. 6.3.2, p. 26) and sends them to the set IP address if necessary. The data is in this format:

```
<MAC Adresse>_<ID>.<Service>,<Zeitstempel>,<Wert>,<Einheit>
```

A current measurement can look like this:

```
0013a2004076843b_SR-FAN-R.IRMS,2013-04-08 11:24:55,121,mA
```

- MAC Address
  0013a2004076843b
- ID
  SR-FAN-R
- Service
  IRMS (current measurement)
- Wert
  121 mA

6.7 Direct Control of Devices

It is possible to directly read and control the ZigBee devices without the support of Nagios. This can be done easily via the ZBG-100 configuration page. You can find this either in the menu item "Sensor / Device" in the LabCon Nagios® menu or directly via the IP address and name of the ZBG-100 under "Settings / Phys. Devices ".

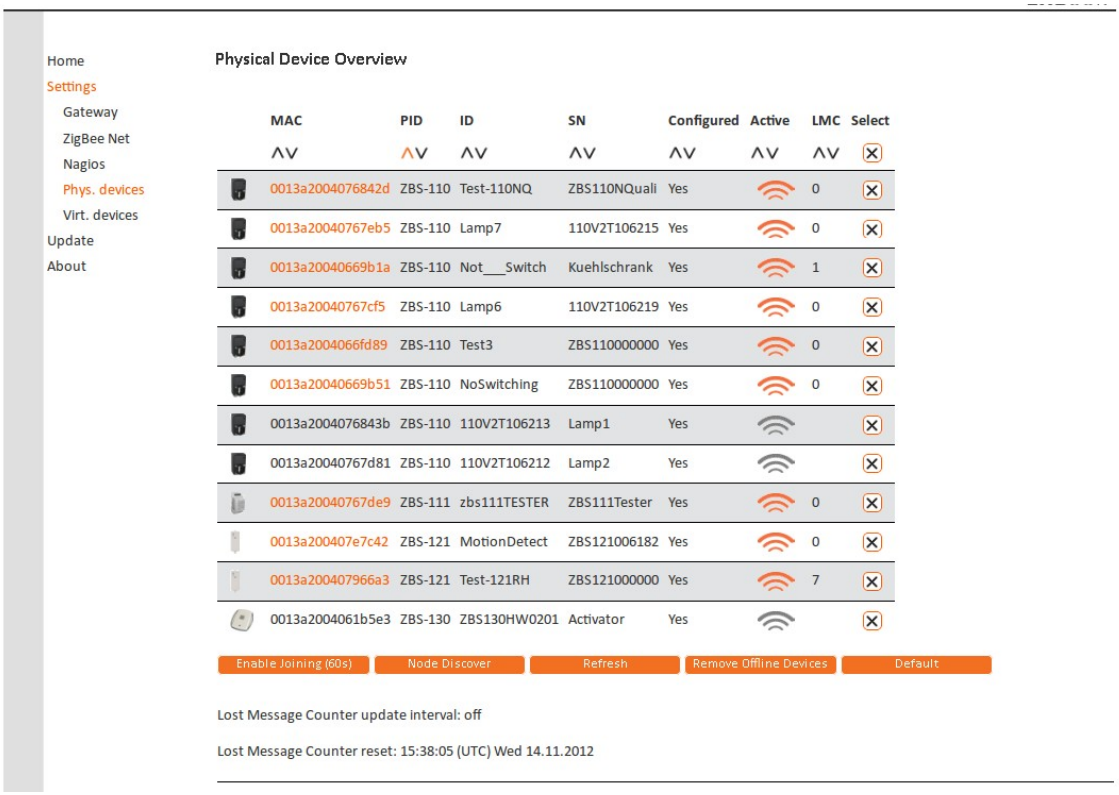


Figure 23: Device Overview

Clicking on the MAC address of the desired device takes you to the page that lists the current values, and where you can change settings and control the device. The page uses ZBS-121 as an example:

The top information block includes the current sensor values, as well as other information including the serial number, hardware, and firmware version etc. In this block, the ID can also be changed. The ID appears on the summary page and in the group configuration. The device is thus identified and is limited to 12 characters.

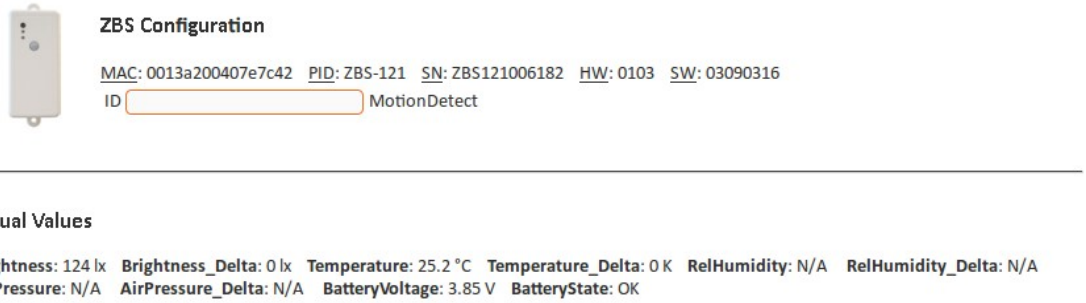


Figure 24: Information Block ZBS-121

The configuration block immediately follows the information block, and all limits and intervals can be configured here. The grayed-out fields are not fixed options of this device, such as the ZBS-121 without air pressure. In order for the changed values to be applied, the data must be transferred to the device by hitting the "Apply" button.. This button is located at the bottom of the page.

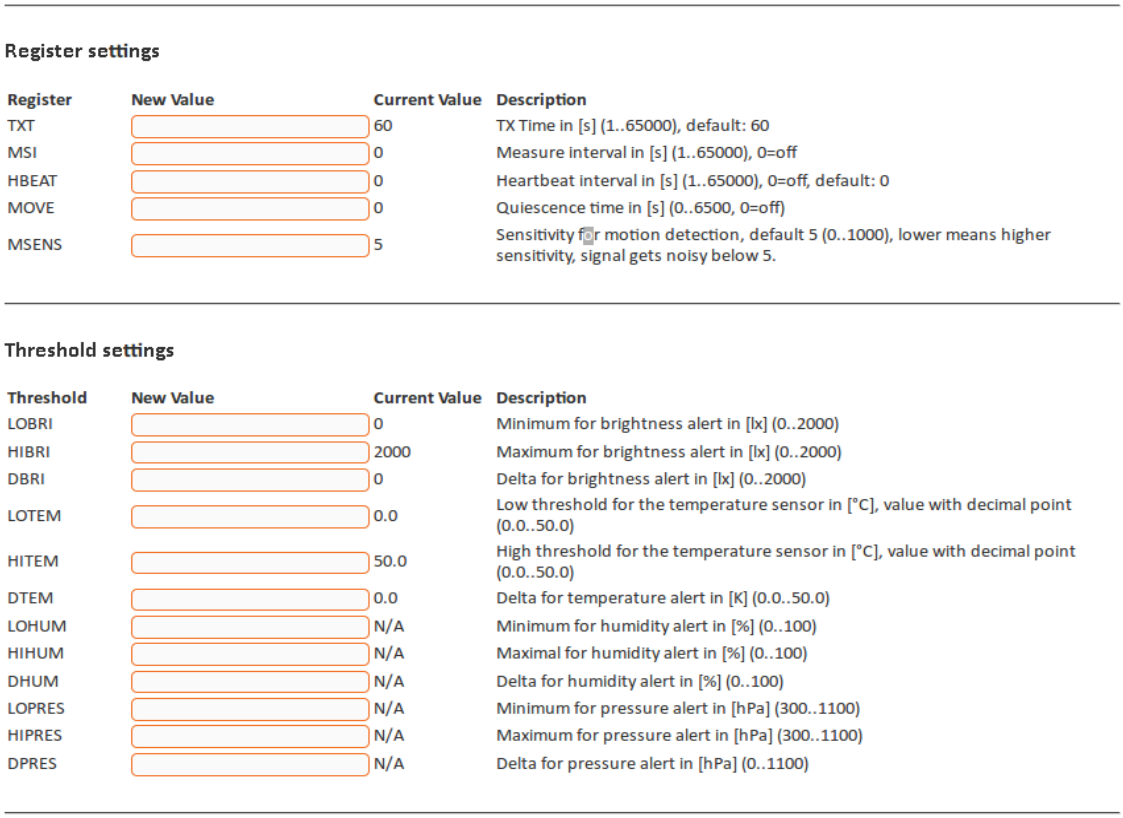


Figure 25: Configuration Block ZBS-110

The third block is the control block and it includes all control options for the respective device. For example, ZBS-110 switch can be controlled here.

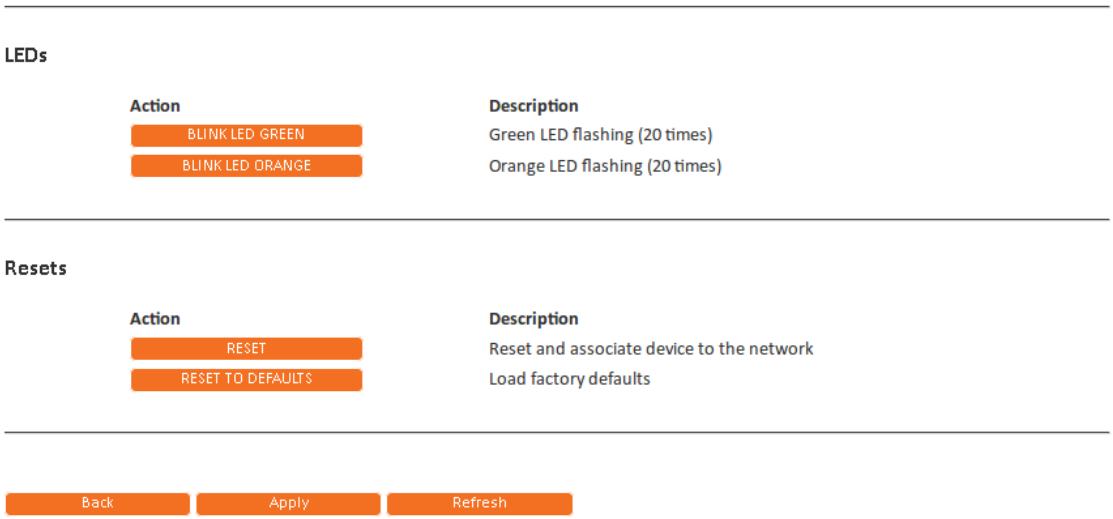


Figure 26: Control Block ZBS-121

6.8 Webmin

All configuration settings outside of the LabCon® system, can also be made via the web front end Webmin. You can find this under `https://<zbg_ip>:10000`

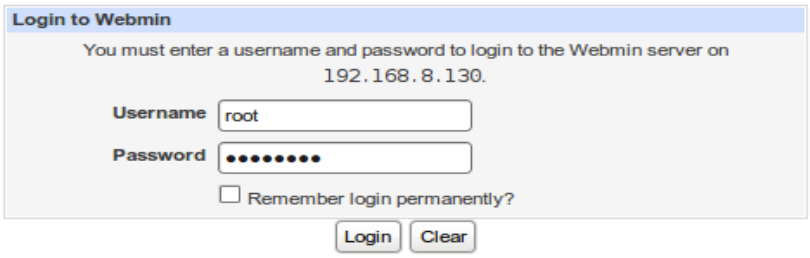


Figure 27: Webmin Login

You can use the same username and password as for the login via SSH. When delivered, these are:

Username: root

Password: rootroot

7 Operating under Nagios / Icinga

For optimum LabCon® functionality in Nagios, you must follow the instructions described in ch. 12. This chapter deals exclusively with operating LabCon®. Points 1-3 are not considered here.

1. Configuring the ZBG-100 (ch. 6 - ZBG-100 Gateways Stand-alone Operation)
   a) finding the devices
   b) configuring the devices
2. Installing Nagios and Its components (ch. 12 - Apendix: Nagios Installation)
3. Integrating in Nagios
   a) downloading the configuration directly from the ZBG-100
   b) loading the scripts and customizing Nagios
4. Creating control loops
   a) selecting the devices to be configured
   b) creating groups
   c) settings for sending emails
   d) operating devices
5. Downloading the created configuration of control loops and providing scripts for Nagios
6. Nagios restart

7.1 Interface for Nagios/Icinga

7.1.1 Communication Model

The following table shows the relationships between LabCon® and Nagios in regard to the terms on the basis of two examples:

<table>
<tr><th>Nagios-/Icinga-Admin-Calculator</th><th>Host</th><th>Device</th><th>Service / Sensor</th></tr>
<tr><td colspan="2">communication via SNMP ⟷</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">communication via ZigBee ⟷</td><td></td></tr>
<tr><td rowspan="8"></td><td rowspan="8">ZBG-100</td><td rowspan="5">ZBS-110</td><td>Temperature</td></tr>
<tr><td>Power</td></tr>
<tr><td>voltage</td></tr>
<tr><td>frequency</td></tr>
<tr><td>...</td></tr>
<tr><td rowspan="3">ZBS-121</td><td>Temperature</td></tr>
<tr><td>humidity</td></tr>
<tr><td>movement</td></tr>
</table>

Some devices also provide an alarm which immediately forwards the message via an SNMP trap to the Nagios / Icinga host. (ie. The transmission of recognized motions, sensor readings showing exceeded thresholds, or of keystrokes on the devices.

7.1.2 Plugins

Integration takes place in Nagios / Icinga via plugins. These are available for download after configuring ZBG-100 (ch. 7.2 and 6.3.2) .

7.1.3 Summary of the Service Groups

LabCon® provides various groups depending on the characteristics of the services / actuators of the ZBS series. The following groups have been established:

- Ambient Atmosphere (climate)
- Energy Metering (energy acquisition)
- Mains Analysis (230V Voltage analysis)
- Access Control
- Battery

However, you can also create your own groups in LabCon®. The following table shows the CSE family in relation to their groups and depending on their sensors / actuators.

Legend

- O Optional
- ✓ belongs to group
- X does not belong to group

Picture	Name	Description	Ambient Atmosphere	Energy Metering	Mains Analysis	Access Control	Battery
	ZBS-110 Smart Energy Meter	Measures the current, voltage, frequency, performance, and tasks Ability to switch loads Optional PIR motion detector Optional temperature measurements	O	✓	✓	O	X

Picture	Name	Description	Ambient Atmosphere	Energy Metering	Mains Analysis	Access Control	Battery
	ZBS-111 Smart Energy Meter (DIN Rail)	Measures the current, voltage, frequency, performance, and tasks	X	✓	✓	X	X
	ZBS-112 Smart Cable Meter	Measures the current, voltage, frequency, performance, and tasks	X	✓	✓	X	X
	ZBS-12x Multi-sensor	Temperature movement (PIR, passive Infrared) humidity, air pressure, and brightness	✓	X	X	✓	✓
	ZBS-130 Handheld	Pressing of button sends messages Blinking as possible feedback	X	X	X	✓	✓
	ZBS-132 Contact-monitoring	Monitors magnetic contacts, volume, and glass breakage	X	X	X	✓	✓

Picture	Name	Description	Ambient Atmosphere	Energy Metering	Mains Analysis	Access Control	Battery
	ZBS-140 Client-specific	Integration / connection external of feedback / sensors	O	O	O	O	O
	Non ZBS	All unknown or recently registered ZigBee devices (which have not yet been identified)	X	X	X	X	X

Table 2: LabCon® ZigBee Devices

7.1.4 Timing End Devices → Gateway → Nagios (Event-based)

The following example refers to a ZBS-121 multi-sensor, which has a set temperature threshold of 24°C.

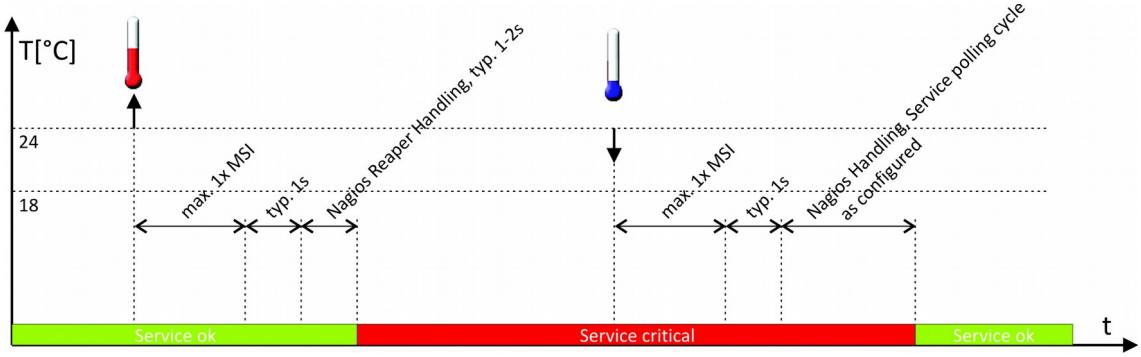


Figure 28: ZBG Device → Nagios Timing

Figure 28 shows a complete cycle assuming the state that a service <Temperature> is within the tolerance range (<= 24°C), exceeding this (> 24°C) and returning to the initial tolerance range. The green and red bar represents the state that LABCON ® displays at the respective points in time.

1. The temperature exceeds 24° C. This is, however only measured by ZBS after the MSI interval expires and is sent wireless to the ZBG.
2. ZBG in turn sends an SNMP trap (ch. 6.5.3) to the Trap-Receiver (ch. Fehler: Referenz nicht gefunden) This forwards the message to Nagios, where it is added onto a command stack. The reception of the wireless packet to Nagios usually takes a second.
3. Nagios-Reaper processes the command, executes the configured alarm scripts by LABCON®, and changes the status from "OK" to "Critical" (usually 1-2 seconds).

If the temperature falls back to 24°C , steps 1 to 3 are repeated.

7.2 LabCon® Configuration

This chapter describes the automated creation of LABCON® services and rules for Nagios.

The individual actuators / sensors are sorted into groups, after which control loops can be created and threshold values set. When these limits are violated, various scripts can be run individually or combined in sequence:

- sending an email
- execute random scripts
- control of actuators
- setting or resetting of flags

7.2.1 Flags

Flags are an easy way to store conditions for later analysis or conditions. Any string of characters can be stored in this flag. The file name corresponds to the global flag-name, and these can be manually controlled via the website, script, external applications, or time-based (ie. a CRON job). At the same time, they provide a simple interface to the outside world or other applications.

Flags are used primarily either to stop running or to continue running the various processes (running scripts on threshold violation). They can not, however, be used to branch off further.

Within the script `Set_Flag.py`, a flag with any given name and content can be set. If at this point (when the script `Check_Flag.py` has expired) the content of each script does not correspond with the given condition, the running of the scripts will be stopped immediately.

7.2.2 Special Features of “Work Limit” and “Load Limit”

An additional drop-down menu aids you when configuring limits for “load limit” and “work limit”. Here the given choices:

- MSG
  When exceeding the limit just one trap message is sent.
- off
  Upon exceeding the limit, the ZBS immediately turns off the relay and sends a trap message. This disables "self-switch-off". To reactivate, you must set a the limit again.

7.2.3 Creating Nagios Configurations for Devices

Before groups or control loops can be created, you must determine which devices and services are to be configured. For this purpose, please select the desired devices. With the button "generate", the basic configurations are created and then downloaded by clicking “download”.

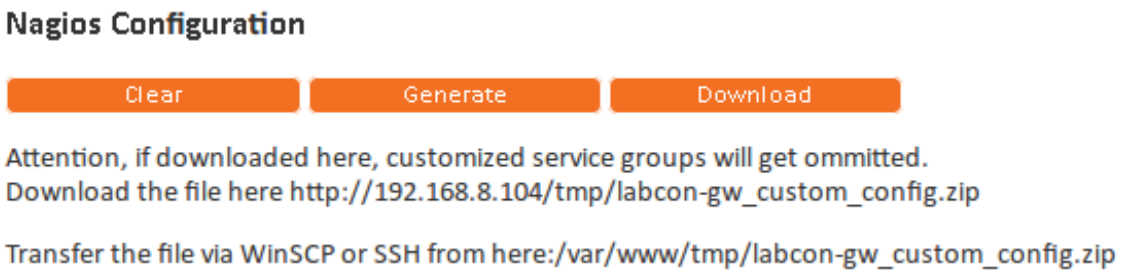


Figure 29: Settings Download

	At this point, the download will be useful only if the devices are to be used solely for displaying and storing the sensor data, or if it is the initial installation of LABCON® in Nagios. Otherwise, the creation and configuration of groups, and rules follows. This is described further in section 7.2.

Please see ch. 7.2.7 - Installations in Nagios, for instructions on how to integrate devices.

	When new devices are added to the network, the configuration must be recreated. Old configurations for devices, which are currently offline, are only maintained if the checkbox has been activated.

7.2.4 Creating and Configuring Groups

The website for the configuration of each group is located in the LABCON® menu "Configuration" on the Nagios page:

Figure 30: LabCon® Menu

Under “sensor/device control config“, you can see the configuration of the devices as explained in ch. 7.2.3 - Creating Nagios Configurations for Devices. This is a basic requirement for the configuration of groups.

Pressing the link "group / event config" displays the following web page:

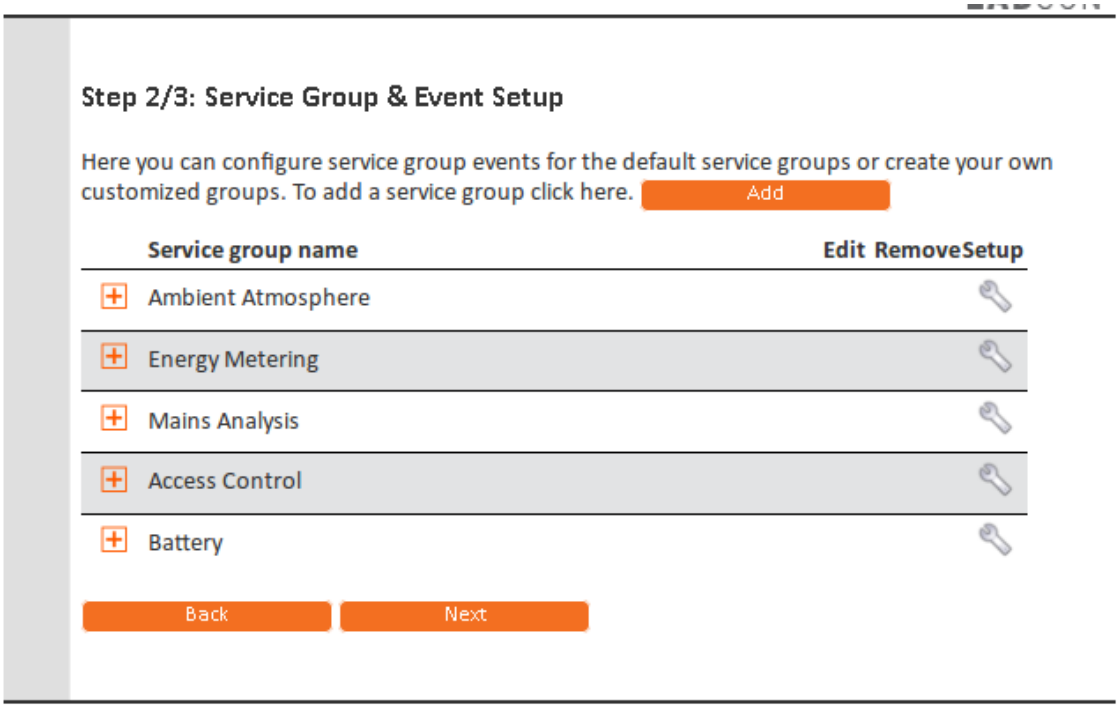


Figure 31: Service Groups

The 6 predefined groups:

- **Ambient Atmosphere**
  Contains all the sensors that monitor the environment, such as air pressure, temperature or humidity.
- **Energy Metering**
  Contains all the power, energy and performance measurements.
- **Mains Analysis**
  Voltage and frequency can be monitored.
- **Access Control**
  All sensors, which are suitable for access control, can be set. These are, amongst other things, the brightness measurement, the keystoke of the ZBS-130 or the motion sensor from ZBS-121st.
- **Battery**
  Monitors the voltage of the battery operated wireless devices, such as the CSE-121, , or the CSE-130.
- **Device Connectivity**
  Monitors the reach of all wireless devices.

7.2.4.1 Adding groups

With "add", groups can be added. It opens the following screen:

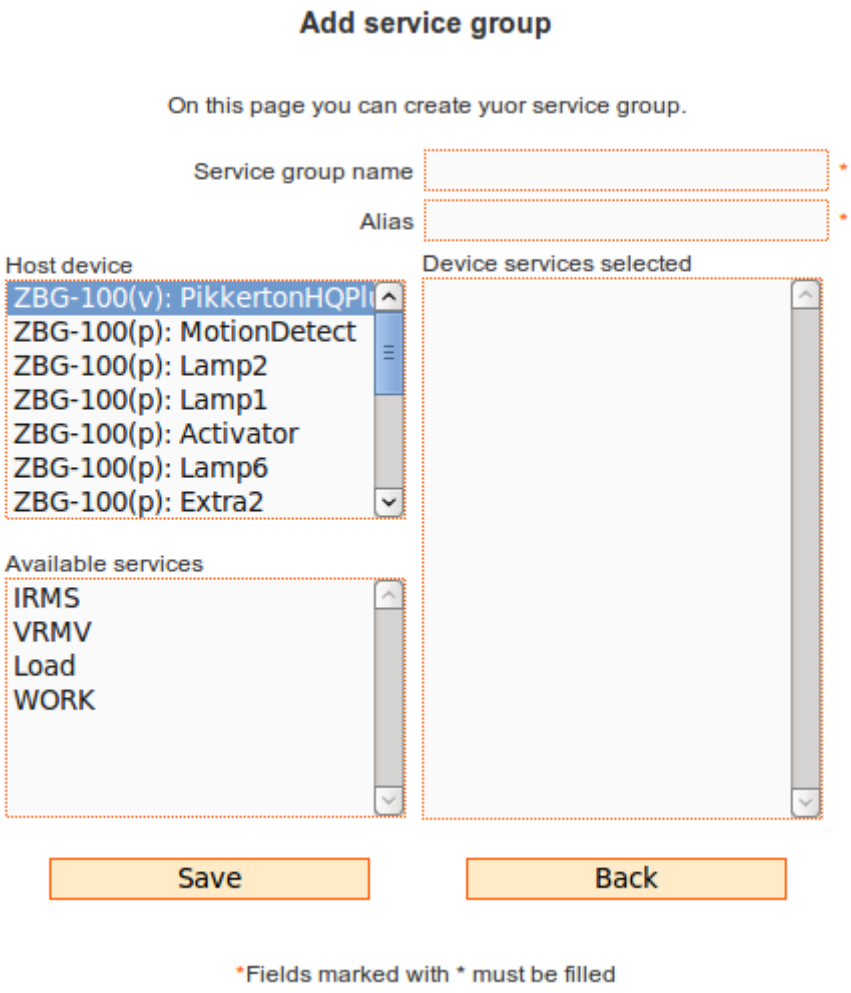


Figure 32: Service Groups

First enter the name of the group. This may consist only of the following characters:

- A-Z
- a-z
- 0-9

- underscore _

The description of the group in Nagios, however, is not restricted. Here you may also use spaces and special characters.

Under “host device”, you find all devices already configured for Naggios, according to ch. 7.2.3 - Creating Nagios Configurations for Devices. You can also find the created virtual sensors. After the hostname, it is possible to see whether it is a virtual (v) or physical (p) sensor.

If a device is selected in this window, you can see all services offered by this device under “available service”. Actuators, such as the switching of relays is configured elsewhere (ch. 7.2.4.3 - Configuration of the group members). The “apply” button takes you back to group menu.

Among others, the following services are available:

Name	Description
BRI	Brightness - Specifies the brightness in Lux
DBRI	"Delta BRI" - difference in brightness, between the last and the current measurement
TEM(x)	Temperature in "C." Some devices have multiple temperature sensors
DTEM	"Delta TEM '- temperature difference between the last and the current measurement
HUM	Relative humidity in percent
DHUM	"Delta HUM" - humidity percentage point difference between the last and the current measurement
PRES	Air pressure in hPa
DPRES	„Delta PRES“ - Difference in air pressure between the last and the current measurement
BAT	Battery status • OK • LOW
UBAT	Battery voltage in V
POW	Relay status: • ON • OFF
FREQ	Frequency in Hz
VRMS	Voltage in V
IRMS	Electricity in mA
LOAD	Performance in W
WORK	Consumption in kWh
BUTTON	Alert for keystrokes

Table 3: ZBS Services Overview

You can find further information regarding services in the information manuals for the respective devices.

7.2.4.2 Assigning Services to Groups

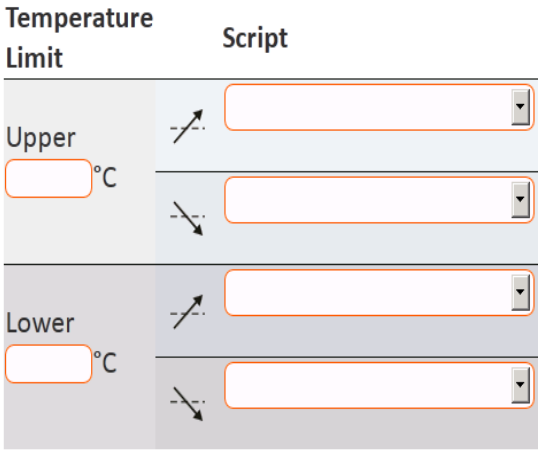
Once a device has been highlighted under "host device", all available services are shown then as "available services" (figure 32). Double clicking on the desired service adds this to the group. All of the group's active services can be found under "device service selected".

7.2.4.3 Configuration of the group members

You can easily reach the configuration page of the group members by clicking on the icon under "setup" on the summery page. Here you can set the actions for threshold violation and alerts (ie. press ZBS-130). Some services have two thresholds, as in temperature. These stand for a value-corridor in which the sensor values are interpreted as "good". When exiting and re-entering the corridor, various actions are executed. If multiple scripts are set for one limit, they are processed consecutively from top to bottom.

Figure 33: Configuring Group Members

Each column allows for four different events to be edited:



- Crossing the upper threshold
- Re-entering the normal range
- Re-entering the normal range
- Falling below the lower threshold

In the first column of the table (Figure 33 No. 2), the upper and lower limits can be set for the corridor. In the next column (Figure 33 No. 3), the scripts for actions above and below the limits are set. Any number of scripts can be set for boundary violations and direction. The scripts need transfer parameters, which you can enter in the third column. Using the last column, each script can be activated. Although an inactive script remains in the overview, it is not included in the configuration of Nagios.

The limits and intervals are transmitted to the respective devices and the set scripts for configuring Nagios on the ZBG-100 gateway are stored with "Submit".

7.2.4.4 Templates for Actuators

The actuators are needed for certain actions following a limit violation or an alert.

	The individual parameters are separated by a comma. The order is important.

7.2.4.4.1 Flags

Set_Flag.py

Actions can be enabled or disabled by means of flags. This can, for example, be used when "arming" an alarm system. This script checks the flag with a string of characters.

Parameter

1. Flags name
2. Single string of characters

Check_Flag.py

Actions can be enabled or disabled by means of flags. This can, for example, be used when "arming" of an alarm system. This script checks the flag with a sting of characters.

Parameter

1. Flag name
2. Default value for the flag if it is not yet initialized, meaning if an other script has not already set or cleared it:
   1: Flag is set
   0: Flag is not set

7.2.4.4.2 Sending Emails

Send_Mail.py

Sends email to recipient,

	You must customize the script after the installation on the Nagios server has concluded. • Sender • SMTP Server and • Password

	Must be specified.

Parameter

1. Email recipient
2. Subject text of the email

7.2.4.4.3 ZBS Device Actuators

ZBS_Buzzer.py

Controls the Piezo-Buzzer. This can be automatically and consecutively switched on and off. Further information on the Piezo-Buzzer are found in the relevant device's manual.

Parameter

1. ID of the ZBS
2. Number of cycles of the buzzer (Sound, Pause, Pause, ...)
3. Duration of the buzzer sound in 100ms
4. Duration of the pause in 100 ms
5. The tone frequency in Hz (ZBS-130 ideally uses 2-4 kHz)

Example (ZBS-130)

```
Button1, 5, 10, 20, 2000
```

With the ID "Button1" on ZBS, the buzzer switches on for 1s and off for 2s, consecutively 5 times. The frequency is 2kHz.

ZBS_LED_Control.py

Enables an LED to be flashed on the device (ie. ZBS-110).

Parameter

1. ZBS ID
2. LED number (0..1)
3. Number of cycles of the LED (On, Off, ...)
4. Duration of activated LEDs in 100ms
5. Duration of inactivated LED in 100ms

ZBS_PWR_Control.py

Switches ZBS-110's relay.

Parameter

1. ZBS ID
2. Status (ON / OFF)

ZBS_PWR_Cycle_OFF.py

Switches the relay for a certain duration of time, and then off (ZBS-110).

Parameter

1. ZBS ID
2. Measures waiting period in seconds

ZBS_PWR_Cycle_ON.py

Turns off the relay for a certain duration of time, and then on again (ie. ZBS-110).

Parameter

1. ZBS ID
2. Measures waiting period in seconds

7.2.5 Example

7.2.5.1 Air-flow Management – Hysterese Loop Circuit

An example of regulation with hysteresis is a temperature-dependent fan control. The fan is connected to a ZBS-110 and the temperature is determined using a ZBS-121 multi-sensor. ZBS-110's ID, to which the fan is connected, is "zbs110_fan".

- 40°C On
- 30°C Off

The temperature values are transmitted every 60 minutes (TXT = 3600s), but every 10 minutes (MSI = 600s) a threshold violation measurement is taken in order to save the battery power.

The sensor is found in the "ambient atmosphere". It is configured as follows:

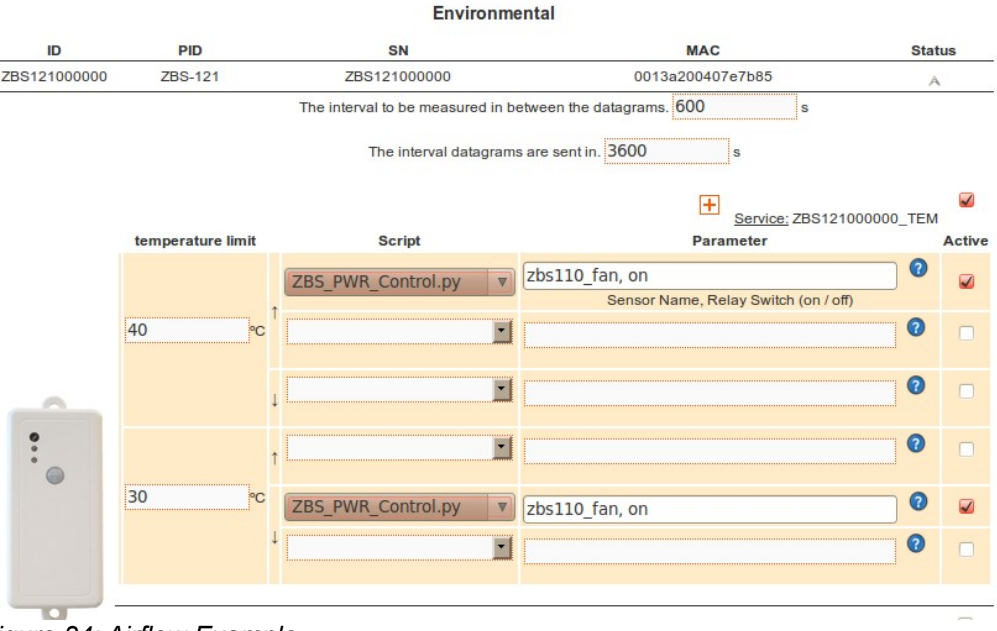


Figure 34: Airflow Example

7.2.5.2 Loop Control without Hysteresis

The requirements are similar to the example "Air-flow management - Hysteresis Control Loop" excluding the hysteresis. In this example, the vents should now be running at a temperature of 40°C, and they should be turned off, if the temperature drops below this.

The configuration looks like this:

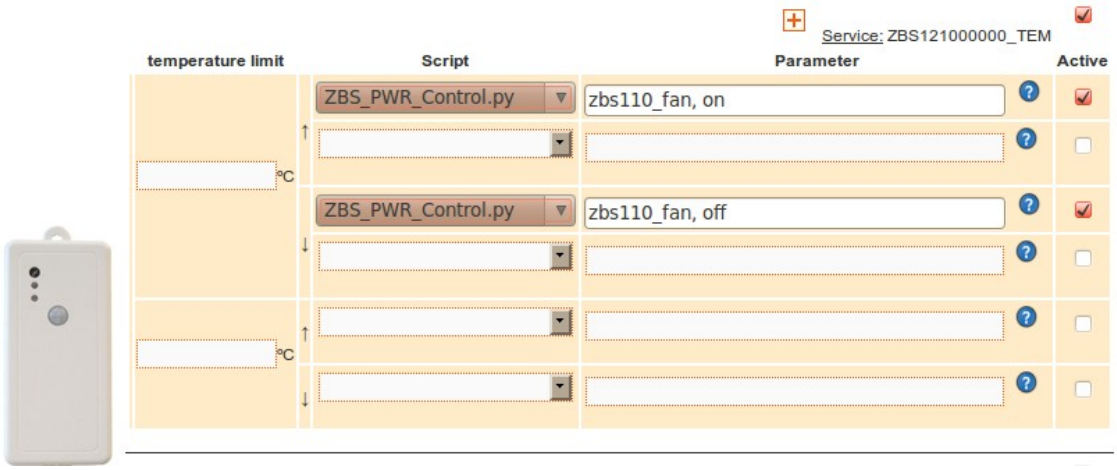


Figure 35: Airflow Example without Hysterese

7.2.5.3 Access Control / Door Opener

If the user has been authorized, he can access a door by By pressing the ZBS-130 (ID = zbs_mueller) button. The door opener is connected to a bell transformer, which in turn, is connected to a ZBS-111 (ID = tuer_buero). For access authorization two flags are checked. The first includes the authorization for the person, and the second, an access restriction of certain times.

7.2.6 Group Settings

In addition to the fixed groups described in ch. 7.2.4, Creating and Configuring Groups, many other custom groups can be created. This allows for an improved functional overview. The group name can be chosen freely, so that a grouping by function, location or use is possible.

7.2.7 Installations in Nagios

After all the services have been configured in the groups, the scripts must be generated and downloaded. The "next" button takes you to the Generation & Download page.

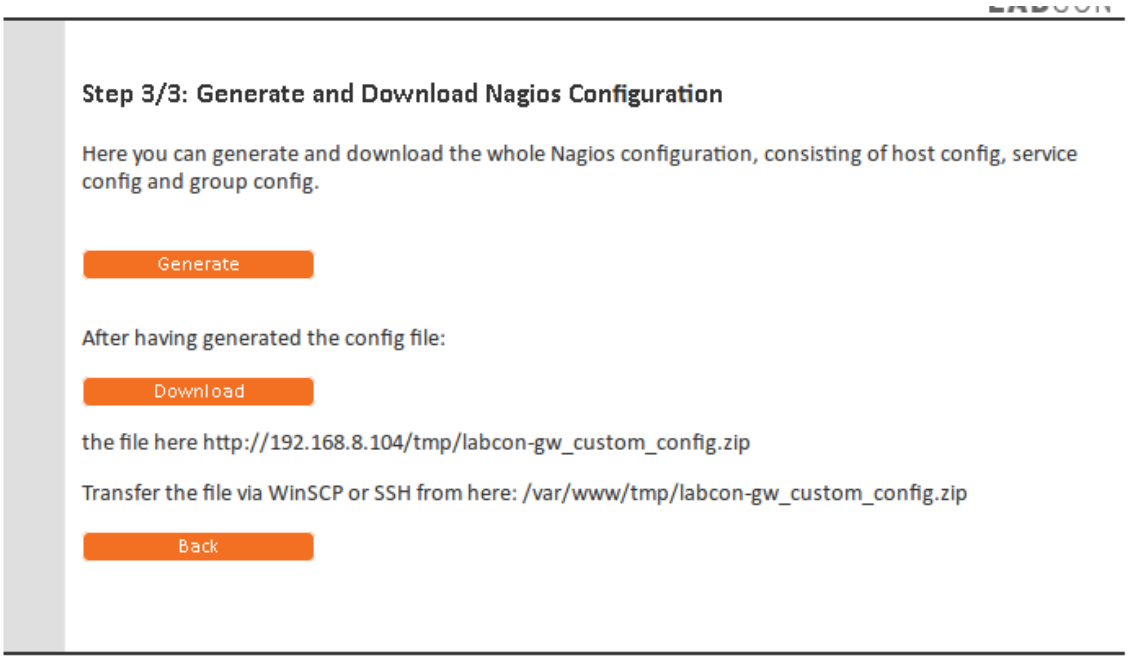


Figure 36: Generate & Download Configurations

The downloadable archive includes scripts and services offered for Nagios. These must be then copied to the LABCON ® directory on the Nagios server.

7.3 Virtual Devices

ZBG-100 enables the creation of virtual sensors. These sensors are the mathematical constructs of any number of physical and virtual sensors (ie. services). The available mathematical functions are:

- Sum (`Sum`)
- Mean (`Mean`)
- Difference (`Diff`)
- Minimum (`Min`)

- Maximum (`Max`)

Virtual sensors behave like physical sensors. They have an interval in which the measured values are re-calculated, and, in addition, alert messages are sent when a violation of threshold values occurs.

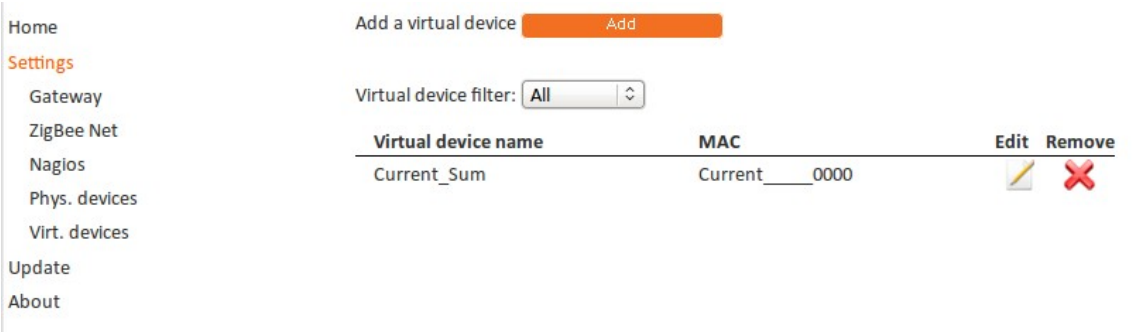


Figure 37: Virtual Device Overview

The virtual sensors can be created under the heading `Setting → Virt. Devices → Add`. Existing Sensors can be configured under `Edit`.

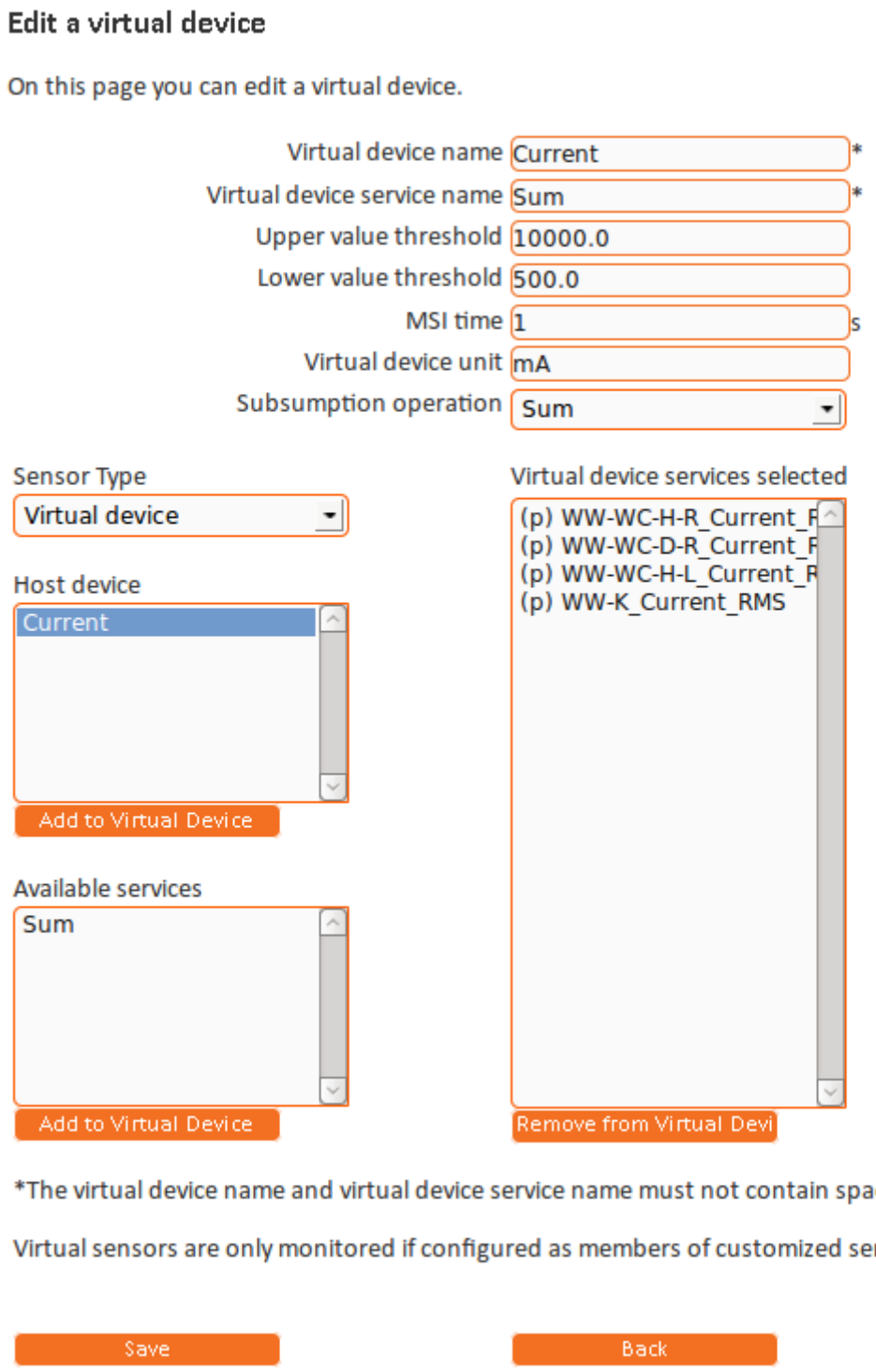


Figure 38: Masks to Edit Virtual Sensor Settings

- Virtual Device Name
  ID of physical sensors

- Virtual Device Service-Name
  Service-name for sensors, (ei. Temperature and battery status)
- Upper/Lower value threshold
  Once a threshold is breached, an alert message is sent.
- MSI time
  Time interval in which the measured value is re-calculated.
- Mathematical operation
  Mathematical function of all measured values under `Virtual device services selected`
- Sensor Type
  Filter for `Host Device` (`Virtual or physical device`)
- Host Device
  Here all configured sensors are listed with your ID
- Available services
  After selecting `Host Devices` Sensor/Device, all available measurements (services) are shown. They can be added by double-clicking on the selected readings.
- Virtual device services selected
  Displays all measurements used to calculate this virtual sensor. Measurement from virtual (v) and Physical (p) devices can be mixed.

7.4 Monitoring

As demonstrated in ch. Fehler: Referenz nicht gefunden - Fehler: Referenz nicht gefunden, all LabCon® sensor values are saved in a “Round Robin” database via the pnp4nagios plug-in. This data can be displayed using the same plug-in.

Monitoring is possible via the LABCON ® side menu located on the Nagios page.

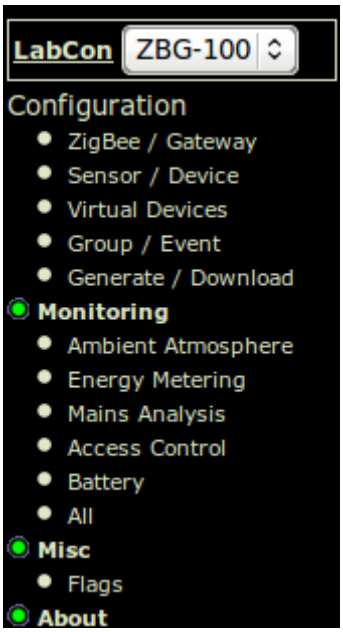


Figure 39: Nagios Menu

You can find an overview page, either via the link “Monitoring”, or via the specific group name. Figure 40 shows the overview found under “Monitoring”.

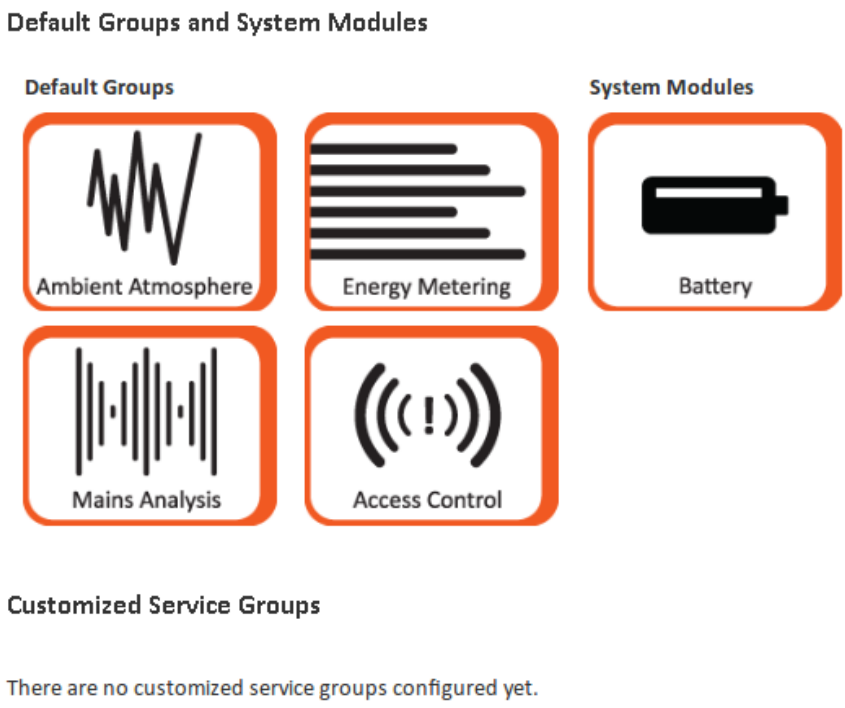


Figure 40: LabCon® Monitoring Overview Page

The following figure shows a temperature profile compiled over a duration of 7 weeks. Pnp4nagios allows for easy zoom of time ranges. These two temporal boundaries can be moved left and right, by using the two arrows in either the bottom right or bottom left corner. You can, however, also zoom using the mouse. Place it over the desired starting value and hold down the right mouse button, bringing it over to the desired end-time. Finally, release the right mouse button.

The rightmost button restores the zoom to its default settings (currently these are set to the last seven weeks).

When ZBS-110 receives a message, the red line automatically indicates the upper limit. This then runs LABCON® scripts. The period in which the temperature is outside the limit is red.

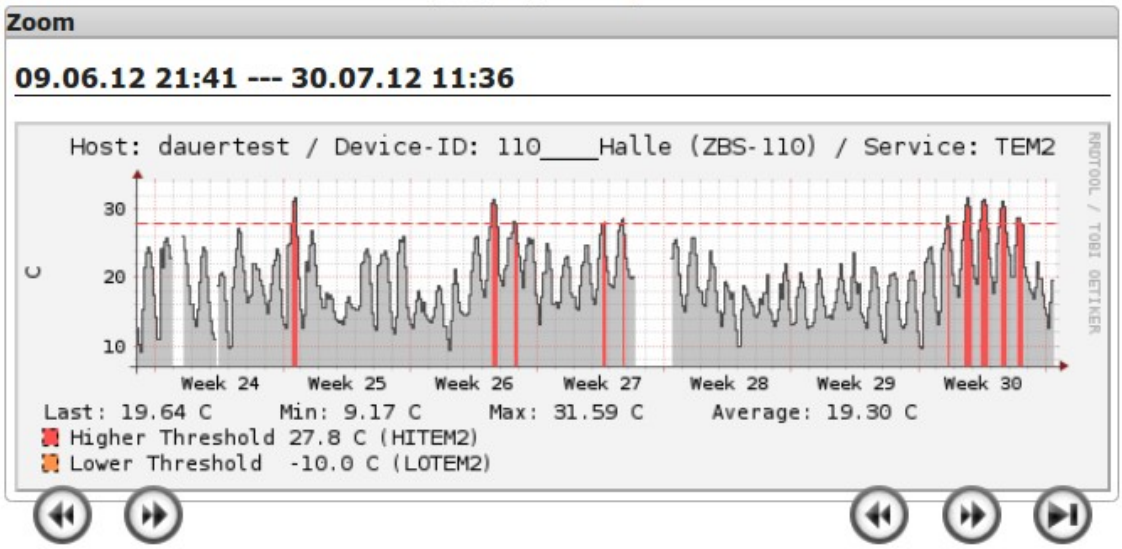


Figure 41: Displays Temperature Flow over a Period of 7 Weeks

The transparent areas indicate that no values have been stored by pnp4nagios. Possible causes for this include, that Nagios' service is not currently running, or that ZBG is not accessible via LAN .

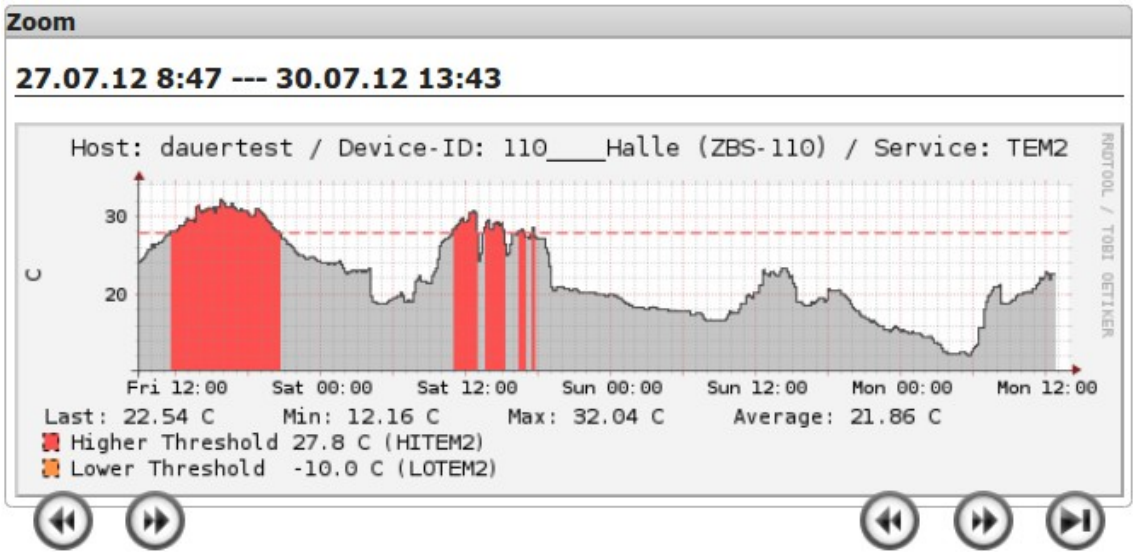


Figure 42: Displays Temperature Flow over a Period of 60h

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10 Additional Information

Icinga
http://www.icinga.org/

LabCon im Web
http://www.pikkerton.de/ITRZ/LabCon/LabCon.htm

MIB Browser
http://ireasoning.com/mibbrowser.shtml

Nagios
http://www.nagios.org/

scp
http://de.wikipedia.org/wiki/Secure_Copy

ZBS-Familie
http://www.pikkerton.de/zigbee/ZigBee.html

ZBG-100
http://de.wikipedia.org/wiki/SheevaPlug
http://www.pikkerton.de/zigbee/ZigBeeGateways.html

11 Appendix: Software and License Update

New updates can be made on the ZBG-100 configuration page via the link "Updates". First, the new firmware files and the license files must be uploaded to the ZBG. You can use the web front-end:

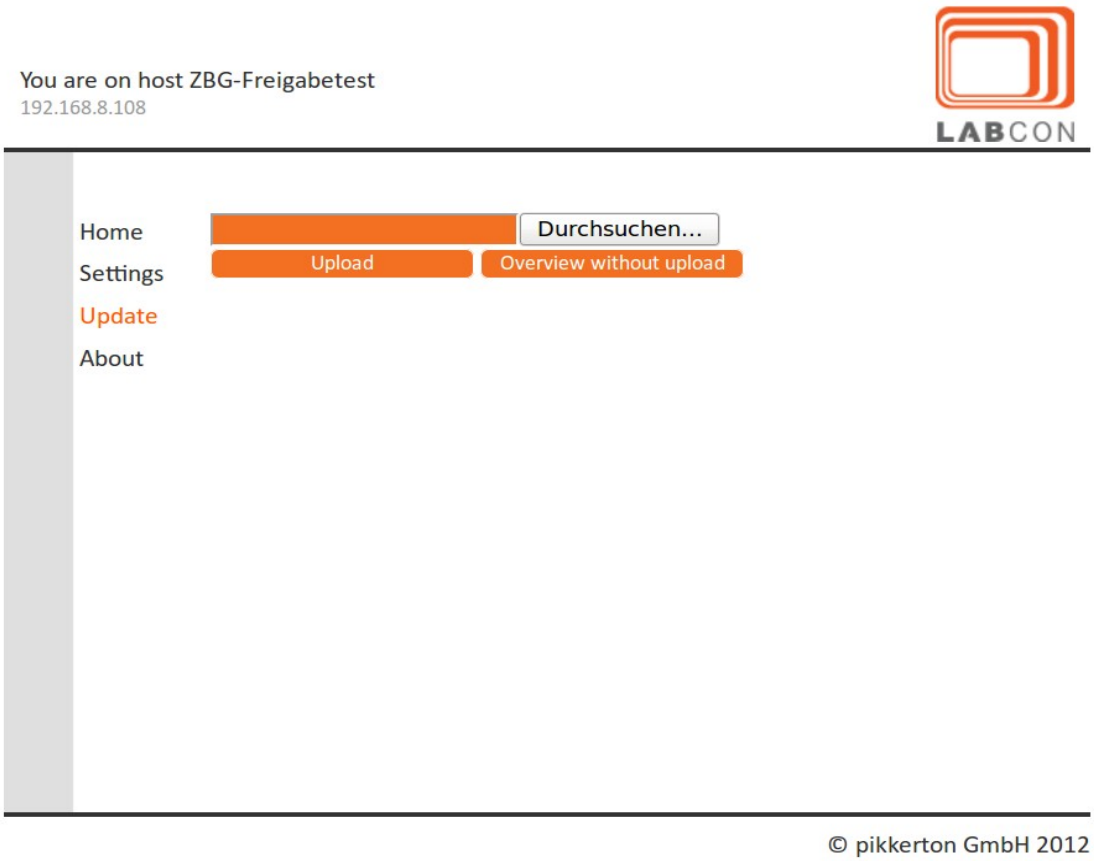

Figure 43: Upload Masks for Update-Files

After successfully uploading the file, you will be prompted to restart ZBG-100. This is done under `ZigBee / Gateway → Settings → Gateway → Reboot & Uptime` by clicking the box next to `Reboot`, and then by confirming by clicking `Apply`.

12 Apendix: Nagios Installation

The description of the Nagios installation and the LabCon integration is outsourced to:
„LabCon installation for Nagios.pdf“