

The world of BAOS

Easy connectivity for KNX with
Bus Access and Object Server

Overview and applications

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Content

1	<i>What is BAOS?</i>	3
1.1	KNX Communication.....	3
1.2	Telegram interface.....	4
1.3	BAOS communication.....	4
1.4	Using KNX BAOS as application specific Gateway.....	5
2	<i>Three Interface Types – One Protocol</i>	6
2.1	KNX Serial BAOS Modules.....	6
2.2	KNX USB BAOS.....	7
2.3	KNX IP BAOS.....	8
2.3.1	KNX IP BAOS 77x – highest performance via IP.....	8
2.3.2	Using KNX IP BAOS 77x as Residential Gateway.....	9
2.3.3	Smart integration of configuration data.....	9
2.3.4	Using KNX IP BAOS 777 with a Web Browser.....	10
2.3.5	Smart with BAOS: Optimal basis for Smartphone apps.....	11
3	<i>Behind the scene: The BAOS Protocol</i>	12
3.1	The Transfer Protocol.....	13
3.2	BAOS Protocol in Net'n Node.....	14
3.3	SDKs for BAOS Protocols.....	16
3.3.1	Demo Application for BAOS Serial Protocol.....	16
3.3.2	SDK for BAOS Binary Services.....	16
3.3.3	SDK for BAOS Web Services.....	16
3.3.4	SDK for BAOS RESTful Web Services.....	16
4	<i>From BAOS to your Product</i>	17
4.1	Product certification with BAOS.....	17
4.2	...and what about the KNX Stack?.....	17
4.3	Any questions left?.....	17

1 What is BAOS?

BAOS – short for "**B**us **A**ccess and **O**bject **S**erver" – is a universal architecture to enable KNX connectivity for a great variety of products. Within its range of KNX BAOS Solutions Weinzierl offers a scalable set of modules and powerful devices which rapidly enable the complete integration of applications into the KNX System.



Our BAOS Modules and Devices can be used as interfaces to connect to KNX both on the telegram and on the data-point level (the KNX Application Layer). Our BAOS Solutions allow an easy integration and implementation of KNX connectivity while releasing the application itself from the complexity of the KNX protocol, including the network management.

While our modules are designed to be fully integrated into your hardware, our KNX BAOS devices enable the connectivity of existing devices to KNX networks as external option but nevertheless with full integration in the ETS tool.

1.1 KNX Communication

Devices that communicate via KNX require an implementation of the KNX protocol. The KNX protocol is specified according to the OSI (Open Systems Interconnection) reference model as a set of protocol layers.

The KNX system itself is a decentralized network and the runtime communication is based on group telegrams in multicast. To participate in the KNX runtime communication each device must be configured, e.g. group addresses must be assigned. Typically this is done via the ETS[®] (Engineering Tool Software) program, the official tool available from the KNX Association. The configuration can be loaded into the distributed devices via the KNX network during the device download. These management procedures are complex and are also part of the KNX Standard.

In our KNX BAOS architecture all the KNX communication is handled within the BAOS Module or BAOS Device. A certified KNX Stack from Weinzierl ensures high performance runtime communication as well as complete compatibility with the ETS and all certified third-party KNX devices.

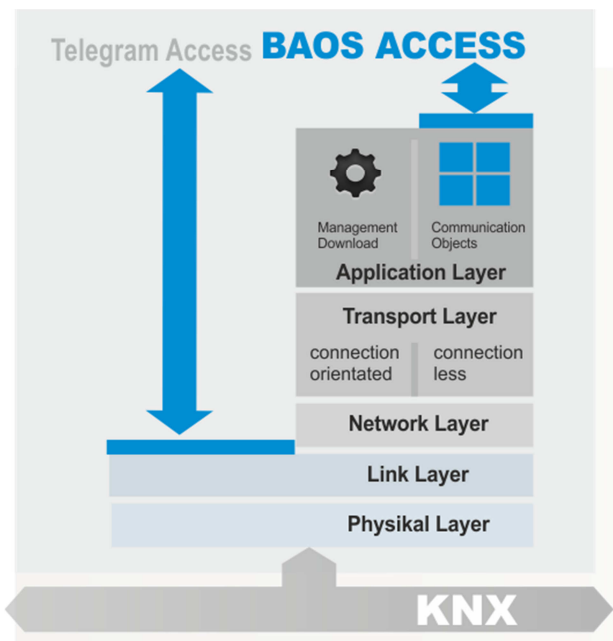
1.2 Telegram interface

In addition to the BAOS protocol all Weinzierl KNX BAOS implementations allow to send and receive any KNX telegrams when setting the communication mode to data link layer. KNX telegrams are coded in cEMI (common External Message Interface) format according to the KNX specification. Today all BAOS Devices and Modules support KNX Long Frames.

The telegram interface based on cEMI is compatible with ETS software. So the USB BAOS as well as the IP BAOS devices can be used as programming interface for ETS. To integrate the telegram interface in applications running on Windows or Linux the cross-platform SDK kDrive is available from Weinzierl.

1.3 BAOS communication

The core of the BAOS implementation is the object server. The client can access the data



of the group objects using the BAOS protocol. This protocol is specified by Weinzierl. It is designed to access KNX group objects and read ETS parameters in an efficient way. Receive events can trigger an indication to the client application.

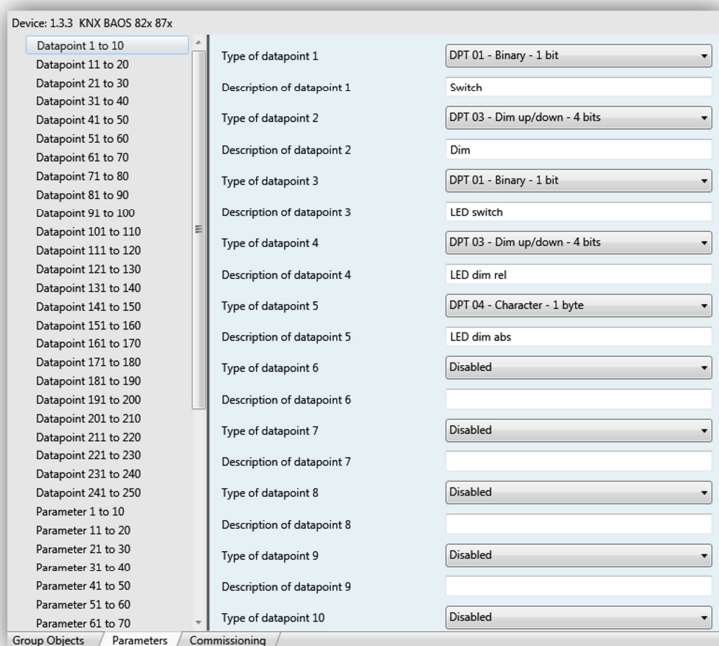
Due to the data storage of the object server the communication to the object server is asynchronous and quite fast. Sending a value to KNX just requires to write an updated value to the object server and to trigger the send process. The KNX Stack of

the BAOS implementation will carry out the send process autonomously. Also the receive process is handled by the object server. So no data is lost even if the client application is busy or not active.

1.4 Using KNX BAOS as application specific Gateway

The KNX BAOS Modules and Devices can be used as application specific Gateways for non-KNX systems. They can be used for example to connect heating devices, audio application and many more to KNX. For a quick start in development the generic ETS product entry can be used. The generic ETS entries implement a flat list of group objects that can be configured from a set of standard datapoint types, for example

- DPT 1 1 Bit Switching
- DPT 3 4 Bit Dimming
- DPT 4 1 Byte Character
- DPT 5 1 Byte Scaling
- DPT 9 2 Byte Float Value
- DPT 10 3 Byte Time



To use the communication object of the BAOS object server, the data points have to be configured. The KNX data point type has to be set and group addresses have to be assigned. To simplify this task for each KNX BAOS Module or Device a corresponding ETS product entry is available from the Weinzierl website.

The generic ETS entry supports either 250, 1000 or 2000 data

points, and the setting of single parameter bytes which can be used by the client. The generic database can be used during product development and testing. For final products we recommend to create an individual database for your application to ensure an optimal representation of your product within the ETS. For further information about development with KNX BAOS Modules and Devices please contact Weinzierl.

2 Three Interface Types – One Protocol

The BAOS Protocol is available in with three different interface types:

- Serial BAOS
- USB BAOS
- IP BAOS

This section gives an overview about current solutions.

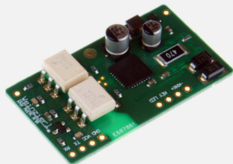
2.1 KNX Serial BAOS Modules

Easy integration into your devices

Typical applications: Sensors, actuators or gateways to non-KNX systems

With our KNX BAOS Modules we offer a quick and efficient solution to connect your devices to KNX. The compact PCBs include both a KNX transceiver and a microcontroller with a certified KNX stack. The modules can be integrated in devices and mounted via pin headers. The communication to the host device is realized via a serial connection.

KNX BAOS 830



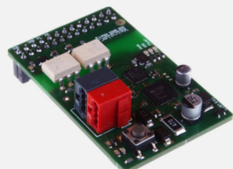
The KNX BAOS Module 820 is powered via the bus and provides galvanic isolation to the host. It supports 1000 group objects.

KNX BAOS 832



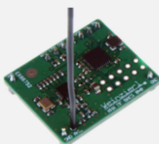
The KNX BAOS Module 832 corresponds to the version 830 but with power from the bus for the application and without the galvanic isolation.

KNX BAOS 838 kBerry



The KNX kBerry comes with the same schematic and firmware as KNX BAOS Module 830 but is mechanically designed for piggyback on popular Raspberry Pi.

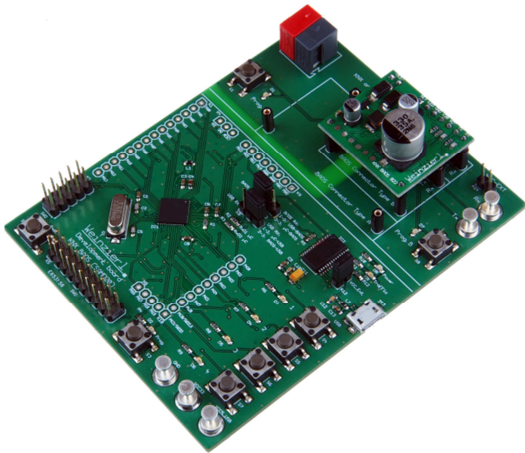
KNX BAOS 840 RF



The KNX BAOS Module 840 RF is the wireless alternative with up to 1000 data points. It implements KNX RF with full ETS support (ETS5 or higher).

A comprehensive user guide is available for our BAOS Modules on our website at www.weinzierl.de. A generic ETS database with up to 1000 group objects is available to get you up and running. Custom ETS databases can be created, as well.

BAOS Development Kit



To start your own project with our BAOS Solution a BAOS Development Kit is available which contains everything you need:

- BAOS Development board
- KNX BAOS Module 830
- KNX BAOS Module 832
- Tools and demo software
- USB cable for power supply

2.2 KNX USB BAOS

The USB connection is an alternative to serial interfaces for more complex devices running an operating system like Windows or Linux. The USB BAOS solution is available in three products:

KNX USB Interface 312



The KNX USB Interface 312 can be mounted on DIN rail with a width of only one unit (18 mm). It can be used as extension unit to connect to the KNX bus.

KNX USB Interface 322



The KNX USB Module 322 can be integrated in a PCB design using standard pin headers (2.54 mm)

KNX USB Interface 332



The KNX USB Stick 332 can be integrated in devices like touch panels but can be used as well as external device.

All of them share the same functionality. They support the BAOS binary protocol V2 but can be used as programming interface for ETS as well.

While the type 312 is for DIN rail mounting the 322 and the 332 are more compact. The Module even can be integrated via pin headers in a PCB design. The Stick version 332 is also very small but comes as a complete device with an enclosure.

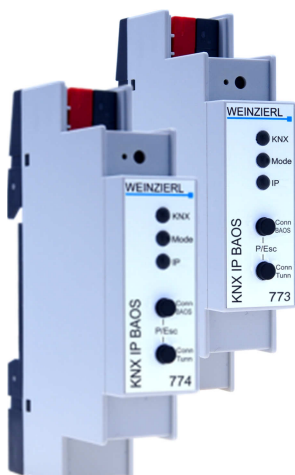
2.3 KNX IP BAOS

With our range of KNX IP BAOS devices we bring the possibilities of our Bus Access and Object Server to LAN Networks

For a link via LAN or Wi-Fi our KNX IP BAOS devices allow interfacing complex devices. Even powerful visualization apps for mobile devices can be easily realized using the KNX IP BAOS architecture.

2.3.1 KNX IP BAOS 77x – highest performance via IP

Typical applications: Interface for devices with high communication capabilities like PLC (Programmable Logic Controller) or smartphone applications for home control.



Using the KNX IP BAOS 773, 774 or 777 the KNX bus is accessible from everywhere via Ethernet. Connection over WiFi (with an extra router) or the Internet is possible, too. The IP settings as well as the data points can be configured with ETS software. The device requires either an external power supply or via Power-over-Ethernet (IEEE 802.3af) directly from the switch. This device can be also be used as a programming interface for ETS.

All variants are based on a tailored hardware with low power consumption. The KNX IP BAOS 773 supports up to 250 communication objects, the KNX IP BAOS 774 up to 1000.

The KNX IP BAOS 777 supports even up to 2000 data points and provides an OLED display and an integrated web interface for visualization and control of your KNX installation.



2.3.2 Using KNX IP BAOS 77x as Residential Gateway

The KNX system is using a very specific protocol which is difficult to handle for non-KNX devices. With the well-tried BAOS architecture, the KNX IP BAOS 777 maps KNX data to an IT-friendly API (Application Programming Interface). Thus, it greatly reduces the effort to connect applications like control or visualization tools to KNX.

The KNX IP BAOS architecture not only allows access to the runtime data. In addition it retrieves the structure of the KNX installation. It encodes the rooms of a building as well as the available functions as a set of meta-data. Using the ETS commissioning tool the installer defines the rooms and which functions are available to the client. While a room is seen as a collection of functions, a function is a collection of datapoints representing a specific KNX interworking function. A simple example is a switching actuator with state which requires two datapoints. Functions are defined for, but not limited to:

- Switching Control
- Switching Control with State
- Dimming Control
- Dimming Control with Switching State
- Dimming Control with Value State
- Temperature with Set Point
- RGB Control

2.3.3 Smart integration of configuration data

The benefit of user parameters is to enable the possibility of configuring the application via the ETS parameter dialog. It is even possible to configure a visualization program just via the ETS.

2.3.4 Using KNX IP BAOS 777 with a Web Browser

The KNX IP BAOS 777 has an integrated web server which allows an easy and fast access to the building using a standard web browser. Using the ETS product entry with

building structure the web server offers a visualization tool. Via the web interface also timers and history are available.

To access the web application, just enter the IP Address of the BAOS 777 into your browser. The IP address can be seen in the display of the device.

Once a connection has been established to the BAOS you should see the login page.

The username and password are by default “admin” and can be set in the ETS database.



2.3.5 Smart with BAOS: Optimal basis for Smartphone apps

The KNX Gadget is just a sample. The main use case of this architecture is home and building control via mobile devices. Indeed this architecture is used by numerous smartphone applications available on the market from different manufactures.



The main advantages are:

- Fast and easy configuration of the app in ETS
- No additional editor for visualization
- No training needed
- Separation of graphical design and building structure
- Separation of building installation and app handling
- very low power consumption
- Object Server holds all actual values
- Simultaneous usage by multiple clients

KNX IP BAOS as micro server builds the interface to the building with semantic information from the installation. Only functions are available which explicitly have been added to the configuration. This increases security as well as safety for users and for the building.

3 Behind the scene: The BAOS Protocol

The BAOS Protocol is a tailored solution to exchange data with an object server. It has a dynamic structure, not only for the length of individual data points but also for the number of data points encapsulated within one frame. That allows that in one request or indication multiple values can be transferred. This is essential for communication systems like IP which typically have a high bandwidth but sometimes quite high delays.

The communication structure of the BAOS architecture is client-server. The KNX BAOS Modules or Devices act as a server. The application is the client. Most services are sent from the client to the server which always sends a response. Asynchronous indications can be sent by the server to inform the client about updates of values via the KNX network.

The BAOS Protocol is used in three different formats:

- KNX BAOS Binary
- KNX BAOS Web Services
- KNX BAOS RESTful Web Services

The BAOS Binary Protocol uses arrays of bytes to code services. It is the best way to implement communication protocols directly in a microcontroller. The serial KNX BAOS Modules and Devices just use the binary protocol. The binary protocol is available as well on all KNX IP BAOS devices but in addition for IP the BAOS Web Service Protocol is available. It uses JSON (Java Script Object Notation) syntax to code the same content as the binary services. The Web Services have been introduced for client applications which run in a web browser. So the BAOS Web Services can easily be integrated in web pages realized with Java Script.

As a new generation of Web Services the KNX IP BAOS 777 now supports all services in a RESTful API. The RESTful web services allow a semantic access to the structure of the installation. That means that the interpretation of the ETS parameters is now done in the KNX IP BAOS 777 device.

Currently the BAOS protocol is used in versions V2. See the protocol specification for details.

	BAOS Binary V2	BAOS Web Services	BAOS RESTful Web Services
KNX USB Interface 312	✓		
KNX USB Module 322	✓		
KNX USB Stick 332	✓		
KNX Module BAOS 830	✓		
KNX Module BAOS 832	✓		
KNX Module BAOS 838 kBerry	✓		
KNX Module BAOS 840 RF	✓		
KNX IP BAOS 773	✓	✓	
KNX IP BAOS 774	✓	✓	
KNX IP BAOS 777	✓	✓	✓

BAOS protocol versions

3.1 The Transfer Protocol

The BAOS Protocol just contains application data. It does not define a transport protocol, so it can be used on different connection types.

For the modules and devices which support a serial link, the BAOS Protocol is encapsulated in a FT1.2 frame which defines the start and the end of the packet as well as a checksum and acknowledgement. FT1.2 is an international standard (IEC 870-5-1 and 870-5-2).

The KNX USB BAOS Devices and Modules use encapsulate the BAOS Protocol in HID reports as it is specified for KNX USB interface devices.

The KNX IP BAOS Devices use either IP UDP or TCP packets as frames. The headers and usage is very similar to the KNXnet/IP specification however they use the BAOS data structure as content. Although in principle UDP is a connectionless communication, there is some kind of transport connection on top of UDP which is required to send asynchronous indications to the client. The KNX IP BAOS Devices always act as a communication server.

A major benefit of the IP protocol is the possibility of multiple connections. Up to 10 clients can be connected to a single KNX IP BAOS device via the IP BAOS protocol.

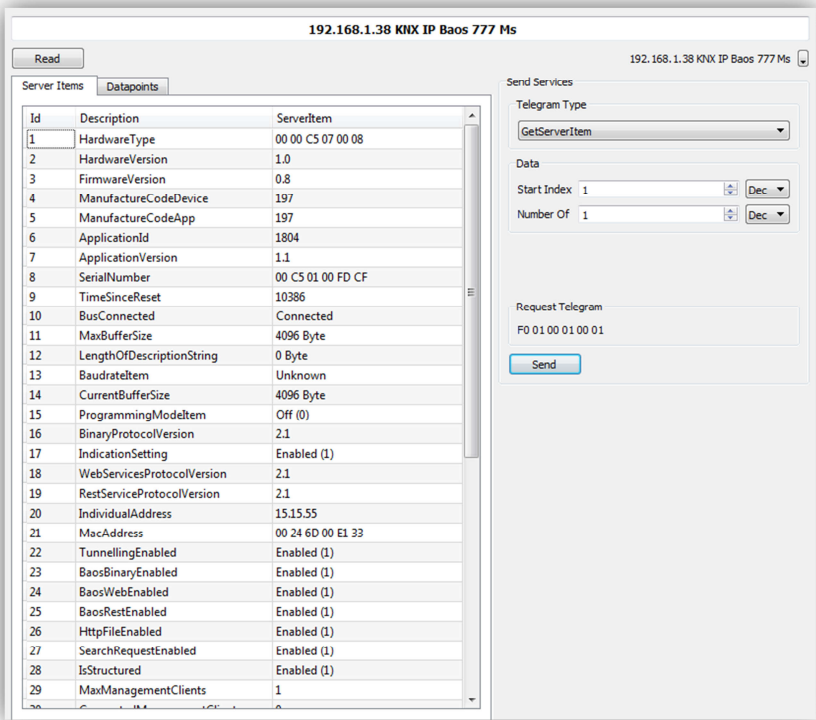
	Serial FT1.2	USB HID	IP UDP	IP TCP
KNX USB Interface 312		✓		
KNX USB Module 322		✓		
KNX USB Stick 332		✓		
KNX Module BAOS 830	✓			
KNX Module BAOS 832	✓			
KNX kBerry 838	✓			
KNX Module BAOS 840 RF	✓			
KNX IP BAOS 773			✓	✓
KNX IP BAOS 774			✓	✓
KNX IP BAOS 777			✓	✓

Frame formats

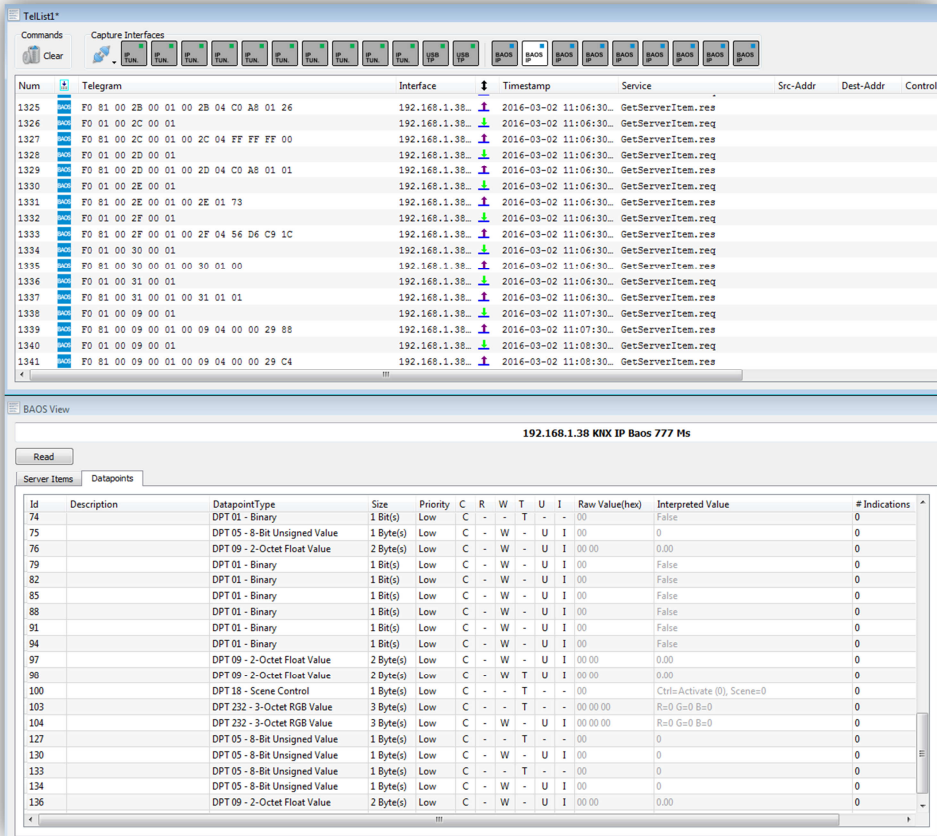
3.2 BAOS Protocol in Net'n Node

The BAOS Binary Protocol is supported in the free version of Net'n Node 5. Net'n Node is a bus monitor and analyzer for KNX especially for development purpose. It supports all KNX media and uses standard KNX interfaces (IP, USB and Serial FT1.2).

The program allows opening one or more BAOS ports via serial, USB or IP even in addition to a KNX telegram port. The integrated BAOS view give access to all BAOS data like server item and data points. BAOS services can be sent via dedicated send masks. Sent and received services are displayed together with KNX telegrams on the bus in the telegram window.



Net'n Node BAOS view showing server items



Net'n Node telegram view with BAOS data points

3.3 SDKs for BAOS Protocols

For easy integration of the KNX BAOS protocol into different environments free SDKs are available in source code also for download on our web page:

- SDK for BAOS Serial Protocol
- SDK for BAOS Binary Services
- SDK for BAOS Web Services

3.3.1 Demo Application for BAOS Serial Protocol

A free software framework is available for download on our web page which integrates the FT1.2 protocol as well as the BAOS protocol. A simple application shows the usage of the communication drivers for embedded micros.

The sample is prepared for Atmel/Microchip SAM D20 microcontroller and can be used with the Atmel Studio free compiler and debugger. The project is prepared to run directly on the development board of our starter kit for KNX BAOS 83x Modules.

3.3.2 SDK for BAOS Binary Services

The Software Development Kit SDK for BAOS Binary Services is a cross-platform C++ implementation of the KNX BAOS Binary Protocol. It can be used for a rapid development of native applications for KNX control which use the KNX BAOS Interfaces and Modules. The SDK is prepared but not limited to Linux and Windows.

3.3.3 SDK for BAOS Web Services

The SDK for BAOS Web Services is a Java Script implementation of the KNX BAOS Web Services Protocol. It can be used for the rapid development of web applications for KNX control which are using the KNX BAOS IP Interfaces. The main use case for this SDK is the development of visualization apps running in a web browser. Web application can be used on nearly any computers as well as on mobile devices such as smart phones or tablet computers. The BAOS Web Service SDKs can be used with the KNX IP BAOS 773/774 and the KNX IP BAOS 777.

3.3.4 SDK for BAOS RESTful Web Services

The SDK for BAOS RESTful Web Services is a Java Script implementation of the KNX BAOS RESTful Web Services Protocol. It can be used for the rapid development of web applications for KNX control which are using the KNX BAOS IP 777 Interfaces.

4 From BAOS to your Product

4.1 Product certification with BAOS

For decades, its cross-manufacturer compatibility of various applications and products is the main pillar of the KNX system. This is achieved by the advanced certification system of the KNX Association. All devices with a KNX logo must be tested by a test laboratory accredited by the KNX Association for compatibility.

The KNX BAOS modules and devices build a perfect basis for applications which can be certified because a certified KNX Stack is implemented. If you are using a BAOS component the Stack is not required to be tested again. Therefore only the application specific tests, i.e. interworking and functionality, are required.

Weinzierl has its own accredited test lab for KNX certification. If you have any questions regarding product qualification please refer to our website or contact us directly.

4.2 ...and what about the KNX Stack?

A KNX Stack is a software solution as a basis for KNX device development. Also in all KNX BAOS Modules or Devices a Weinzierl KNX Stack is running. The usage of a stack gives a maximum on flexibility and can be integrated with the application on a single micro.

The application development on a KNX Stack typically requires more effort and system knowledge compared to the usage of a BAOS solution. It is mainly used for devices with a higher volume. For more information, please visit our web page at weinzierl.de

4.3 Any questions left?

The choice of the best architecture for an application is not trivial but always necessary at the beginning. If you have any questions how to start KNX development or about our solutions please do not hesitate to contact us.