ZIGBEE ROUTER R0
REFERENCE MANUAL

ubisys®

Thank you for purchasing this ubisys ZigBee Router.
You have decided for a high-quality product with first-rate support!

This reference manual provides operating and maintenance instructions, interface specifications, command references and more. It is primarily intended for system integrators, not end-users.

An installation guide specific to your region is available as a separate document and is included in printed form in the product package.

If you have any questions or need additional support, please visit the support pages that best fit your background:

If you are a consumer (private household) or installer, please visit the Smart Home support pages at http://www.ubisys.de/en/smarthome/support.html for contact details.

As a commercial customer, please visit the Engineering support pages at http://www.ubisys.de/en/engineering/support.html for contact details.

ubisys.

2. Contents

www.ubisys.de ubisys.

- ZigBee Router
- Reliable, unattended, maintenance-free operation; designed for in-wall flush-mounting
- Made in Germany using high-quality, enduring parts for many years of life expectancy
- Universal power supply: 90-270V~, 50/60Hz or 12-400V=
- Low power dissipation: 0.3W
- On-board MCU: Advanced 32-bit ARM micro-controller running at 48MHz with 64KB SRAM
- On-board PHY: Texas Instruments CC2520, 5dBm transmit power, -98dBm receiver sensitivity
- On-board inverted-F antenna
- Leverages ubisys IEEE 802.15.4 MAC and ZigBee stack for best-in-class reliability and performance
- Supports all channels in the 2.4 GHz band, i.e. channels 11-26 as per IEEE 802.15.4
    - o   Primary channel set = { 11, 15, 20, 25 }
    - o   Secondary channel set = { 12, 13, 14, 16, 17, 18, 19, 21, 22, 23, 24, 26 }
- Suitable for ZigBee Home Automation Profile and other compatible profiles
- Supports joining centralized and distributed security networks as router
- Supports forming simple centralized security networks as Coordinator and Trust Center
- Supports forming distributed security networks as router
- Three pre-configured Trust Center Link-Keys for joining:
    - o   Global Default Trust Center Link-Key ("ZigBeeAlliance09")
    - o   Global Distributed Security Link-Key (ZLL pre-certification key by default, others upon request)
    - o   Device-individual link-key derived from installation code
- Includes 128-bit installation code for secure joining (text and QR barcode)
- Extended neighbour table with up to 78 entries for routers and end-devices - more than three times the capacity required by the standard (25)
- Extended routing table with up to 96 entries for ad hoc and many-to-one routes - nearly ten times the capacity required by the standard (10)
- Extended buffering for sleeping end-devices with up to 24 buffers - 24 times the capacity required by the standard (1)
- Extended APS duplicate rejection table with up to 64 slots - 64 times the capacity required by the standard (1)
- Extensive transmit and receive queues for optimum through-put and minimum packet drop rate
- Reliable and scalable network-wide broadcasts featuring passive acknowledgments
- Reliable packet forwarding with automatic network-level retries
- Very sophisticated routing algorithm for reliable ad hoc routing – avoids routing loops even in case of concurrent route requests with overlapping source/destination
- Firmware upgradable over-the-air during normal operation using ZigBee OTA Upgrade Cluster
- Man-Machine-Interface: A push-button and a LED for network steering, factory reset etc.
- Customized versions available upon request
- OEM versions available upon request
- Ready for the upcoming ZigBee 3.0 release (will be offered as OTA upgrade image)

4.1. Mains Powered Operation

Please refer to the hardware installation guide, which was included in the product package. It provides detailed installation instructions.

4.2. Low-Voltage Operation

Instead of applying dangerous mains voltage to the Router R0, you may connect a low-voltage DC source (e.g. 12V=, 24V=, 48V=) to the supply lines of R0. Its built-in universal power supply is able to operate from both kinds of supplies, direct and alternating current.

For DC operation, connect the **DC ground (0V, "minus",** negative) of your power supply to the phase **input of R0 (marked "L",** brown) and the **DC supply voltage (12…48VDC, "plus", positive) to the neutral input of R0 (marked "N",** blue). Once powered, you should observe the normal device start-up behaviour (the green LED will flash a few times).

The built-in universal power supply can accept up to 400V=, which is an absolute maximum rating.

If you are not using a safe low-voltage power-supply, utilizing the services of a professional installer/electrician is imperative.

The router will search for an open ZigBee network to join when you first apply power to it.

Open the ZigBee network for joining and then power-up the device.

R0 will blink quickly to indicate a search in progress. Once a search cycle is complete it will either blink five times slowly to indicate it has joined a network, or blink three times quickly to indicate a joining failure – for example no network found, not permitted onto the network, etc. It will continue to search for a network in case of failure.

Subsequently, when the device is power-cycled, it will blink five times slowly to indicate it is operating as a router on the network, ten times slowly to indicate that it is operating as a coordinator and trust center or blink **quickly to indicate it is searching for a network to join. When commissioned, the router's** LED will remain off after the five/ten blink cycles during normal operation. Afterwards, it will turn on only for as long as it is permitting other devices to join the network.

After reboot, if the device is properly commissioned, it resumes **operation doing a "silent rejoin", i.e. it** does not broadcast a device announcement in this case. After joining a network, the device will prolong the joining window by three minutes via a fresh ZDO permit joining request[1].

---

[1] Stretching the joining duration is done in products with ubisys ZigBee Stack version 1.48 or above.

www.ubisys.de   ubisys.

R0 offers a push-button behind a tiny hole in the front-face of the device, as well as a LED right next to it. This man-machine interface provides access to a menu.

To enter the menu, press and hold the push-button for more than a second until you see three short flashes followed by a sequence of one blink, pause, one blink, pause, etc. This indicates that you have successfully entered the menu. With each short button press (less than a second), you advance through the menu. For example, pressing the button once brings you to the second menu item, which R0 indicates by two blinks, pause, two blinks pause, etc. Once you have reached the menu item that you want to run, press and hold the button for more than a second to execute the selected item. The exact meaning of each menu item depends on the particular device and may vary from firmware version to firmware version.

This is the menu for Router R0 running firmware version 1.01 and above[2]:

Menu Item #	Operation
1	**ZigBee Commissioning: Network Steering** While in this mode a single press on the button instigates ZigBee Network Steering ("EZ-mode"). If the device is on a network it will open the network for new devices for three minutes, otherwise it will attempt to join an open network.
2	ZigBee Commissioning: Finding & Binding Instigates the ZigBee Finding & Binding procedure ("EZ-mode") on an initiator or target endpoint. Target endpoints will enter identify mode for three minutes. Initiator endpoints will query targets and create suitable bindings to these targets. After leaving the menu in this mode, the first button press starts the selection of the endpoint and each subsequent press (within half a second) increments the endpoint number. Once the desired endpoint is reached, wait for the LED to blink the selected number of times. Then, press a single time to accept the selection or wait for three seconds to cancel the command. The LED will blink one time to confirm an affirmative choice, or two times to indicate the request has been cancelled. This menu item is not implemented on router R0.
3	ZigBee Commissioning: Clear Bindings Clears bindings on an initiator endpoint. Select this menu item and leave menu mode. Afterwards the device expects the selection of an initiator endpoint. The first button press starts the selection of the endpoint and each subsequent press (within half a second) increments the endpoint number. Once the desired endpoint is reached, wait for the LED to blink the selected number of times. Then, press a single time to accept the selection or wait for three seconds to cancel the command. The LED will blink one time to confirm an affirmative choice, or two times to indicate the request has been cancelled. This mode is active for one round only. Afterwards the device reverts to mode #1. This menu item is not implemented on router R0.
4	**ZigBee Commissioning: Set Device Role and Factory Reset** Selects the ZigBee device role for this device on the network, resets the remaining settings to factory defaults and restarts the device. Select this menu item and leave menu mode. Afterwards the device expects the selection of an option. The first button press starts the selection of the option and each subsequent press (within half a second) increments the option number. Once the desired option is reached, wait for the LED to blink the selected number of times. Then, press a single time to accept the selection or wait for three seconds to cancel the command. The LED will blink one time to confirm an affirmative choice, or two times to indicate the request has been cancelled. The following options are available: Option #1: Join an existing ZigBee network as router Option #2: Form a new distributed security network as the first router Option #3: Form a new centralized security network as the coordinator and trust center
5	**Factory Reset** Put the device into the same state as it was when it left the factory, then reboot. The only exception is the outgoing network security frame counter, which is preserved across factory resets.

[2] Notice: Prior versions have different menu items. Only the factory reset command (menu item #5) is identical across all released versions of the firmware.

www.ubisys.de   **ubisys**

6	**ZigBee Commissioning: Advanced Commands** Provides a number of advanced ZigBee commissioning command options. Select this menu item and leave menu mode. Afterwards the device expects the selection of an option. The first button press starts the selection of the option and each subsequent press (within half a second) increments the option number. Once the desired option is reached, wait for the LED to blink the selected number of times. Then, press a single time to accept the selection or wait for three seconds to cancel the command. The LED will blink one time to confirm an affirmative choice, or two times to indicate the request has been cancelled. The following options are available: Option #1: Perform a simple reset (reboot), then continue operating seamlessly (silent re-join) Option #2: Perform a simple reset (reboot), then re-join the network Option #3: Perform a full factory reset, including security frame counters and preserved settings
7	Reserved for internal use. Do not leave the menu in this mode.

Please refer to the following IEEE and ZigBee Alliance documents, which apply to this product:

[R1] IEEE Standard 802 – Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)
[R2] ZigBee Specification, Revision 20, Document No. 05-3474-20
[R3] ZigBee PRO/2007 Layer PICS and Stack Profiles, Revision 5, Document No. 08-0006-05
[R4] ZigBee Cluster Library Specification, Revision 4, Document No. 07-5123-04
[R5] ZigBee Home Automation Public Application Profile 1.2, Revision 29, Document No. 05-3520-29
[R6] ZigBee Smart Energy Standard 1.1b, Revision 18, Document No. 07-5356-18

Device Anatomy

The routers main task is to act as a range extender by improving network connectivity and meshing capabilities as well as acting as a connection point ("parent") for sleeping end-devices. As such, it does not provide any particularly useful application endpoints, except for device management.

This router provides three ZigBee application endpoints:

Endpoint #	Profile	Application
0 (0x00)	0x0000: ZigBee Device Profile	ZigBee Device Object (ZDO) – standard management features
200 (0xC8)	Private	Private. This endpoint contains a legacy private application and provided for backwards-compatibility, only. This feature is deprecated and will be removed in a future firmware release after a grace period.
232 (0xE8)	0x0104: Common Profile (HA)	Device Management (0x0507)[3]

Notice: Currently, this product does not support ZigBee Green Power. Support for Green Power is scheduled for a future firmware release. When available, it will be provided as ZigBee over-the-air upgrade image for already deployed devices.

The ubisys ZigBee manufacturer ID is 0x10F2. This manufacturer code is used to identify OTA upgrade images, for accessing manufacturer-specific ZCL attributes and commands etc.

Installation Code

This router has a pre-configured link key, which is derived from the installation code printed on the back of the router's housing in text format and as a two-dimensional barcode (QR code). The format specified in [R6], section 5.4.8.1.1 is used with a full 128-bit installation code + 16-bit CRC. The QR code contains additional information as illustrated in the following example:

```
ubisys2/R0/001FEE00000000FF/0F7C1CD805F91649EBA84580AA1CB432F51A/21
```

Here, "ubisys2" is the data format identifier, R0 is the model string, followed by the EUI-64, the installation code, and a checksum that covers the entire information (including model, EUI-64 and installation code), all separated by a single dash character ('/'). The check sum is an unsigned 8-bit integer, which is calculated by performing a byte-wise exclusive-or (XOR, "⊕") of the ASCII characters of the model string, the binary representation of the EUI-64 (in big endian format), and the binary representation of the install code.

---

[3] Since application version 1.01. Prior, device ID 0x0008 (Range Extender) was used.

For the example above, this calculation yields:

```
52 ('R') ⊕ 30 ('0') ⊕
00 ⊕ 1F ⊕ EE ⊕ 00 ⊕ 00 ⊕ 00 ⊕ 00 ⊕ FF ⊕
0F ⊕ 7C ⊕ 1C ⊕ D8 ⊕ 05 ⊕ F9 ⊕ 16 ⊕ 49 ⊕ EB ⊕ A8 ⊕ 45 ⊕ 80 ⊕ AA ⊕ 1C ⊕ B4 ⊕ 32 ⊕ F5 ⊕ 1A = **21**
```

Notice: The data format "ubisys1" is identical to "ubisys2" except for the check sum, which is present, but invalid. If you encounter "ubisys1" labels, then do not verify the trailing check sum field.

7.1. Application Endpoint #0 – ZigBee Device Object

Please refer to the ZigBee Specification [R2] for details on the ZigBee Device Object (ZDO) and the protocol used for over-the-air communication, called the ZigBee Device Profile (ZDP). Notice that the ZDP is fundamentally different from typical application endpoints, which build on the ZigBee foundation framework and the ZigBee Cluster Library (ZCL).

The ubisys ZigBee Router R0 supports the following ZDO services:

Primitive	Description
nwk_addr_req/ nwk_addr_rsp	**Network address request/response** Translates a 64-bit IEEE address into a 16-bit network short address. Use only when really required, because this message employs a network-wide broadcast (flooding) and utilizes a large proportion of the available bandwidth.
ieee_addr_req/ ieee_addr_rsp	**IEEE address request/response** Translates a 16-bit network short address into a 64-bit IEEE address.
node_desc_req/ node_desc_rsp	**Node descriptor request/response** Returns information such as the manufacturer ID, power supply, etc.
active_ep_req/ active_ep_rsp	**Active endpoints request/response** Returns a set of available application endpoints on the device.
simple_desc_req/ simple_desc_rsp	**Simple descriptor request/response** Returns a descriptor for a certain application endpoint with a list of available services (clusters).
match_desc_req/ match_desc_rsp	**Match descriptor request/response** Searches for a certain cluster or set of clusters and returns the matching endpoints, if any.
device_annce	**Device announcement** Advertises the presence of a new device in the network.
bind_req/ bind_rsp	**Bind request/response** Creates an application binding
unbind_req/ unbind_rsp	**Unbind request/response** Removes an application binding
mgmt_lqi_req/ mgmt_lqi_rsp	**Management: Neighbor table request/response** Returns information about neighboring devices, including the link quality, device type etc.
mgmt_rtg_req/ mgmt_rtg_rsp	**Management: Routing table request/response** Returns information about routes established on the device.
mgmt_bind_req/ mgmt_bind_rsp	**Management: Binding table request/response** Returns information about application bindings on the device.
mgmt_leave_req/ mgmt_leave_rsp	**Management: Leave request/response** Makes the device leave the network or removes one of its end-device children.
mgmt_permit_joining_req/ mgmt_permit_joining_rsp	**Management: Permit joining request/response** Opens the network for new devices to join.

Notice: Binding table operations are supported, but not useful for a pure router (range extender).

7.2. Application Endpoint #232 – Device Management

This endpoint provides device management functions using standard ZigBee foundation paradigms and the ZigBee Cluster Library [R4]. You may use the standard ZCL frames to enumerate, read and write attributes, configure attribute reporting, invoke commands, etc.

The application endpoint exposes the following clusters:

Cluster	Direction	Description
0x0000	Inbound (Server)	**Basic** Provides basic information about the device, such as the manufacturer ID, vendor and model name, stack profile, ZCL version, production date, hardware revision etc. Allows a factory reset of attributes, without the device leaving the network.
0x0003	Inbound (Server)	Identify[4] Allows to put the endpoint into identify mode. Useful for identifying/locating devices and required for Finding & Binding.
0x0015	Inbound (Server)	**Commissioning** Offers fine-grained commissioning options, for example, configuring a certain short address, channel mask, concentrator setup etc. This cluster is rarely used.
0x0019	Outbound (Client)	**OTA Upgrade** Pull-oriented firmware upgrade. Searches the network for mating servers and allows the server to control all stages of the upgrade process, including which image to download, when to download, at what rate and when to install the downloaded image.

7.2.1. Basic Cluster (Server)

The basic cluster might be accessible via more than one endpoint. Most of its attributes are singleton attributes, i.e. all instances of the cluster share the same attribute value storage.

Attributes supported:

Attribute	Type	Description
0x0000	unsigned8, read-only	**ZCLVersion** The version of the cluster library
0x0001	unsigned8, read-only	**ApplicationVersion** The application version
0x0002	unsigned8, read-only	**StackVersion** The stack version
0x0003	unsigned8, read-only	**HWVersion** Specifies the hardware revision number
0x0004	string, read-only	**ManufacturerName** "ubisys"
0x0005	string, read-only	**ModelIdentifier** "R0 (5501)"
0x0006	string, read-only	**DateCode** "YYYYMMDD-XX-FBV", where YYYY = year, MM = month, DD = day of production (hardware), XX = production facility, V = factory block version. For example, "20130411-DE-FB0" refers to a device built April 11, 2013 in Germany and programmed with factory block format version 0.
0x0007	enum8, read-only	**PowerSource** Always set to mains-powered, single phase (regardless of the connected supply voltage)
0x0010	string, persistent	**LocationDescription**

---

[4] Only in Version 1.00. Later versions of R0 do not include the Identify server cluster any more. Other ubisys products include the client side of Identify for Finding & Binding.

ubisys

		Empty string by default. Might be set by commissioning software during installation
0x0011	unsigned8, persistent	**PhysicalEnvironment** **"Unspecified"** by default. Might be set by commissioning software during installation

Cluster commands supported:

Command	Description
0x0000	**Reset to factory defaults.** Restores the values of all attributes of all clusters across all endpoints to their factory fresh default settings. Does not affect network settings or bindings. Notice: In the current version, the command does actually behave like a leave command with factory reset. This will be fixed in a future release.

7.2.2. Identify Cluster (Server)

Attributes supported:

Attribute	Type	Description
0x0000	unsigned16	**IdentifyTime** The remaining time, in seconds, the device will be identifying itself. Notice that R0 currently does not provide any visual feedback in identify mode.

Cluster commands supported:

Command	Description
0x0000	**Identify** Puts the device into identify mode, or terminates identify mode.
0x0001	**Query Identify** Determines whether the device is currently identifying, and returns the remaining time if so.

7.2.3. Commissioning Cluster (Server)

This implementation supports all attributes and most commands. However, the cluster has limited value. It is rarely used and might be removed in the future.

7.2.4. Over-the-Air Upgrade Cluster (Client)

The image type for R0 is 0x7b0a. You may request the latest firmware in ZigBee OTA image format to upgrade devices in the field using your own OTA server and back-end. If you operate the Router R0 together with the ZigBee/Ethernet Gateway ubisys G1, the latest firmware for R0 will always be available automatically and you do not need to request it explicitly.
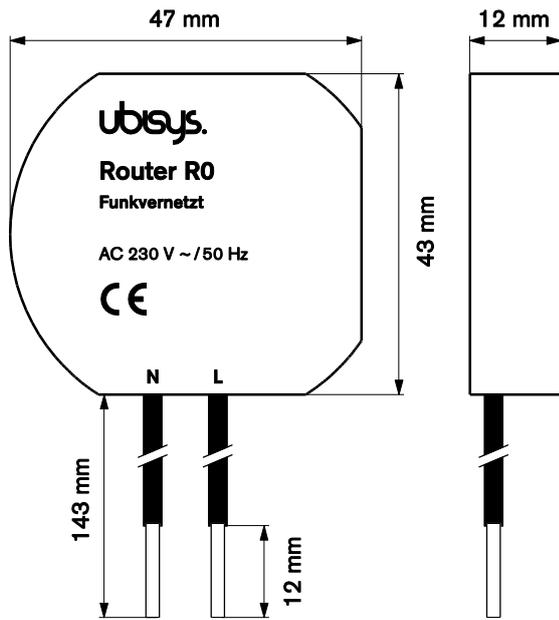
www.ubisys.de **ubisys.**

Figure 1: Flush-mounted In-wall ZigBee Router R0 – Dimensions

www.ubisys.de

9. Ordering Information

The following tables list the product variants available. Use the specified order code for your orders. Please contact ubisys support if you require any customization.

Order Code	Description
1182	ZigBee Router R0

The housing is flame retardant (V-0), Color: Black, RAL 9005.

ubisys.

When placing your order you agree to be bound by our General Terms & Conditions of Business, "Allgemeine Geschäftsbedingungen", which are available for download here:
http://www.ubisys.de/en/smarthome/terms.html

CE

We – ubisys technologies GmbH, Am Wehrhahn 45, 40211 Düsseldorf, Germany – declare under our sole responsibility that the ubisys ZigBee Router R0 with order codes as detailed in section 9 under the trade name "ubisys" to which this declaration relates are in conformity with the following directives and standards:

Directive/Standard	Description/Scope
1995/5/EC	Radio and Telecommunications Terminal Equipment Directive (R&TTE)
2004/108/EC	Electromagnetic Compatibility Directive (EMC)
2006/95/EC	Low Voltage Directive (LVD)
2002/96/EC	Waste Electrical and Electronic Equipment Directive (WEEE)
2002/95/EC	Restriction of Hazardous Substances Directive (RoHS)
EN 300 328	ERM; Wideband transmission systems; 2.4 GHz ISM band
EN 300 440	ERM; Radio equipment to be used in the 1 GHz to 40 GHz frequency range
EN 301 489	EMC
IEEE 802.15.4	IEEE Standard 802 – Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)
ZigBee	ZigBee PRO 2012 with latest additions and enhancements

Düsseldorf, Germany
Place of issue

November 14, 2014
Date of issue

Dr.-Ing. Arasch Honarbacht
Full name of Authorized Signatory

Managing Director, Head of Research & Development
Title of Authorized Signatory

Signature

Seal

Revision	Date	Remarks
1.0	11/14/2014	Initial Public Version
1.1	11/17/2014	**Added documentation about "ubisys2" QR**-code format and **note about issue with "ubisys1" check sum.**
1.2	11/24/2014	Announced support for ZigBee 3.0 via OTA upgrade. Added information about joining and rejoining behavior to start-up section. Added information about APS duplicate rejection table size.
1.3	01/06/2015	Includes documentation of ZigBee Network Steering **("EZ**-mode") in firmware revisions **1.01 and above.**
1.4	01/19/2015	Added a note about removal of Identify server cluster in firmware revisions 1.01 and above.

www.ubisys.de ubisys.

UBISYS TECHNOLOGIES GMBH
AM WEHRHAHN 45
40211 DÜSSELDORF
GERMANY

T: +49 (211) 54 21 55 - 00
F: +49 (211) 54 21 55 - 99

www.ubisys.de
info@ubisys.de