The *EIB*-Radio Frequency system

System description

and

Status report

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1. Summary

The European Installation Bus (EIB) is already widely accepted as bus system in functional buildings. Efforts of the member companies of the EIB association are now focussing on opening up and stimulating the private home market.

An EIBA expert group has developed an EIB Radio Frequency (RF) system, which is compatible to EIB Twisted Pair (TP) and EIB Powerline (PL).
Bosch Telecom has committed itself to system responsibility.

The development of RF as third transmission medium will contribute considerably to further establishing the position of EIB in the European market.

The EIB RF system is operated in a new frequency range, which in Europe was especially allocated to RF devices with limited transmitting power (868-870 MHz).

The bi-directional EIB RF system operates with a high data rate of 38.4 kbit/s and a limited transmission level of 5 mW, in order to reduce bus traffic and transmission errors.

Similar to EIB TP and PL, EIB RF also uses a bus access and telegram confirmation procedure.

In order to enhance system security, a special process called retransmission technique is applied.

First prototypes of RF bus devices are currently being tested. From mid of 1999 onwards series production will start.

2. Introduction

The transition from conventional single installations to bus systems mastering several building disciplines is rapidly progressing in Building System Engineering. The reason lies in the possibility to satisfy additional customer needs via synergies between individual building disciplines.
In this respect interoperability between heating, ventilation, security, lighting, shutters and even white goods is gaining momentum.

The basis of such system integration is on the one hand a bus system as uniform communication platform for all involved building disciplines on the other hand the bus components with compatible interfaces.

The "European Installation Bus" (EIB) was especially designed for building system engineering and is highly suited for system integration.
More than 100 leading companies of electrical installation material have joined hands in the EIB Association (EIBA), in order to promote the development of building system engineering.
More than 4.000 products have in the mean while been launched on the market. The uniform trademark EIB is the visible sign guaranteeing compatibility of products, thus setting a paramount condition for the joint success of EIBA and its members when establishing a standard in the market.

EIB is already widely accepted as bus system in functional buildings. Efforts of EIB member companies are concentrating on opening up and stimulating the private home market.

In order to achieve the highest degree of flexibility of the EIB system and particularly meet the requirements of the renovation market, in 1996 EIBA decided to start work on a third transmission medium next to Twisted Pair (TP) and Power Line (PL), namely EIB Radio Frequency (RF).
As a result a RF expert group was set up, which in the last two years and on EIBA's behalf has developed the future EIB RF system.
Bosch Telecom has agreed to take up RF system responsibility, to develop EIB RF components and supply the latter to other interested EIBA member companies.

3. General requirements for the EIB RF system

- The EIB RF system shall fully integrate into the logical EIB topology,
  - both as a stand-alone network
  - as well as a sub-network in a complex EIB system, operating together with TP and PL

- To recognise and detect collisions, the EIB RF system shall use a medium access protocol

- Particularly when using radio as a medium, communication reliability shall be guaranteed. In case of correct reception, a confirmation (ACK) shall be transmitted from the receiver to the transmitter

- It shall be possible to configure the EIB RF system both with the ETS, i.e. the EIB tool software (in case of complex systems) or with simple means, i.e. Easy Configuration (in case of stand alone RF systems)

- The RF EIB system shall allow the interoperabilty of EIB RF devices among themselves or between EIB RF and EIB TP respectively PL devices, by using the uniform data formats already standardised by EIBA.

- The EIB RF system shall use a data rate comparable to that of the EIB TP system

- The components of the EIB RF system shall be structured according to the open systems interconnection (OSI) model.

The realisation of an access procedure and the confirmation of reception respectively the transmission of status messages therefore oblige a bi-directional communication.

4. Choice of the Radio Frequency

In order to achieve a future proof RF system, which moreover fulfils market requirements, the radio frequency was selected with great care. The following aspects were mainly considered:

- high system reliability
- Costs and prices fulfilling market requirements
- Availability of the radio frequency throughout Europe.

As part of detailed feasibility studies, several frequency bands were investigated with regard to their suitability for a European bus system. Investigations especially concentrated on those bands, in which Short Range Devices (SRD) may be operated. The following bands were investigated:

- 40 MHz
- 433 MHz
- 870 MHz
- 2440 MHz.

After thorough investigation, the frequency bands 433 MHz and 870 MHz were taken into consideration.

4.1. Frequency band 433 MHz

The frequency band 433 MHz is today already used for many purposes. In addition to a multitude of SRD this band is also used by RF systems for industrial, medical and scientific purposes (ISM) as well as radio amateur stations (RA).

Unlike SRD, which may have a maximal radiated power of 10mW, ISM and radio amateur systems may radiate much more power. Radiated power of e.g. radio amateur systems can reach up to 750 W.

Not only the radiated power but also the transmission duration of all transmitters in this band has to be taken into account as source of interference. This band is for instance used by a multitude of audio equipment, which may be operated during several hours. Depending on the location, interference can arise, which either considerably disturb RF systems with low radiated power or even make them inoperative altogether.

4.2. Frequency range 868-870 MHz

The European Council for Post and Telecommunication (CEPT) has included the frequency range 868-870 MHz in the harmonised European Frequency Table and has reserved it exclusively as special frequency range for Short Range Devices. This frequency range is thus forbidden for ISM or radio amateur equipment.

To minimise the interference in this SRD frequency range, some important limitations for such radio frequency devices were defined. These include:

- Limitation of the radiated power for all users of the frequency range
- Limitation of the maximal transmission duration (Duty Cycle limitation).

The Duty Cycle indicates the total transmission duration of a device per hour. The frequency range 868–870 MHz is divided into several bands, in which different duty cycles are permitted. In this way, the coexistence of RF systems operating in this frequency range is also guaranteed in case of increased future use.

Table 1: Duty Cycles of universal SRD Bands in the Range 868 – 870 MHz

Duty-Cycle category	Abbreviation	Total transmission duration	Frequency range
Very low	VLDC	< 3,6 s/h	868,7 - 869,2 MHz
low	LDC	< 36 s/h	868,0 - 868,6 MHz
high	HDC	< 360 s/h	869,4 - 869,65 MHz
Very high	VHDC	≤ 3600 s/h	869,7 - 870,0 MHz

The longer the Duty Cycle, the higher the probability of interference.

The total transmission duration of most applications of the EIB RF system are so short that they may work in the band with the lowest interference probability, the Very Low Duty Cycle band. Only in exceptional cases it is necessary switch to the Low Duty Cycle band.

According to the responsible German regulation authorities the necessary admission rules will be passed next month, so that the first authorisations can be expected beginning 1999. This is also the case for other European countries.

For the reasons stated above, the EIBA expert group on Radio Frequency has decided in favour of the frequency range 868-870 MHz.

Even groups of other radio users like for example Automotive (radio-controlled car keys) or Telemetering (remote-controlled reading of the heating and energy consumption) have admitted the advantages of this SRD radio range and they will change from 433 MHz to 868 MHz for their future products.

5. Structure of the EIB radio frequency system

Both bands VLDC and LDC of the frequency range 868-870 MHz with a bandwidth of respectively 500 or 600 kHz were selected for the EIB RF system. The maximal permitted radiated power in these bands amounts to 25 mW and the duty cycle is limited to 0.1 or 1 % per hour respectively.

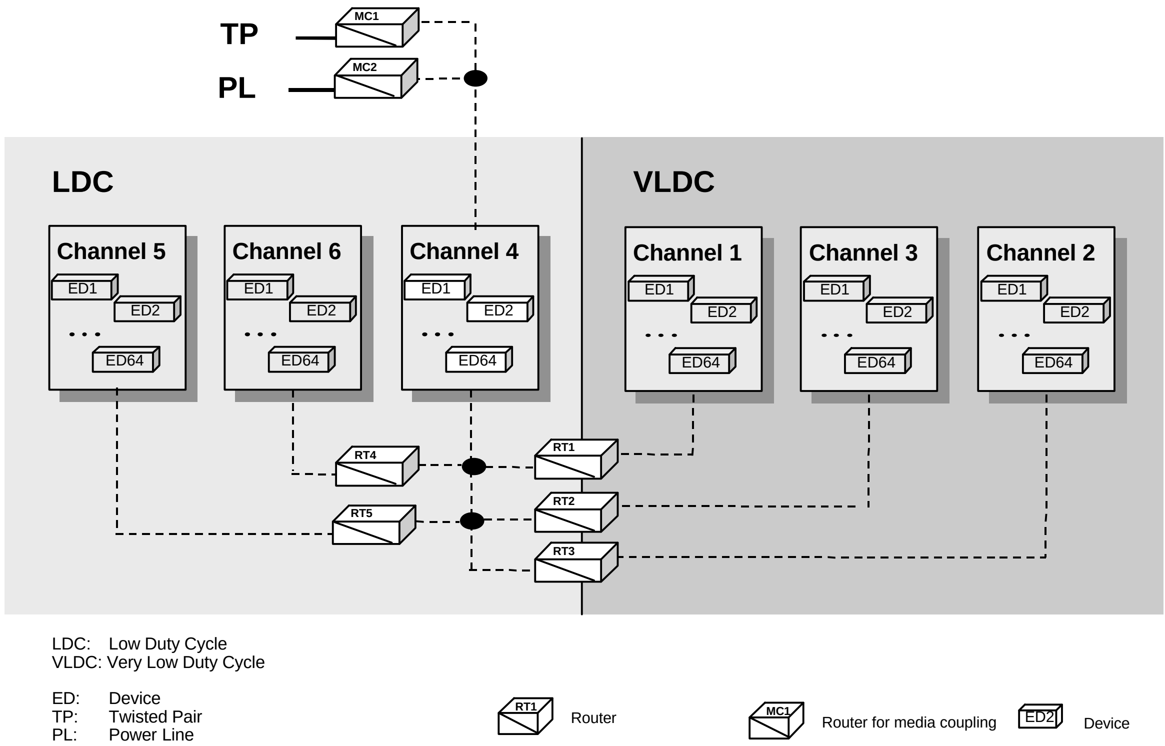

Fig. 1: Structure of the Radio System

The RF system shown in the figure 1 is compatible with the EIB topology (lines, line coupler, media coupler) and takes into account the EIB requirements listed in the paragraph 2.

- Similar to the EIB TP lines, 6 separate radio channels are available in a channel spacing of about 150 kHz. 3 of those channels are located in the VLDC band and another 3 in the LDC band
- Similarly to EIB-TP, each channel (line) may contain up to 64 RF devices
- Communication between different channels is ensured via a router (similar to line coupler in EIB-TP). In order to avoid unnecessary use of the radio medium, the routers also offer filter functions
- Media Couplers between RF/TP and RF/PL are used to integrate a RF subsystem into an EIB network.

6. Parameters of the RF EIB system

- Frequency band: 868.0-868.6 MHz (LDC)
  868.7-869.2 MHz (VLDC)
- Frequency of the centre channel: VLDC band: 868 953.6 kHz
  LDC band: 868 339.2 kHz
- Effective radiated power (ERP): < 5 mW
- Data rate on the medium: 38,4 kbit/s

- Sensitivity of the receiver: < -95 dBm
- Communication range: > 100 m (free field)
- Change direction duration: < 1.5 ms (transmission mode ↔ reception mode)
- Media access control: CSMA/CD
- Confirmation of reception: -direct ACK in case of individual addressing
  - indirect ACK in case of group addressing.

7. Aspects regarding system security

During development of the EIB RF system, special attention has been applied to communication reliability.

Due to the attenuation, which depends considerably on the location and intermittent interference, a reliable transmission for an open medium such as ”radio” can not be ensured without additional arrangements.

As a consequence, a communication protocol with subsequent confirmation of reception (acknowledgement) is indispensable for the EIB RF system.

Generally in EIB systems a distinction shall be made between a transmission from one source device to only one destination device (point to point) and a transmission from one source device to a group of destination devices at the same time (point to multi point).

7.1. Acknowledgement in case of a Point to Point Communication

In a point to point communication the destination device, as depicted in figure 2, sends back an acknowledgement immediately after correct reception of the message (immediate ACK).

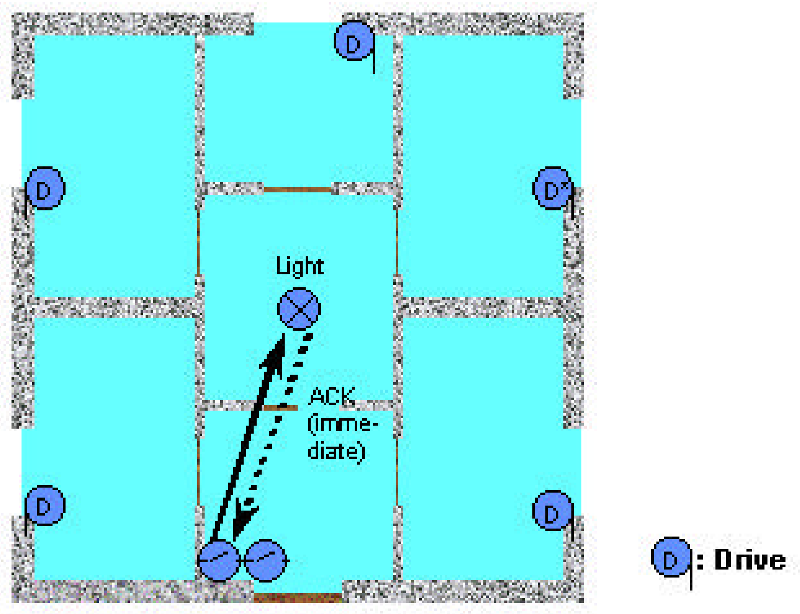

Fig. 2 : Immediate Acknowledgement

7.2. Acknowledgement in the Point to Multi Point Communication

An immediate acknowledgement of all destination devices in case of a point-to-multi-point transmission is not possible in the radio medium for the following reasons:
A simultaneous transmission of acknowledgements would inevitably lead to collisions
Consecutive acknowledgements from all addressed devices in a group would lead to a long-time use of the channel; it would moreover constitute a considerable effort during each commissioning process of EIB RF systems.

As part of the development of the EIB RF system, a special technique has been worked out. It minimises the influences of location dependent attenuation and intermittent interference of the medium. At the same time it enables a procedure for the acknowledgement of group addressed messages. This procedure is called Retransmitter Technique.

8. Retransmitter-Technique

In the Retransmitter Technique a device configured as retransmitter receives the message and immediately repeats it. The message repeated by a retransmitter can in this way also reach EIB RF receivers in locations, which can not be directly reached with high reliability by the initiating RF transmitters.

Since the message is sent out several times consecutively, a higher probability for a correct reception is guaranteed.

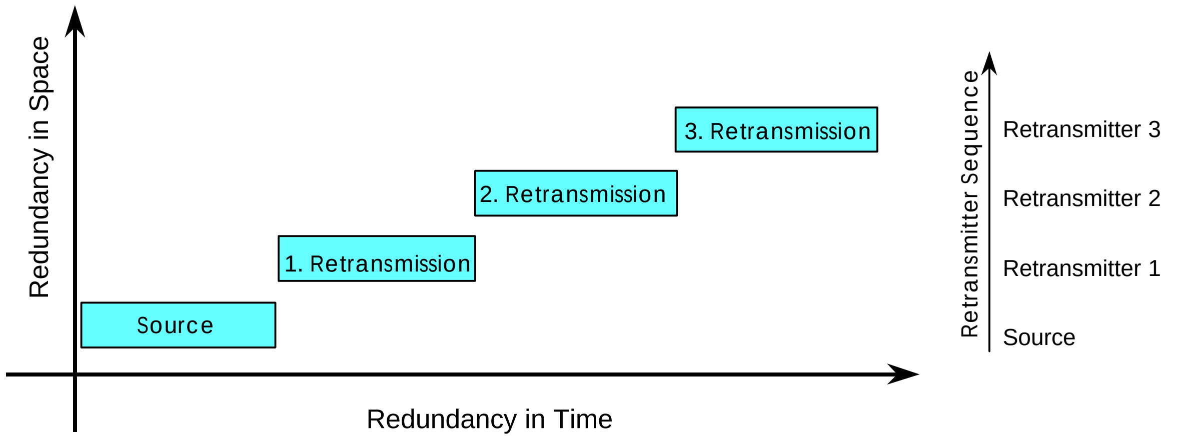

Fig. 3: Example of Communication with Redundancy in Time and Space using Retransmitter Technique

The Retransmitter Technique guarantees both redundancies in space and time as shown in the example in figure 3.

Every EIB RF device (transceiver) can act as a retransmitter in addition to its normal functions. For this, the retransmitter functionality is attributed to the EIB RF device at the time of configuration.

An additional device assuming retransmitter functionality is therefore not required.

Each EIB RF line may contain up to three devices with retransmitter function.

The following figures 1a and 1b depict an example for the use of Retransmitter Technique including the acknowledgement for group-addressed messages.

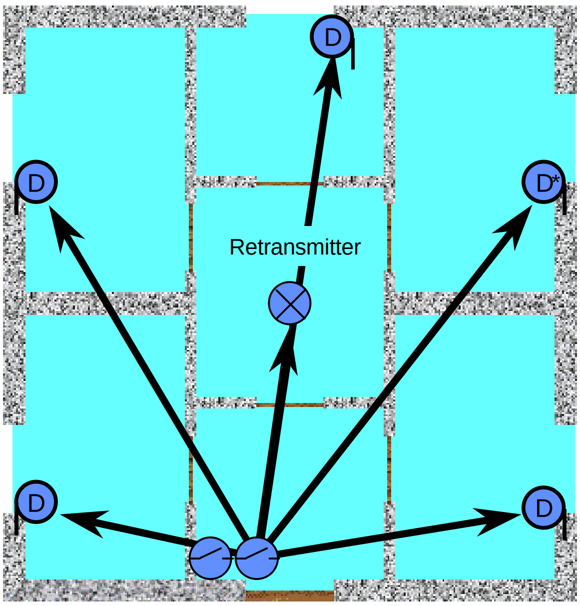

Fig. 1a: request transmission

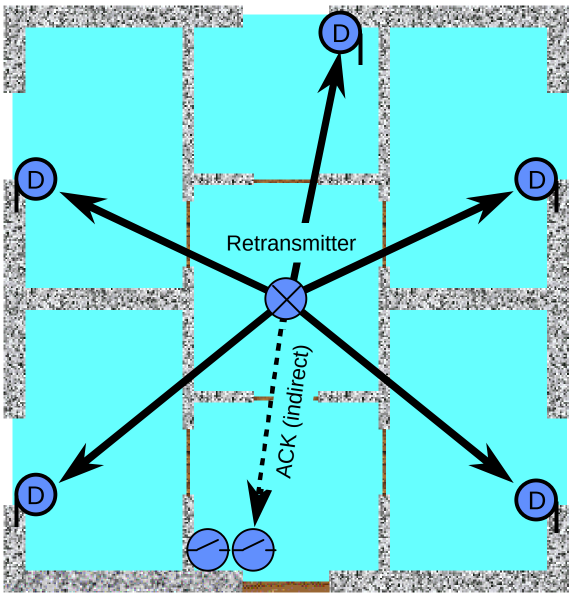

Fig. 1b: Retransmission and Acknowledgement to the sending device

The sensor (e.g. a push button) sends the message once (figure 1a). All devices including the light (that is configured as a retransmitter) receive this message. As shown in figure 1b the retransmitter repeats the entire message so that all devices receive the message once again via an additional transmission way.

The transmitting device receives the signal sent out by the retransmitter and interprets it as an acknowledgement. For the transmitting device the retransmission is a guarantee that the message has been received correctly by at least one EIB RF device and that the message has been transmitted at least twice without interference.

9. Configuration of an EIB RF System

The EIB RF system is put into operation using the same configuration procedure as for all EIB media, i.e. the EIB tool software (ETS).

Version 1.2 of ETS2, which will be available in 1999, will also be suitable for the configuration of EIB RF systems. As regards RF, the new ETS will support the following additional features:

- Choice of the radio frequency channel
- Supervision of the duty cycle
- Acknowledgement from the retransmitter in case of group addressing
- Supervision of the type and status of the power supply.

Compared to EIB twisted pair and EIB power line, the electrician will not notice any substantial changes as regards planning and configuration, since:

- The EIB RF system is in line with the logical EIB topology
- The supervision of the duty cycles and the frequency channel is largely automated by ETS.

In addition a new method, called Easy Configuration, will enable the configuration of small EIB RF systems without the use of a PC with ETS.

The conception of this method particularly focuses on a simple and economical configuration.

10. Frame Structure and addressing

The frame structure used in the EIB RF system is shown in the figure 5.

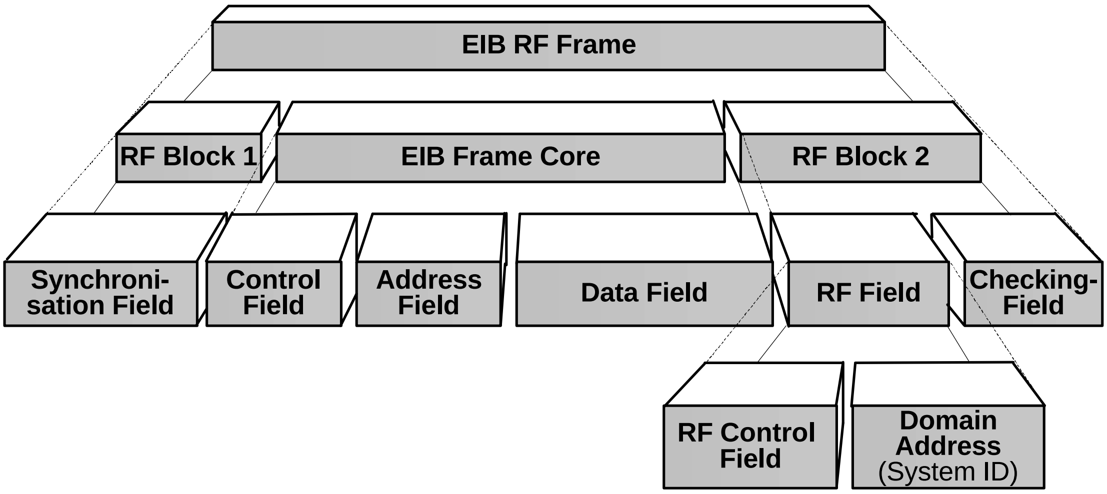

Fig. 5: Frame Structure of the EIB RF System

The EIB RF data frame starts with a RF specific synchronisation field. It is followed by the EIB frame block, which is identical to the EIB data frame in EIB twisted pair and power line systems. The following RF block is composed of a RF specific control field and a domain address (system ID).

Similar to EIB twisted pair and power line systems, a checking field verifies the consistency of the EIB RF frame.

11. Structure of the EIB RF Components

The basic structure of an EIB RF component is shown in the figure 6. Its structure is identical to the structure of EIB twisted pair bus devices. In principle a bus component is composed of a RF bus coupling unit and an application module.

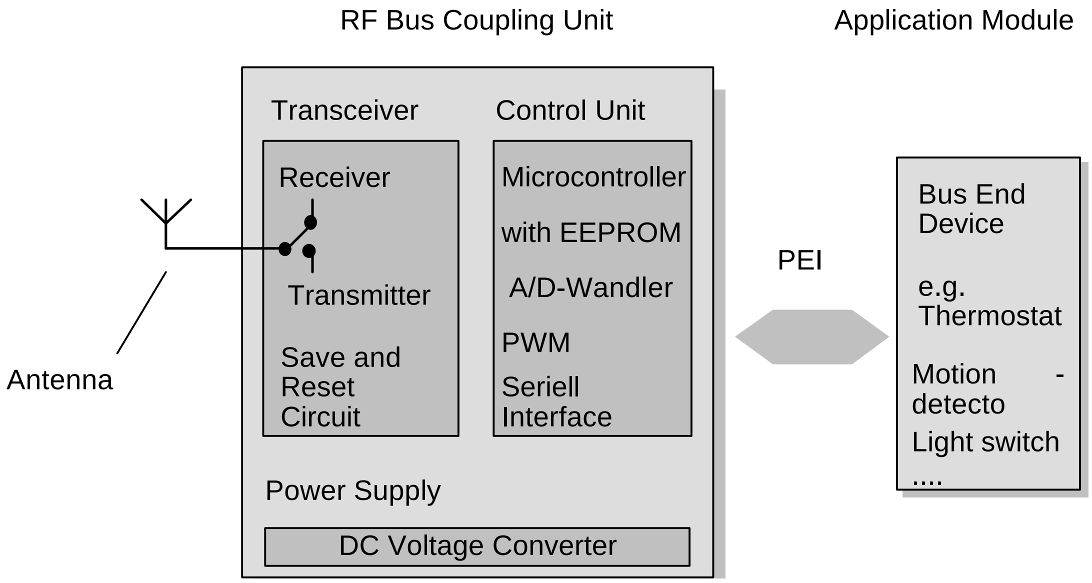

Fig. 6: Structure of an EIB RF Bus device

The EIB RF bus coupling unit consists of a transceiver and a control unit with micro-controller. Basically the transceiver contains the transmitting and the receiving stage for the radio medium. It is equipped with an antenna, which is optimised to the housing design. The antenna is used to send and receive. It is switched between sending and receiving mode with the help of an antenna switch. From the battery or from a mains power supply unit the DC voltage converter generates a supply voltage of 5 V.

12. The first EIB RF Bus Devices

All EIB RF devices are compatible with BCU2 and are equipped with the EIB standardised physical external interface (PEI).

12.1. EIB RF Bus Coupling Unit for the Flush Mounting

For flush mounting, two power supply versions are developed:

- EIB RF bus coupling unit with 230V mains supply
- EIB RF bus coupling unit with 3V battery supply.

The figure 7 shows the housing design of the EIB RF bus coupling unit for flush mounting.

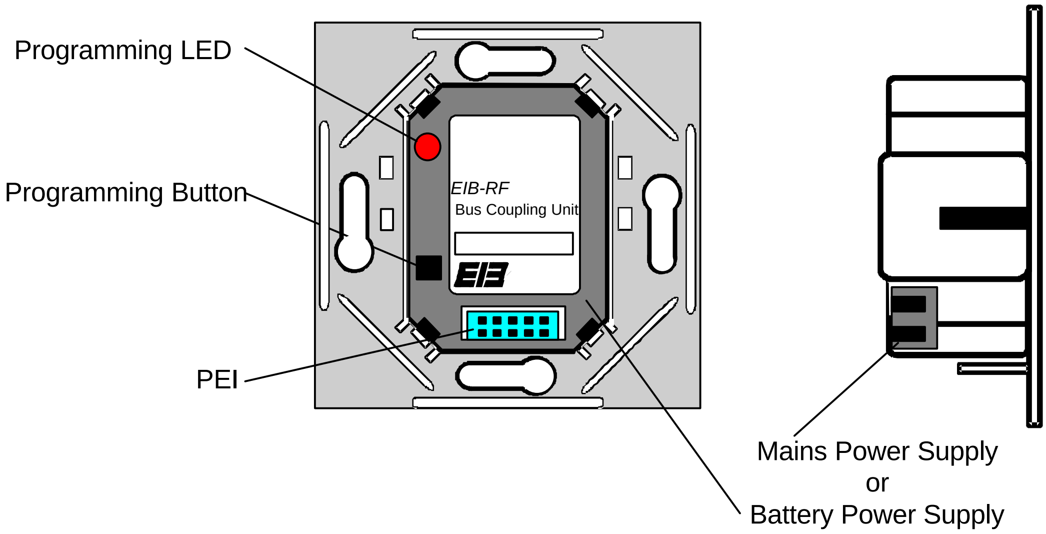

Fig. 7: EIB RF Bus Coupling Unit for Flush Mounting

Mechanically and electrically both versions ensure that application modules originally designed for the twisted pair medium and their corresponding software can principally be reused. In line with the general EIB installation philosophy, the different applications are mounted on the PEI.

In order to guarantee a long life time of at least 5 years for the battery supplied version, it is however recommended to use only applications that can be switched to energy-saving mode.

The RF bus coupling unit with mains supply is connected via connection clips on the lateral sides.

In the version with battery supply the battery is installed in such a way that it can be easily replaced from the front and without the removal of the RF bus coupling unit.

12.2. EIB RF Router for Media Coupling

The router for media coupling is realised by combining a twisted pair control unit with an EIB RF bus coupling unit in a ”DIN rail” housing. Similarly to the usual ”EIB DIN rail” design, energy supply is ensured by the EIB twisted pair contact block. The ”DIN rail” housing design of the EIB RF bus coupling unit is shown in the following figure.

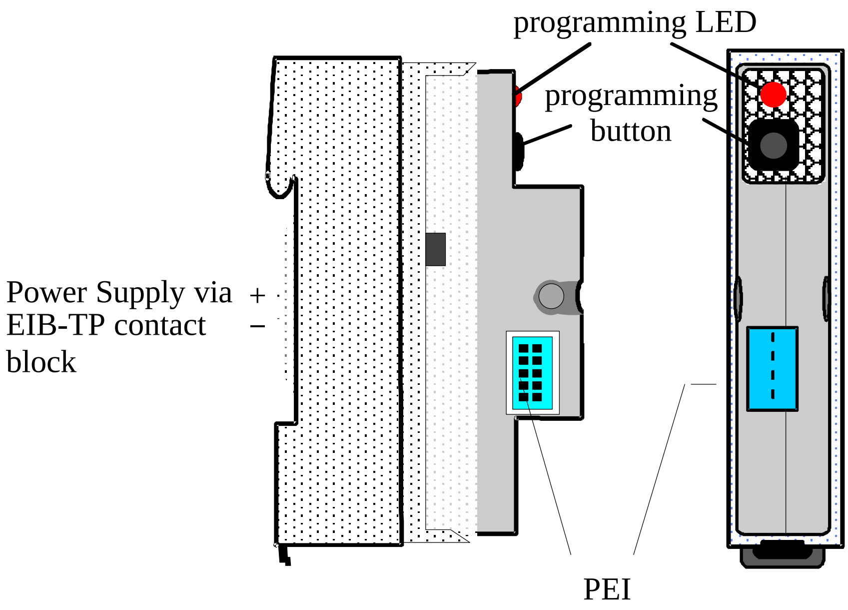

Fig. 8: "DIN rail" EIB RF Bus Coupling Unit

12.3. EIB RF Bus Coupling Unit as a Built-in Module

In order to integrate devices with several housing designs into EIB RF systems, a built-in module is being developed. The energy supply of this module is ensured via low voltage connectors.

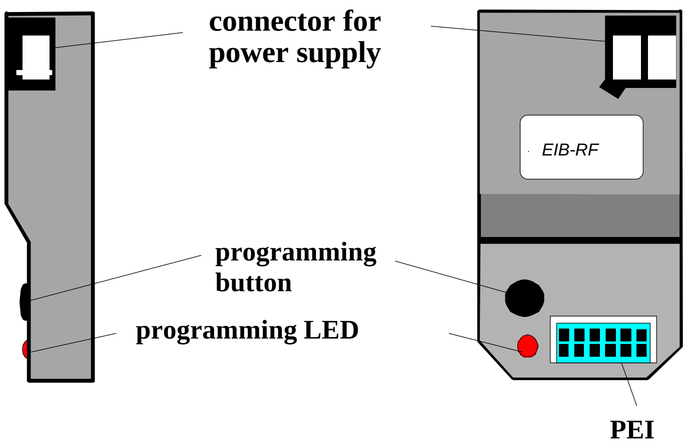

Fig. 9: "Built-in" EIB RF Bus Coupling Unit

13. Milestones and Outlook

The conception phase as well as the specification phase for the EIB RF system have been finalised.

The development of the EIB RF devices mentioned in chapter 11 is going on and is in good progress.

The first prototypes are at present under test.

From the middle of 1999 first EIB RF devices will be available on the market.

Therefore the medium RF will be available for the EIB system from the middle of 1999.

The EIB RF system will bring a considerable contribution to the private home market, and in particular the renovation market segment.