

Radio solutions from Beckhoff for industrial applications

Alternatives to wiring: WLAN or IEEE 802.15.4

One of the main aims of automation technology is to minimize equipment installation efforts and costs while achieving ideal system performance. Radio technology enables more cost-effective solutions for expensive installations and maintenance due to slip rings, trailing cables or difficult terrain, particularly when moving parts are involved. Beckhoff offers industrial products for such applications in the form of the KM6551 wireless data exchange terminal and the CU8890 USB to WLAN adapter.

Radio technology basics

Radio technology utilizes electromagnetic waves transmitted and received through antennas for transferring information. The transfer takes place in different frequency ranges (Fig. 1).

Frequency usage

Different frequencies have different propagation characteristics. The following applies:

- | the higher the frequency, the higher the attenuation (= poorer propagation)
- | the higher the bandwidth, the more data can be transferred.

The task, therefore, is to strike a balance between good propagation characteristics and high data rate (= bandwidth).

The frequency usage is subject to different regulations in different countries. There are fixed bands for TV, radio, licensed radio, amateur radio, GSM etc. Unfortunately, no dedicated frequency band has been specified for automation, although there are approved ISM (industrial, scientific and medical) bands (see table).

Historically, different countries specified different usage permissions for different frequencies. The only global frequency band with a relatively wide bandwidth (approx. 80 MHz) and acceptable propagation characteristics is the 2.4 GHz band.

While the utilization of frequencies in ISM bands is generally free of charge, it is subject to certain conditions (including max. transmission power and radiated emissions in other bands), for which the system must be certified. These conditions are regulated through country-specific legislation and stan-

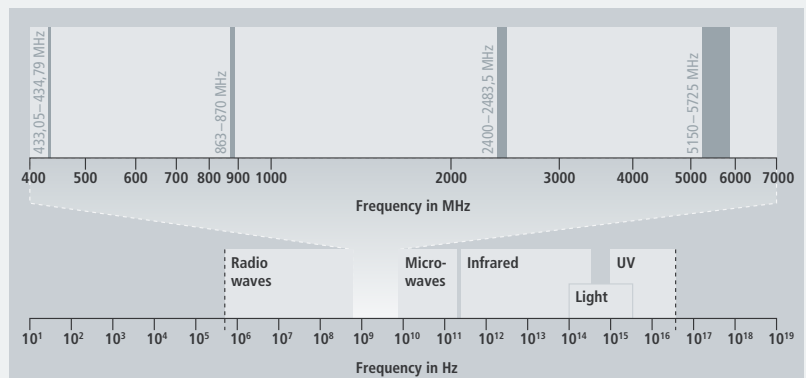


Figure 1: Frequency bands in the electromagnetic spectrum that can be used without a license (Source: ZVEI)

| Important ISM bands and their applications | | |
|--|------------------------------------|----------------------------|
| Frequency in MHz | Application examples | Notes |
| 433 | car keys, alarm systems | primary amateur radio band |
| 2400–2485 | WLAN, Bluetooth, IEEE 802.15.4 | worldwide |
| 5.18–5.32 + 5.5–5.835 | WLAN | |
| 868** | domestic weather stations, EnOcean | duty cycle* |

* Duty cycle = band utilization and is restricted on a time basis, e.g. transmission is permitted during 1% of the time.

** no ISM, but approved in the EU for general utilization for short-range devices (SRD)

| Radio technologies and their characteristics | | | | | | |
|--|------------------|------------|-----------------|--------------------|--------------------|-----------------|
| System | Frequency in MHz | Modulation | Data rate | Transmission power | Energy consumption | Topology |
| WLAN 802.11b | 2400 | QAM/DSSS | up to 11 Mbit/s | 100 mW | high | PtP, star |
| WLAN 802.11g | 2400 | QAM/OFDM | up to 54 Mbit/s | 100 mW | high | PtP, star |
| WLAN 802.11a | 2400 + 5500 | QAM/OFDM | up to 54 Mbit/s | 100 mW* | high | PtP, star |
| IEEE 802.15.4 | 2400 | QAM/DSSS | 250 kbit/s | 10 mW SRD | low | PtP, star, mesh |
| EnOcean | 868 | ASK | 125 kbit/s | 10 mW SRD | very low | PtP, star |

* in special cases up to 1,000 mW, based on the IEEE 802.11 a+h standard

dards (in Germany the relevant authority is the Federal Network Agency [BnetzA = Bundesnetzagentur]).

Radio technology

Different radio technologies are available for transferring data in frequency bands, which differ in terms of modulation technique (data rates), transmission power (ranges), energy consumption etc.

Automation engineers tend to meet their requirements with existing technologies (e.g. RS232) or adaptations (EtherCAT based on Ethernet physics). This also applies to radio technology, which usually utilizes components of WLAN, IEEE 802.15.4, Bluetooth, GSM/GPRS/UMTS, 868, EnOcean or proprietary technologies. The systems can roughly be divided into three groups:

- | developed for the office world: WLAN, Bluetooth
- | developed for automation/building services: IEEE 802.15.4, EnOcean
- | general: 868 MHz, 433 MHz, 2.4 GHz proprietary

The technical components can be described based on the OSI/ISO layer model. Committees such as IEEE or ETSI usually define PHY and MAC layers, and chip manufacturers then develop different radio chips based on these specifications. The upper protocol layers are defined by interest groups such as the ZigBee Alliance. Mutual compatibility is often a key requirement.

| OSI layer | CU8890 | KM6551 | ZigBee | |
|-----------------------------|----------------------|---------------------------|--|----------|
| Application | Remote Desktop, HTTP | PLC program | Definition of profiles through the ZigBee Alliance | Software |
| Presentation | | | | |
| Session | | | | |
| Transport | TCP/UDP | | | |
| Network | IP | KM6551 master | ZigBee protocol stack | |
| Media access control | IEEE 802.11 | IEEE 802.15.4 | IEEE 802.15.4 | Hardware |
| Physical (bit transmission) | IEEE 802.11 b/g | IEEE 802.15.4 for 2.4 GHz | IEEE 802.15.4 for 2.4 GHz | |

WLAN for Industrial PCs

With the proven WLAN standard according to IEEE 802.11 b/g, the CU8890 offers a solution that is compatible with all common WLAN access points. It therefore enables access to existing infrastructure networks. Any Beckhoff Industrial PC with a USB port can be used as a WLAN client.

The CU8890 industrial WLAN controller supports WLAN based on the IEEE 802.11 b/g standard and is designed for control cabinet installation. In conjunction with a Beckhoff Industrial PC, the module can be used as an access point and as a client.

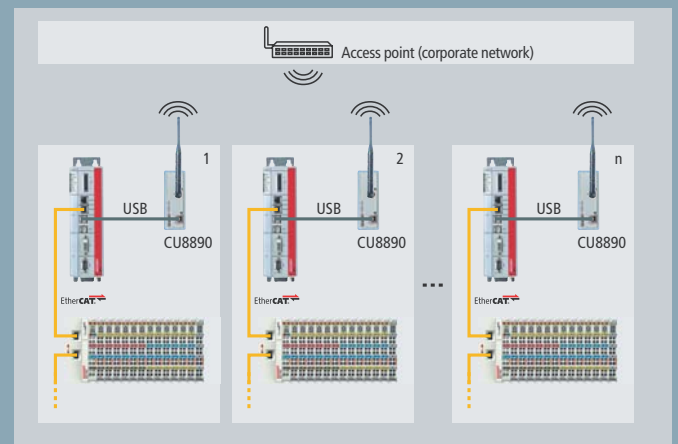
Client drivers are available for Windows XP, XP Embedded and Windows CE, and therefore for any Beckhoff Industrial PC and Embedded PC. They also support the Adhoc mode. With the drivers for Windows XP and XP Embedded, the CU8890 can also be operated as an access point.

Encryption mechanisms are possible with AES 128-bit up to WPA2. The module is Cisco-CCX-compatible and supports PEAP and LEAP. The data rate is adjusted dynamically up to 54 Mbit/s (gross).

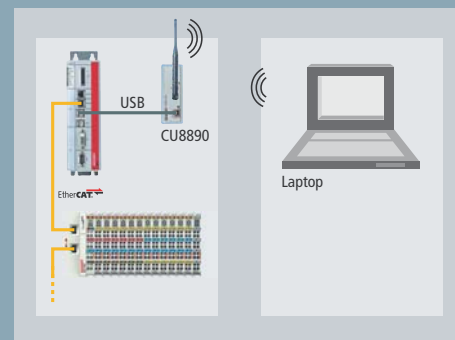
The CU8890 has a reverse SMA plug, to which various radio antennas can be connected. The free choice of aerial enables adaptation to the respective environment. Beckhoff offers a wide range of accessories, including antennas and cables.

Depending on ambient conditions, the free-field distance between two CU8890 modules may be up to 300 m (984 ft). 11 channels in the 2.4 GHz band are available for selection. The status and data transmission are displayed via LEDs, enabling fast and convenient diagnostics.

CU8890 as client

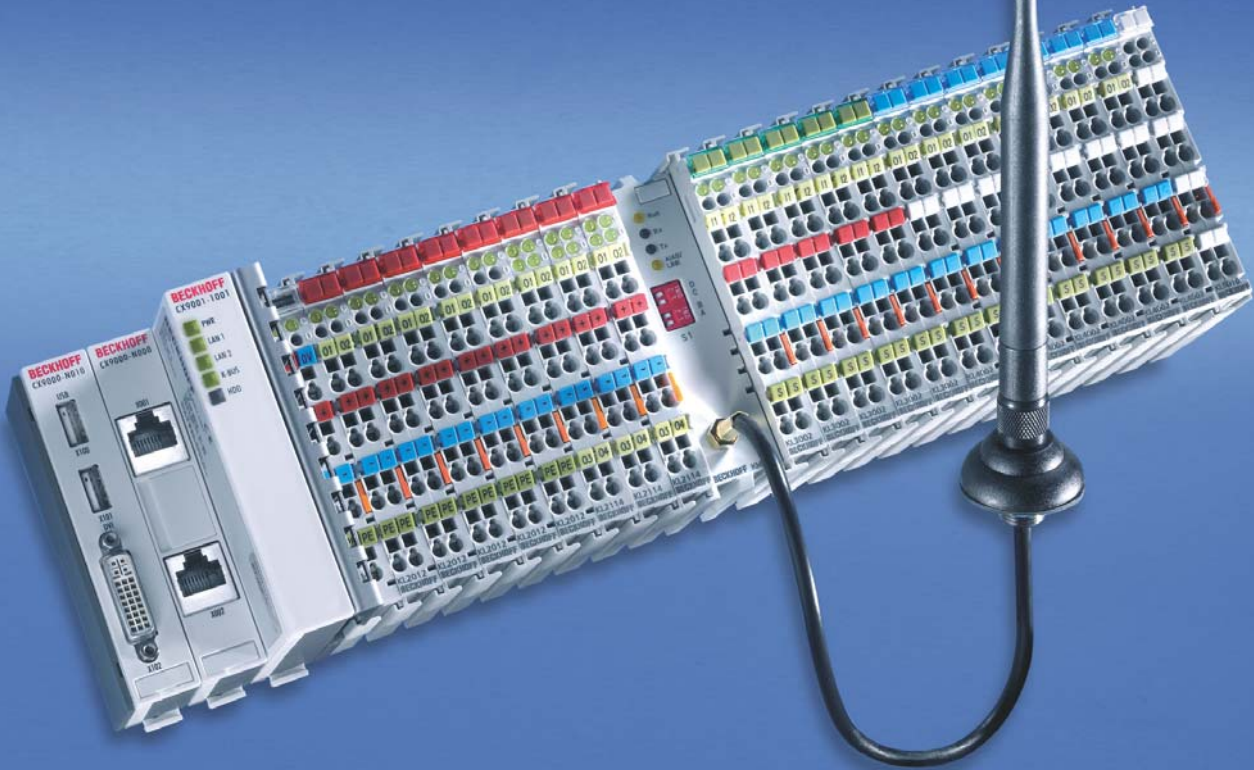


CU8890 as access point



With the CU8890 WLAN controller, any data based on UDP/TCP/IP can be transferred. UDP/TCP/IP = Remote Desktop, http, Publisher/Subscriber via UDP/TCP, etc. (real-time Ethernet and EtherCAT are not possible).

Data exchange via radio with KM6551



The KM6551 data exchange terminal for the Beckhoff Bus Terminal system uses a solution based on basic, standardized technology (IEEE 802.15.4) that offers good physical conditions with 16 independent channels and the DSSS (Direct Sequence Spread Spectrum) frequency spreading technique for wire-

less data communication. A proprietary, fast protocol was developed and adapted to automation requirements. Communication is only possible among KM6551 terminals. The ZigBee protocol is not supported.

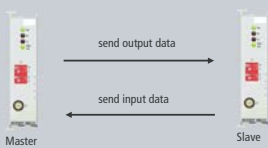
Data is exchanged or transmitted between two independent controllers via radio, independent of the higher-level fieldbus. The free-field distance between two KM6551 units can be up to 300 m (984 ft).

The data exchange module has a reverse SMA plug (Straight Medium Adapter), to which different radio aerials can be connected. The free choice of aerial enables adaptation to the respective environment. 16 channels in the 2.4 GHz band are available. Status and data exchange are displayed via LEDs, thereby offering fast and simple diagnostics. A library for the use of the KM6551 module is available with TwinCAT.

The automation industry requires deterministic, fast communication. For radio systems this is topology-dependent. With the KM6551 Bus Terminal, Beckhoff offers a cost-effective and high-performance option for establishing PTP, star and broadcast configurations via radio. Thanks to the large number of more than 300 available Bus Terminals and the simple configuration via the TwinCAT System Manager, a wide range of signal types can be conveniently transferred in a 10-byte process image. Transfer of safety-relevant data via TwinSAFE Terminals is also possible.

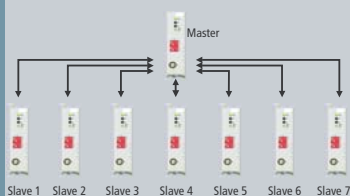
Several configuration examples are shown below.

Option 1 | Data exchange peer-to-peer

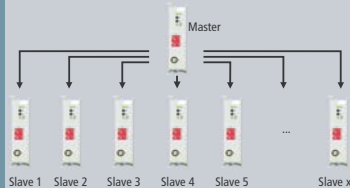


Operating modes for the KM6551 data exchange terminal: point-to-point, point-to-multipoint (star), broadcast

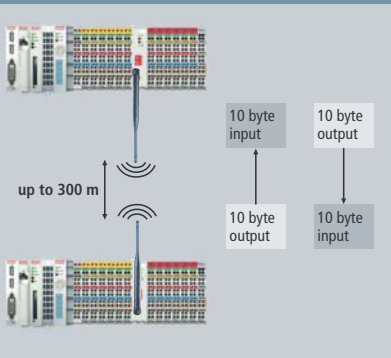
Option 2 | Data exchange up to max. 7 devices



Option 3 | Broadcast up to x devices

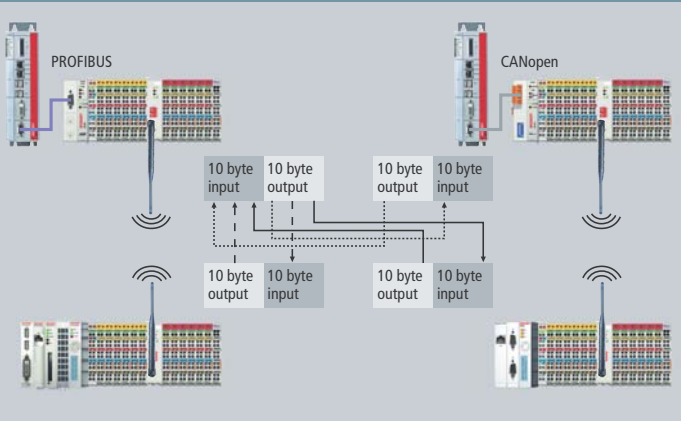


KM6551: Master/slave function



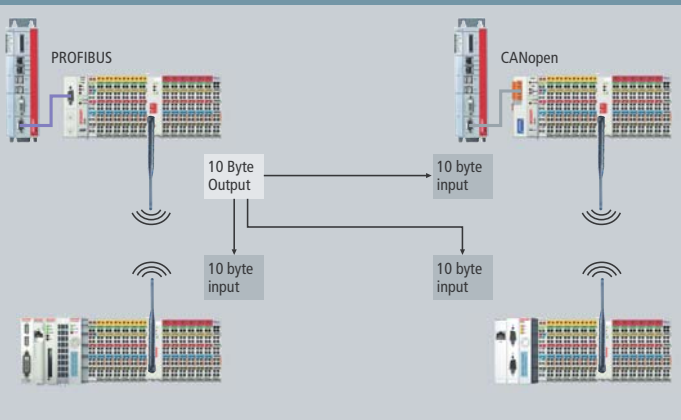
Cyclic exchange of 10 byte input and output data packages. The complete exchange takes 20 ms.

KM6551: Master function with up to 7 slaves



Cyclic exchange of 10-byte input and output data packages with up to seven slaves. For each slave the complete exchange takes 20 ms. The slaves can be addressed by the master from the PLC. The communication sequence can thus be programmed from the PLC.

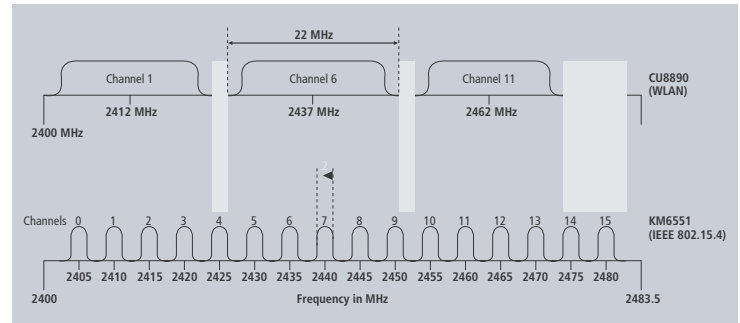
KM6551: Broadcast function



In broadcast mode, the master sends new data to all broadcast slaves every 10 ms. Unlimited number of broadcast slaves

Coexistence – simultaneous operation of radio systems

Simultaneous operation of two radio systems at the same frequency and in the same location can lead to interference. In order to prevent this, most systems have several separate transmission channels (e.g. WLAN and IEEE 802.15.4), so that the user can operate the systems in parallel.



Parallel operation of CU8890 (WLAN) and KM6551 (IEEE 802.15.4)

With the KM6551 and CU8890 products, the channels can be set freely so that several systems can be operated in parallel at the same time. The 11 WLAN channels overlap, which means that only channels 1, 6 and 11 can be operated in parallel. The KM6551 channels will then slot into the free frequency ranges for parallel operation.

Other radio products

The Beckhoff KL6023 EnOcean receiver has been available for some time and works in conjunction with EnOcean products, which function without batteries or wired electricity. The EnOcean switches and sensors etc. obtain their energy from temperature differences, switch pressure or illuminance and are ideal for buildings, since no wiring is required. Thanks to the modularity and flexibility of the Beckhoff system, different radio systems such as RFID readers can be integrated with interfaces such as RS232 or Ethernet.

Approvals and accessories

The CU8890 and KM6551 products with Beckhoff accessories are approved for the EU, Switzerland and Liechtenstein. Certifications for additional countries will be added in the future. Beckhoff offers a wide range of accessories including antennas and cables in order to permit optimum application of the products (including installation in control cabinets).

Outlook

With the KM6551 and CU8890 products, Beckhoff offers options for flexible system configurations and cost reductions. The challenge for radio products is to not only offer suitable radio technology and a suitable protocol, but also seamless integration with the world of automation. This is what Beckhoff offers through integration in the TwinCAT System Manager and flexible configuration options.