

Smart home and building solutions. Global. Secure. Connected.

# KNX RF development with Weinzierl solutions

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# WEINZIERL







# Agenda

- About Weinzierl
- KNX System Overview
- KNX RF with ETS
- KNX BAOS Modules
- KNX Stack NGS
- Demo with Net'n Node









# **Weinzierl Engineering GmbH**

- Founded 2001
- Burgkirchen / Alz
  - South East of Germany
- System solutions for KNX
  - KNX Stacks & Modules
  - KNX Development Tools
- Testing
  - KNX accredited Test Lab
- Production
  - KNX Devices









# **KNX RF History**

- Since 2002
  - Medium RF specified
  - Mainly for Easy Mode, no ETS
  - Only a few manufacturers
- Since 2014
  - For System Mode
  - Now in-line with TP & IP
  - Fully integrated in ETS
- Since 2017
  - KNX Security
  - Growing number of products









# **Application Area**

- KNX wireless devices
  - Sensors
  - Actuators
  - Remote control
  - ...
- RF-only Installations
  - Renovation market
- Hierarchical Installations
  - RF combined with TP and IP
  - In one ETS project





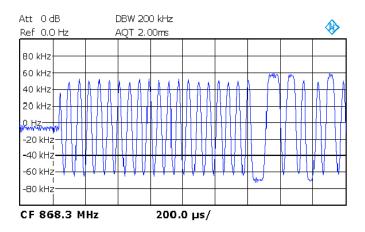






# **KNX Radio Frequency - RF**

- Short range device
  - ISM Band 868 MHz
  - FSK Modulation
- Good range within buildings
  - Very reliable
  - No Mesh required
  - Re-transmitters possible
- No dedicated KNX transceiver required
- Low cost production

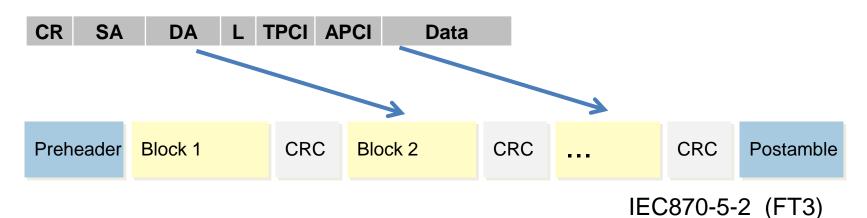








# Frame format KNX RF ready



- KNX Data in FT3 block format
  - Preheader 176 chips
    - First block 10 bytes (fixed length), RF specific (SN / DoA)
  - Further blocks 16 bytes (variable length), KNX telegram
  - Last block
    - CRC 2 bytes CRC after each block
  - Postamble

2 to 8 chips, end of frame

1 to 16 bytes







# **Addressing Modes**

#### Destination Address on KNX TP

Destination	n Address	Addressing Mode
IA	DAF = 0	Individual Address
GA	DAF = 1	Group Address
GA = 0x0000	DAF = 1	Broadcast

#### Destination Address on KNX RF

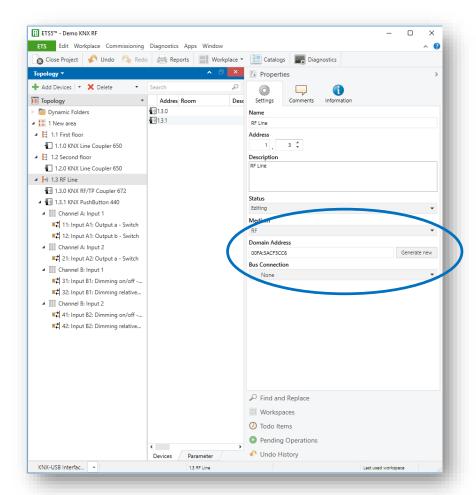
Block 1	Block 2, De	st. Address	Addressing Mode
SN	GA	DAF = 1	Ext. Group Address (PB Mode)
DoA	GA	DAF = 1	Group Address
DoA	IA	DAF = 0	Individual Address
DoA	GA = 0x0000	DAF = 1	Broadcast
SN	GA = 0x0000	DAF = 1	System Broadcast





# ETS & RF

- What's new
  - Lines for RF
  - Domain addresses
  - Connection via USB / RF Interface
  - RF / TP Coupler
- What's unchanged
  - Group Objects
  - Group Addresses
  - Parameters
  - Download

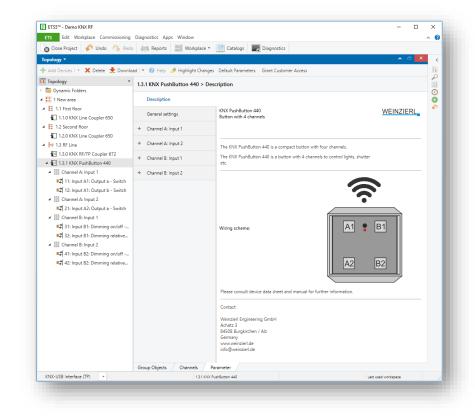






#### **ETS – Group Objects & Parameters**

- Group Objects
  - Linked via group addresses
  - Configured by flags
- Parameters
  - Device configuration
  - Set in parameter dialog
- Download
  - Via KNX network
  - Via USB / RF Interface
  - Via TP and RF / TP Coupler
  - Local USB connection







# **Topology: RF-only Installation**

- Minimal RF Setup
  - KNX RF Devices
    - 2..255
  - KNX Interface to PC
    - USB, optional
    - For commissioning only



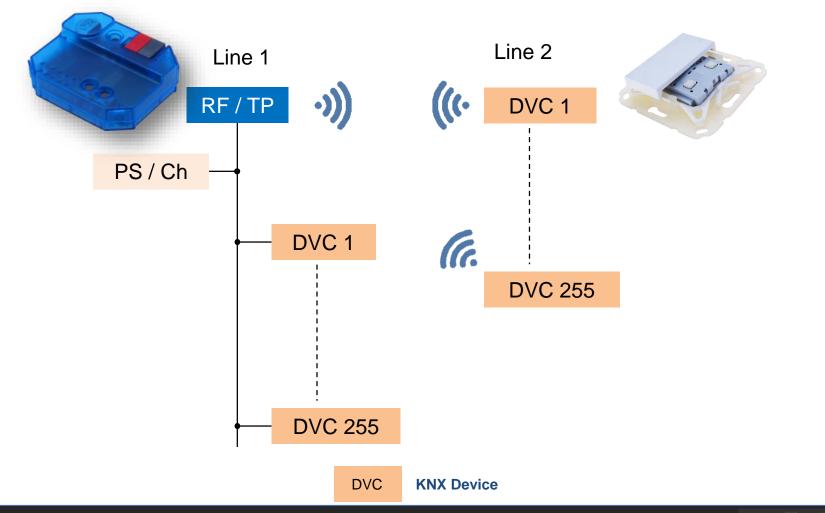








#### **Topology: TP line + RF line**





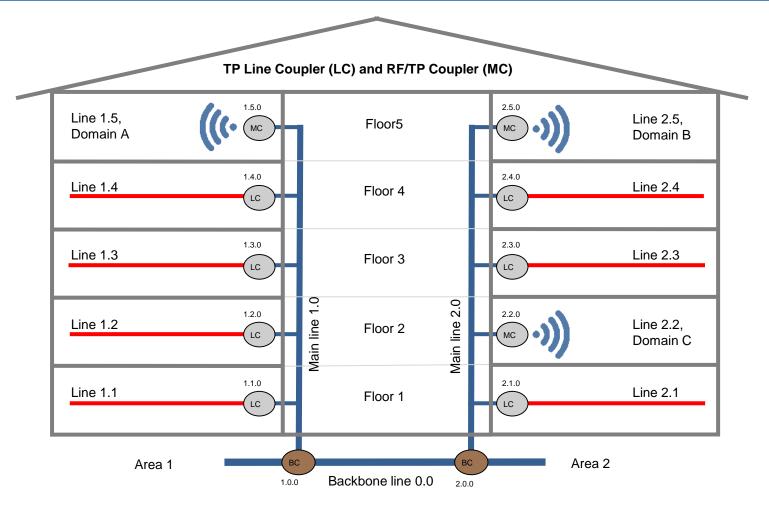




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#### **Topology: Structure in building**



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#### Further aspects about KNX RF

- Semi-bidirectional devices
  - For battery driven sensors
  - Bidirectional for commissioning
  - Unidirectional during runtime
- Segment coupler
  - Extend TP line with RF/TP Coupler
- Secure Proxy
  - Connect secure and unsecure segments





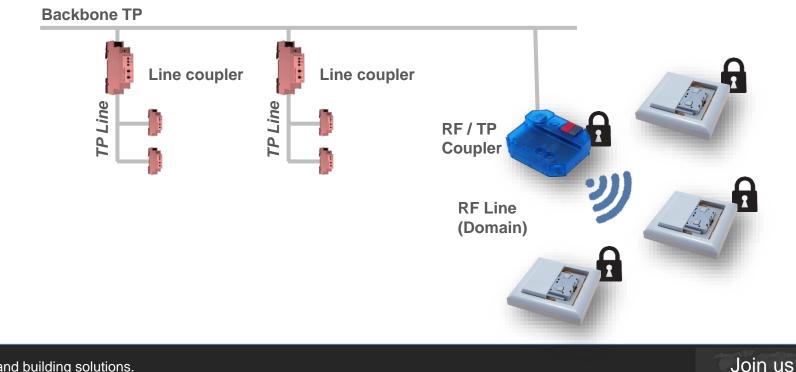




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# **Mixing secure and non-secure Communication**

- Security per link
- Security in sub-systems
  - KNX Secure Proxy
  - Supported by ETS







# **KNX Security**

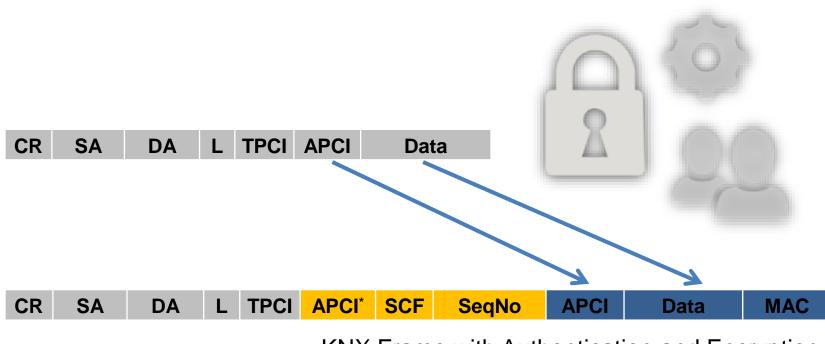


- Based on standard security technologies
- Based on AES
  - Advanced Encryption Standard
  - Block length: 128 bits
  - Key length: 128 bits
- Challenge: KNX System aspects
  - E.g. group addressing





#### **KNX Data Security: Frame Format**



KNX Frame with Authentication and Encryption







# **KNX Data Security: Keys & Counters**

- FDSK (Factory default setup key)
  - Set by manufacturer, shown as QR-Code
  - Reactivated after master reset



- Tool key
  - Replace FDSK
- Group keys
  - Runtime communication
- Sending counter
  - One per device
  - Persistency required







#### **KNX Security in ETS**

- Fully Integrated since ETS5
- Using camera for QR-Code
- Secure configuration
- Secure Download



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		00C5:FFFFEE22	0001030	04050607090	0A0B0C0D0E0F				

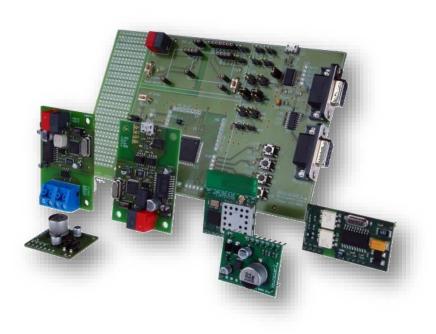






# **KNX Development**

- Development solutions for KNX manufacturers
- KNX BAOS Modules
  - KNX Stack on HW
- KNX Stack NGS
  - Full integration
  - Scalable
- Tools
- Services
  - Development
  - Test Lab









# **Development with BAOS solutions**



- Bus Access and Object Server
- Bus Access
  - Telegram level
  - Programming interface for the ETS
  - Object Server
    - Object Level
    - Allows a fast integration of non-KNX devices into a KNX network
- Host interface
  - Serial, USB, IP





# **KNX BAOS Modules: Application Area**

- When using a module?
  - Low and medium quantities
  - Extension for existing devices
- Benefits
  - Fast time to market
  - Low impact to application
  - Low investments
  - Certified system software

- ETS product database
  - Available as generic
  - Individualization possible
  - Up to 1000 data points

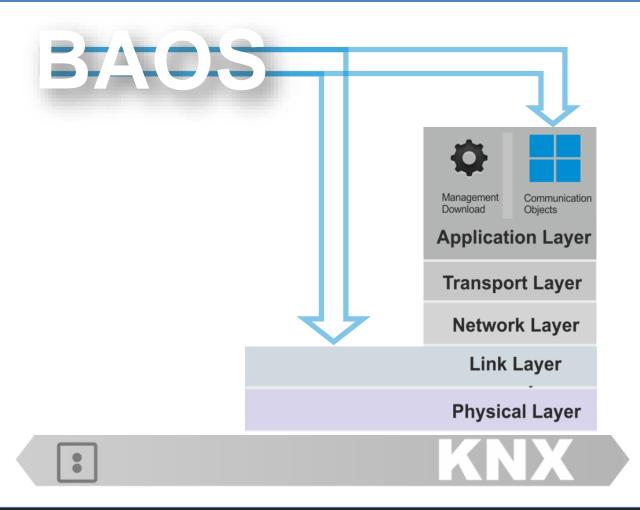








#### **Access on different layers**



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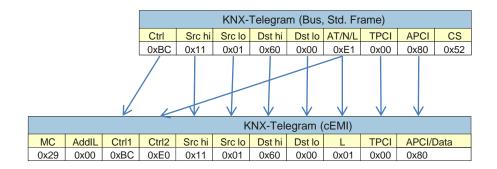
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#### **Telegram Access: common EMI**

- Send and receive KNX telegrams
- Access to Data Link Layer
- Message Protocol cEMI defined in KNX
- Embedded into an FT1.2 frame





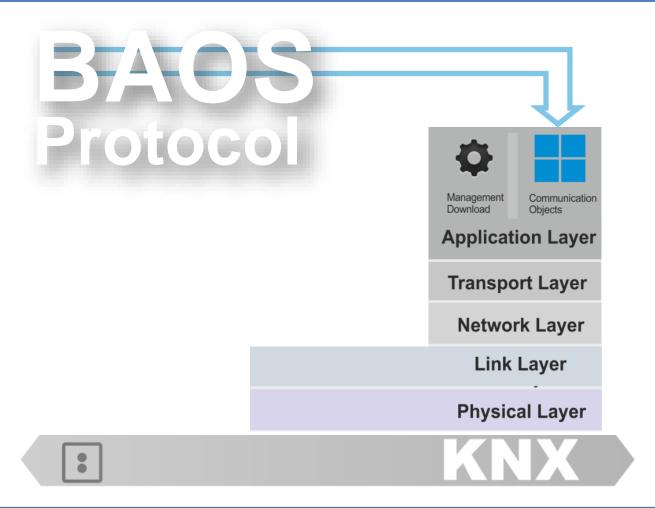


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#### **Application: data points**







# **BAOS Protocol: Object Server**

- BAOS
  - Bus Access and Object Server
- Abstraction
  - Separates KNX handling from client
  - Client communicates to BAOS module
  - No KNX telegrams to be handled by client
- BAOS data
  - Data points (group objects)
  - Parameters (ETS)
  - Server items (Module related)

	<b>\$</b>	
	Management Download	Communication Objects
A	Applicat	ion Layer
	Transpo	ort Layer
	Netwo	rk Layer
	Link	Layer
	Physic	al Layer





#### Advantages of the object server

- No handling of KNX telegrams required
  - No knowledge of group addresses
- The object server always keeps the current values
  - Even if the application is not connected
  - No group-value-read required
  - Short latencies
- ETS download handled by BAOS
  - Decoupling from user application



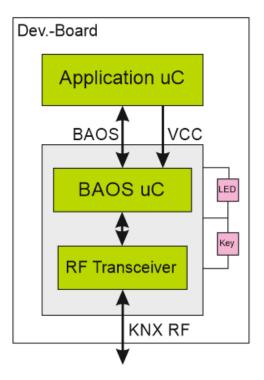






# HW structure using BAOS RF Modules

- KNX BAOS 840
- Power supply
  - By application
- Module
  - Microcontroller
  - KNX RF Transceiver
  - Antenna output
- Development board
  - Microcontroller for application
  - USB, virtual Comport
  - Some IOs





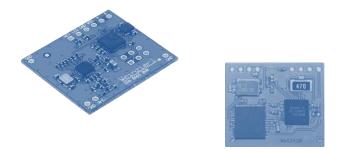




# **KNX BAOS Firmware**

- Certified KNX Stack
- BAOS Protocol
  - Bus access (telegrams)
  - Object server (data points)
- Serial protocol 'FT1.2'
  - Universal frame format
  - IEC 0870-5-1 /-2
  - Well-tried in KNX





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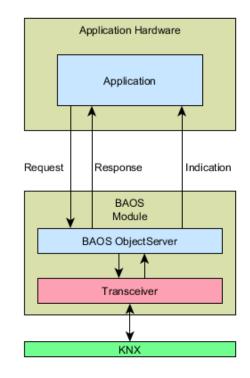




#### **BAOS Protocol: Communication**

- Request-response architecture
- Indications for object updates
- Access to Group Objects
  - GETDATAPOINTVALUE.REQ / RES
  - SETDATAPOINTVALUE.REQ / RES
  - DATAPOINTVALUE.IND
- Access to ETS Parameter
  - GETPARAMETERBYTE.REQ / RES

		В	AOS protocol				
Byte 0	Byte 1		Byte 2		Byte 3		Byte 4
7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0	76	5 4 3 2 1 0	76	5 4 3 2 1 0	76	5 4 3 2 1 0
Main service	Sub service		Start		Number		Error code or
0xF0	000 3011000		item		of items		First item ID
			BAOS protocol				
Byte 5	Byte 6		Byte n-2		Byte n-1		Byte n
7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0		7 6 5 4 3 2	1 0	7 6 5 4 3 2	10	7 6 5 4 3 2 1
First item data length	First item data		Last item ID		Last item data le	ength	Last item data



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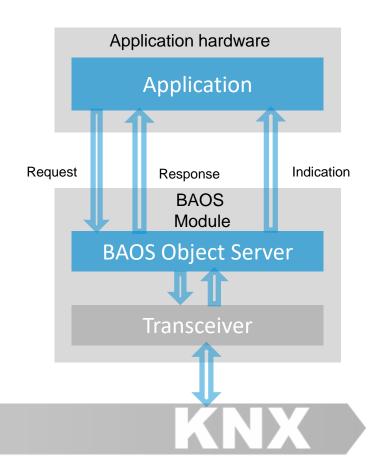
#### **BAOS Protocol: Communication**

#### Access to communication objects

- GETDATAPOINTVALUE.REQ
- GETDATAPOINTVALUE.RES
- DATAPOINTVALUE.IND
- SETDATAPOINTVALUE.REQ
- SETDATAPOINTVALUE.RES

#### Access to ETS parameters

- GETPARAMETERBYTE.REQ
- GETPARAMETERBYTE.RES



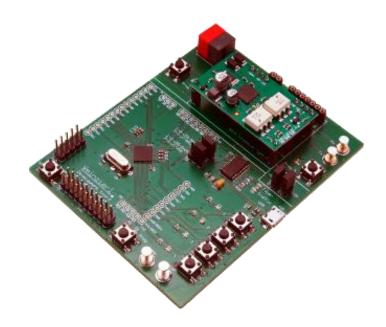






#### **SW Framework & API**

- Free demo code
  - Framework for KNX devices
  - Handling of BAOS protocol
  - Simple demo application
- For BAOS dev. board
- Prepared for Cortex M0x
  - Project for Atmel Studio
  - GCC compiler
- Can be ported to any µC
  - UART / Timer









#### Framework & API

- Change and send a data point value:
- uint8\_t nValue = LED\_OFF;
- MnxBaos\_SendValue(1, DP\_CMD\_SET\_SEND\_VAL, 1, &nValue);
- Get response of data point change:
- void App\_HandleSetDatapointValueRes(
- uint8\_t nStartDatapoint)
- {
- Implement this
- }

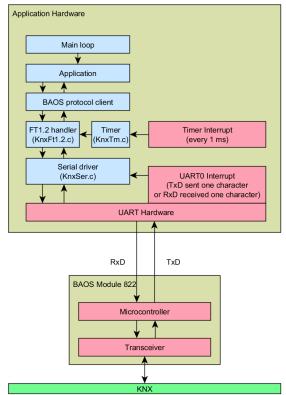






#### Framework & API

- Get notification of data point value change:
- void App\_HandleDatapointValueInd(
- uint8\_t nDpId,
- uint8\_t nDpState,
- uint8\_t nDpLength,
- uint8\_t\* pData)
- {
- // Implement this
- }









# ETS database entry

- Generic ETS database entry for a quick start
- DCA for import/export

Device: 1.1.1 KNX IP BAOS 771			
Common	· · · · · · ·	DPT 01 - Binary - 1 bit	
IP configuration 1	Type of datapoint 1	DPT 01 - binary - 1 bit	
IP configuration 2	Description of datapoint 1	Light Living Room	
Datapoints 1 to 10			
Datapoints 11 to 20	Type of datapoint 2	DPT 03 - Dim up/down - 4 bits 🔹	
Datapoints 21 to 30	5 1 K K K K K K K		
Datapoints 31 to 40	Description of datapoint 2	Dimmer Living Room	
Datapoints 41 to 50	Type of datapoint 3	DPT 09 - Float value - 2 bytes -	
Datapoints 51 to 60	21 1		
Datapoints 61 to 70	Description of datapoint 3	Temperature	
Datapoints 71 to 80	Type of datapoint 4	DPT - Unknown - 1 byte	
Datapoints 81 to 90	Type of datapoint 4	UPT - Offkriowit - I byte	
Datapoints 91 to 100	Description of datapoint 4	Value	
Datapoints 101 to 110			
Datapoints 111 to 120	Type of datapoint 5	Disabled 🔹	
Datapoints 121 to 130	Description of datapoint 5		
Datapoints 131 to 140	Description or datapoint 5		
Datapoints 141 to 150	Type of datapoint 6	Disabled 🔹	
Datapoints 151 to 160			
Datapoints 161 to 170	Description of datapoint 6		
Datapoints 171 to 180	Type of datapoint 7	Disabled 🔹	
Datapoints 181 to 190	Type of datapoint 7	Uisabled •	
Datapoints 191 to 200 +	Description of datapoint 7		
Device objects / Parameters / Con	nmissionina /		

- Individual ETS database entries
  - By the manufacturer using KNX MT
  - As service from Weinzierl Engineering





#### **Net'n Node**

- Busmonitor program
  - Free edition
- Multiple port architecture
  - USB, IP, Serial
- For all KNX media
  - TP, RF, IP
- For BAOS Protocol
  - BAOS view

# net'n node

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#### **KNX BAOS solutions for RF**

- KNX BAOS Module 840 RF
  - Host interface with serial FT1.2
  - To extend embedded devices with KNX RF
- KNX USB Stick 340 RF
  - USB Stick for ETS
  - Host interface with USB HID
  - Support of KNX BAOS Protocol
  - As external KNX RF stack for devices with OS like Linux





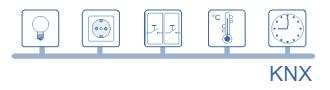




#### **KNX Stack NGS: Application Area**

- For KNX end devices
- When using a stack?
  - High volumes
  - Many device types
- Benefits
  - High flexibility
  - Low cost production
- Take into account
  - High investment, also in the team
  - For skilled developers



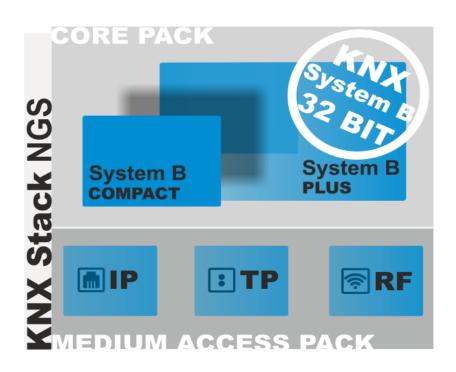






#### **KNX Stack Implementation NGS**

- Professional solution for high volume products
- KNX Security integrated
- Modular
  - Twisted Pair TP
  - Radio Frequency RF
  - Ethernet / IP
- Scalable
  - Compact
  - Plus
- Development HW
- Tools





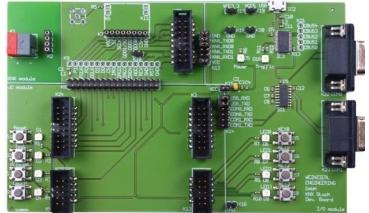




#### **Modular Development Boards**

- Base Board
- Micros
  - Broad range 8..32 Bit
- Bus Access
  - KNX TP
  - KNX RF
  - KNX IP

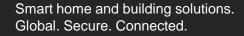












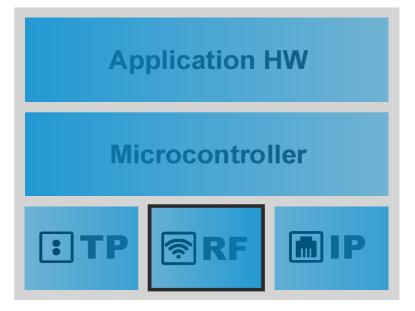






#### **Medium Access Pack RF**

- Bus-Access
  - KNX RF
  - Data link layer for ISM Transceiver
  - SPI Driver for Data & Configuration





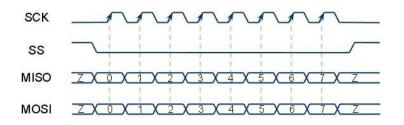






#### **Hardware Connection**

- Use schematic of RF transceiver
- Add microcontroller with clock, etc.
- Connect RF configuration interface
  - 4-wire interface
  - uC is master
- Connect RF data interface
  - SPI interface
  - uC is slave
  - Bit clock generated by RF chip
- Add application specific parts









#### **ISM Transceivers**

- Microchip MRF89XA
- Semtech SX1211
- Silicon Labs Si4431 / Si4432
- TI / Chipcon CC1101
- ST S2LP







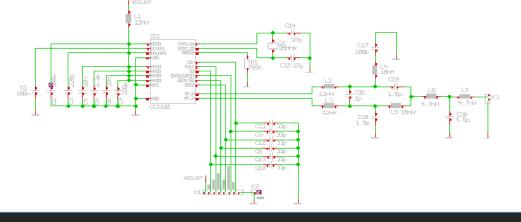
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#### **Modules for KNX RF**

- Standard ISM Solutions
  - Microchip MRF89XA / Semtech SX1211
  - Silicon Labs Si4431 / Si4432
  - TI / Chipcon CC1101
  - ST Spirit 1 / S2LP
- Transceiver Modules
  - For Weinzierl Development Boards
  - For Products
- Antenna
  - Wire, PCB, Chip
  - Matching required









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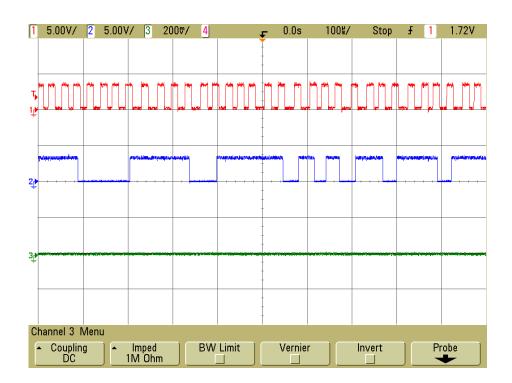






#### Sending & Receiving

- Sending
  - Pre-header
  - Manchester Coding
- Receiving
  - Transceiver in NRZ mode
  - Not synchronized
  - Permanent sampling
  - Chip rate 32 768 cps
  - 4 096 patterns per second
  - Manchester decoding



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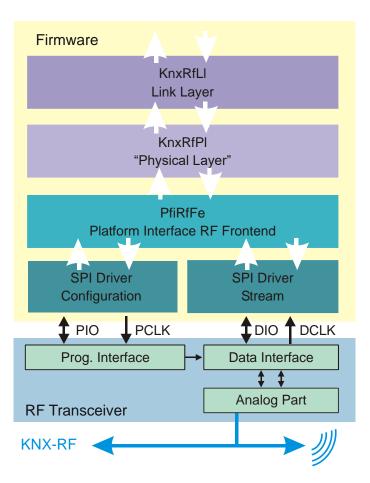
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#### **Physical & Link Layer**

- Link Layer
  - Block building
  - Checksum
- Bit handling
  - Pre-header sending/detection
  - Manchester coding/decoding
- HW driver
  - Interface to transceiver
  - Interrupts



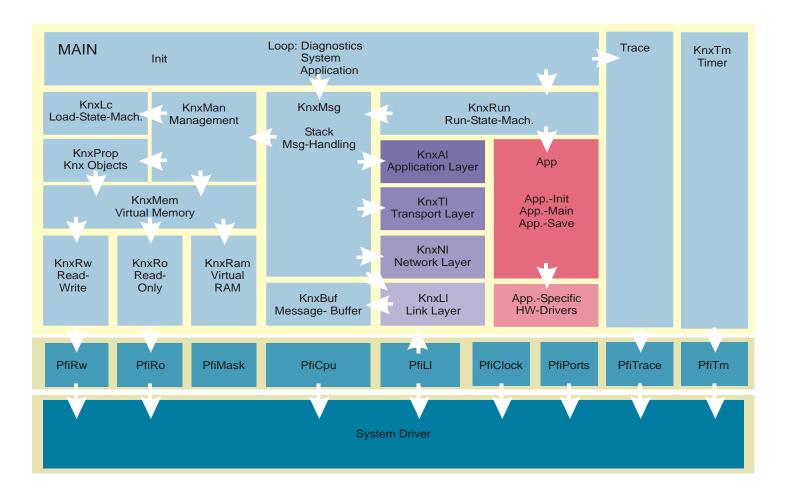
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#### **Firmware Overview**





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#### **Additional Services for RF**

- Services for open media
  - APCI\_DOMAINADDRESS\_WRITE
  - APCI\_DOMAINADDRESS\_READ
  - APCI\_DOMAINADDRESS\_SER\_NUM\_WRITE
  - APCI\_DOMAINADDRESS\_SER\_NUM\_READ
  - APCI\_DOMAINADDRESS\_SER\_NUM\_RESP





#### **KNX Development Tools**

- Net'n Node
  - Bus Monitor and Analyzer
- TraceMon
  - Optimized debug support
- kScript
  - Model driven design
  - Script based system
  - Automated generation of ETS product entries
- kDrive SDK
  - For tool development
  - Bus access and services
  - Free and commercial versions

## net'n'node kScript kDrive







#### Conclusion

#### KNX RF

- Fully integrated in the KNX System
- One tool fits all: ETS6
- Potential for complex topologies
- Security enables new applications
- Technology available
  - Specification, ETS, EITT
  - KNX Stack and Modules
  - Development tools







# Thanks.

### KNX RF development with Weinzierl solutions

For general questions: info@knx.org – www.knx.org



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