IP-TUNNELING OF KNX BUILDING AUTOMATION SYSTEM AS AN IOT REABILITY STUDY

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Abstract

At the present time the smart technology enhanced to be utilized for the human life in many fields, especially in the houses. The building automation experienced a rapid growth in techniques and methods to provide an advanced management for operational advantages in buildings and develop the equipment in the houses to the consumption of energy and operation. When the KNX system has been developed to be the most important building automation, the ethernet system has evolved to be global communication system and use it as automation system. Among the various technological developments is IoT, which is the essential development the future achievement via the internet techniques, Meanwhile the different available communication mediums of KNX and the need of utilizing IP network in compiling extensive areas of KNX has led us to conduct this comparison.

(I) Introduction

KNX is an open standard for commercial and domestic building automation. KNX devices can manage lighting, blinds, shutters, HVAC, security systems, energy management, audio video, white goods, displays, remote control, etc. KNX evolved from three earlier standards; the European Home Systems Protocol (EHS), BatiBUS, and the European Installation Bus (EIB or Instabus). It can use twisted pair (in a tree, line or star topology), powerline, RF, or IP links . On KNX network, the devices form distributed applications and tight interaction is possible. This is implemented via interworking models with standardised data point types and objects, modelling logical device channels. KNX has the following results and sequels: It should be controlled and regulated to access to the bus network (bus access method) ·KNX bus system has an important advantage so that make it a smart system among all the devices, which is its decentralised framework. For that there is no need for a central control unit. The feature of the decentralised in KNX system, is that if there is any problem in any device, the other one will keep working and do the job.

(II) KNX System Elaboration

KNX system has devices that classified into three types: The first one is the sensors, the second is the actuators, and the third one is the system devices (controller, memory controller, programming moderator, etc) (Fig 1). Sensors are machines that discover any moving objects or any unusual moves in the buildings and houses or any place that install sensors (e.g., pressing elevators button, anybody moves, change in temperature up or down, etc.), then it will change these moves to telegrams (information packets), and transmit them to another electronic device by the bus network. Every machine and devices have an actuator. The actuator receive telegram via bus network and change the orders and function embedded in them into action. Sensors produce commands and give orders, while the actuators receive them and do the job.

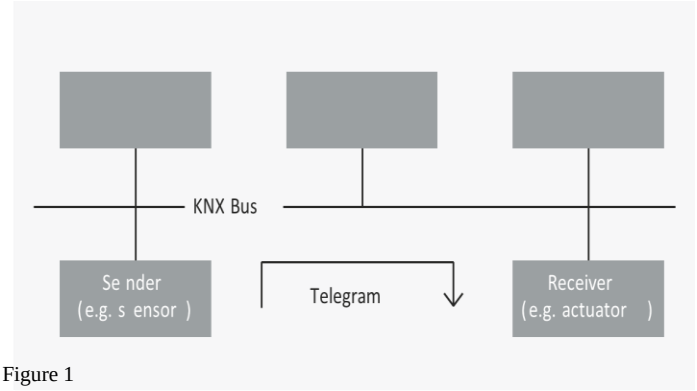


Figure 1

2.1 KNX communication medium

In KNX system there are various communication media could be employed for the interchange of information between instruments. Bus system is extremely suitable to setup and generally to act with. The enormous chosen of KNX communication media ready implies that whatever the request, KNX will recognize them.

Type of KNX communication network:

KNX Twisted Pair (KNX TP) communication through a twisted pair information cable (bus cable)

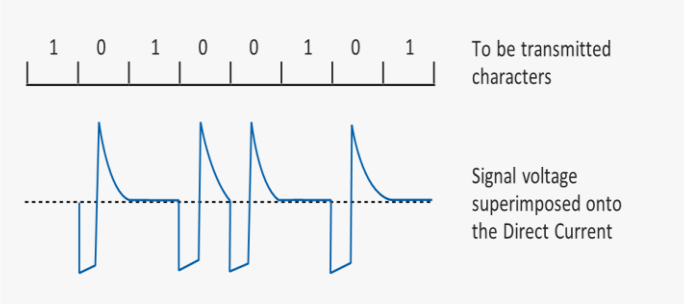
KNX Powerline (KNX PL) uses the existent 230 V major network.

KNX Radio Frequency (KNX RF) communication through radio signal

KNX IP communication through Ether

2.1.1KNX Twisted Pair (TP)

The most popular and spread communication medium in KNX installations is the two-core twisted pair information cable (bus cable). Which all machines are linked and paired with each other through the bus cable. Twisted pair cables are low-cost to purchase and not difficult to install. The bus cable provides all bus devices with facts and information and energy in KNX TP. The voltage supplied by the power equipment is 30 V, and the estimated voltage of the bus system is 24 V. The bus equipment works and do the job without mistakes at voltage between 21 V and 30 V, thus the allowance domain of 9 V is obtainable to recompense for voltage falling in the cable connect impedance. In the electronic devices, the information-carrying AC voltage will be separated from the DC supply voltage. While the transformer separates the information-carrying AC voltage, the DC provide voltage is produced by a capacitor. The transformer also avails to compose the outgoing information onto the bus voltage, and that in transferring devices. In KNX TP, the important advantage of communication through KNX TP is that the signals are connected symmetrically to the bus, for example: the information cable has no specific reference point versus ground. And this kind of communication is called symmetrical. The average of information that transmit is 9,600 bit/s, and the information transfer in sequence, one byte at a time, through asynchronous information transmit. When a logical zero is sent, the voltage goes down for a while, and then after not more than 104 µs, it will go up again to even out at the original voltage. This incident happened because of the impact of the inductor of the choke (Fig. 2). The transition of logical ones coincides to idle state of the bus. One of the important advantages of communication through KNX TP is that the signals are connected symmetrically onto the bus, i.e., the information cable has no specific reference point versus ground.



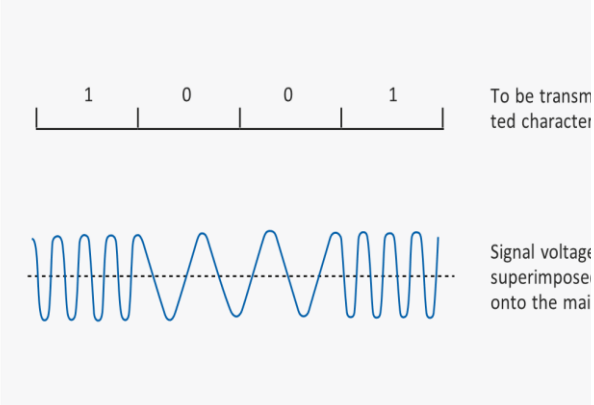
(Figure 2)

Moreover, the one of TP disadvantages is the possibility of signal distortion due to electromagnetic interferences that may be caused by adjacent power cables and induced voltages from any source of current variations, therefore the TP cable should be maintained shielded with its original aluminium foil tape and grounded ultimately by using the proper earth points. And that what justifies the limitation of TP medium usage in backbone lines in KNX.

2.1.2KNX Powerline (PL)

In an old building that need to add a new feature with KNX, it is a cost-effective way when they are using the existent electricity wires in the structure as the KNX connecting medium. In KNX power line the electricity wires are already installed, so it does not need to put a certain bus wire, because the wires become the connecting medium. The information signals are placed onto the main voltage. The potential that needs by the bus devices are come from the 230 V central electricity networks, so there is no need for additional power supplies. To

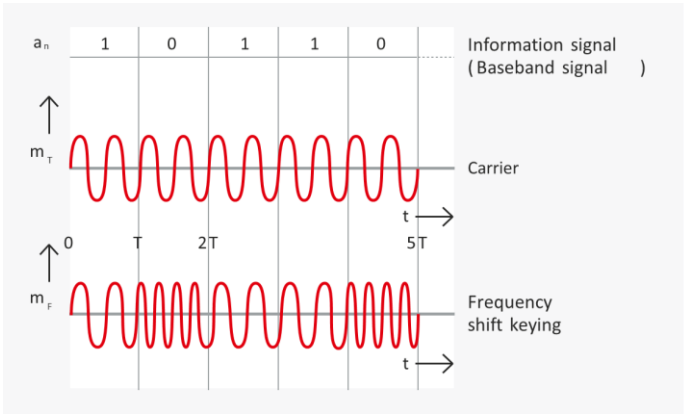
assure that the information communication will occur through all three phases. The phase coupler is used while band stop filter stop the broadcasting of information via the building connection towards the central network. As another option, the system couplers can be used as a replacement of phase couplers. The information transmits average in KNX power line is 1,200 bit/s. The logical zeros and ones are transferred through propagation frequency shift keying (S-FSK). A logical one is appeared by a frequency of 115.2 KHz, while a signal of frequency 105.6 KHz sent by a sender corresponds to a logical zero (Fig. 3). The signals are placed over the major voltage.



(Figure 3)

2.1.3 KNX Radio Frequency (RF)

In the building that has a problem and difficulties to place a new cable in it, radio is a suitable KNX communication medium in those cases. (For instance, the sensors and cameras in unreachable regions). KNX RF is as well especially appropriate for expansion as current KNX TP assembly. The KNX RF will permit the whole technology in the construction to monitoring without using cables, but it will stay the immunity instead of the standard. The RF sensors are mostly provided with batteries to allow it to be a placement wherever there is no entrance to central energy. It is at most potential if these instruments do not want to be in a lasting ready-to-receive situation. In KNX system the unidirectional instrument type has been known that can only transmit telegrams if it necessary and does not have a receiver. Furthermore, actuators are capable of receiving all time, so must be bidirectional. So, RF actuators mostly take their energy from the major 230 V. In KNX system all receivers should be able to send. The individual ability of KNX system glint out of when looking the rending of the system at all (Fig 4).



(Figure 4)

2.1.4 KNX IP

Ethernet is a type of communication protocol that connects devices with each other via a local area network (LAN), and vast region network (WAN), and compliant with the international standard policies IEEE 802.3 (Ethernet). Ethernet network is used to connect devices in one area, and for domestic network, especially in synchronism with the internet. There are many different network textures in the whole world. The Ethernet standard realize the physical areas. There are many protocols used for sending information between the devices, and the protocols are important in internet. Protocols are necessary for computers, because the protocols are the language that communicate between computers in the network. There are many protocols used in the network like TCP/IP-a group of protocols or rules introduced in 1984-is currently very vastly used in the network. “TCP/IP”, TCP (Transmission Control Protocol) and IP (Internet Protocol) are two featured protocols

and widely used. UDP (User Data Protocol) is a third protocol and important with TCP/IP protocols. IP (Internet Protocol) is the main protocol, it avails to guarantee that the information is sent from one computer to another, and when they do that, they are seeking the best way for solution. And it is made likely by so-called IP addresses. The TCP protocol is used for a huge number of popular network applications, so the TCP protocol is based on IP protocol. The TCP protocol founds a constant, assure that all the information packets are sent in the right order and without any mistakes rested by the receiver, and check the error is connection. The UDP protocol is used for implementation (e.g., video and audio streaming) in which it is reasonable for information packets to sometimes not found. The transmission of information packet is not controlled (connectionless control), and the connecting is not error-checked. UDP protocol is faster and weaker than TCP. In automation building they use UDP protocol very often.

Commercially there are two types of IP-Gateway device, one of them is "IP-Interface" which is a solid converter between KNX/TP and IP/LAN, while the other type is "IP-Router" which has an extensive functionally than IP-Interface since it acts also as a WLAN adapter with wireless control as well as an IP link.

2.2 **Individual Addresses**

In KNX system each instrument is given a singular digit (its unique address). It contains of three digits discrete by dots. Theses digits based on the spot of the bus instrument in the topology. The first digit indicates the digit of the zone. And the second digit indicates the digit of the line. And the third digit is a sequential digit pointing the instruments place in the line. Physical addresses are necessary to recognize instruments obviously, and to program them. It is important to mention that, when referring physical addresses. Zone/line couplers should always be specified the digit 0 as their sequential digit.

Examples:

Individual address 1.1.0: line coupler coupling the first line with the major line in the first zone.

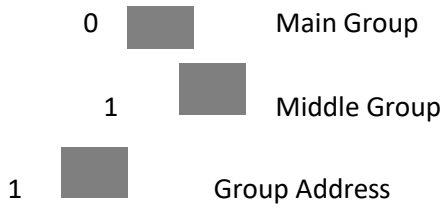
Individual address 3.4.15: bus device 15 in the 4th line of the 3rd.

KNXnet/IP routers (routing) are given the sequential number 0 (like area and line couplers). KNX IP interfaces (tunnelling) can be given any sequential number.

2.3 Group Address

Group address is a unique three levels number addressed for a certain control group of devices (or the other word a group of individual address)

For example, the three levels of the group address number 0/1/1 are.



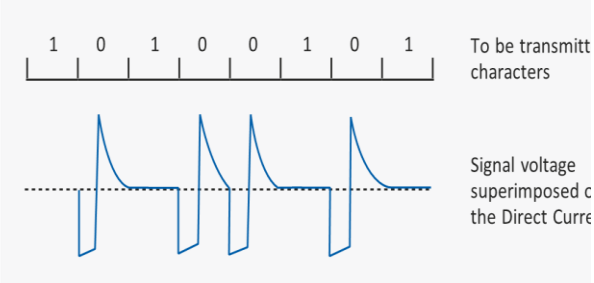
Hence, The main Group can accommodate many middle Groups , and consequently each middle group can comprise more than Group Address.

Also one the vital parts in KNX Topology logic structure are : the Line couplers (LP) and area couplers which acts as a data traffic limiters for all exchanged telegrams through the same network, since it has a refernce "Filter tables" based on it's possion on the topology, and allowing telegram to pass through will be based on the "Target address" , in this case the data congestion in KNX line will be diminished.

The IP-gateways are also functions as Line/Area couplers since they do filtering transfer telegrams, this feature considered as an advantage to eliminate data traffic through communication network.

2.4 Telegram

The current payload locates the kind of order. When the (write) order the last bit on the consist of a (1) or (0) for (switch on) or (switch off), a (read) order calls the addressed set object to report its situation. The answer could be a 1-bit message as in the example of the (write) order or it may use up to 13 bytes "bytes 2 to 15 ". The longitude of the information is resting on the datapoint form used (Fig 5).



(Figure 5)

Telegram structure

Data that swapped between bus devises in the form of so-called telegrams. Telegrams contain a series of symbols, and each symbol contain of eight zeros and ones, and it called eight bits or one byte. Often many symbols are merged with each other to form a field. KNX telegrams have four fields (Fig 6).

Control field the control field determine priority sequential of the telegram to access the communication line and whether or not transmission of the telegram was repeated (if the receiver did not reply)

Address field the address field specifies the Individual Address of the sender and the destination address (Individual Address or Group Address) of the receiver.

Data field the data field, which can be up to 16 bytes long, contains the telegram's payload or what so called "useful data" which comprises the control signal details.

Checksum field the checksum field is used for parity checks in order to identify and confirm the control data intact.

KNX Telegram

(Figure 6)

(III) METHODOLOGY

In this paper our aim is to evaluate the IP – tunnelling reliability in KNX as a communication media, since as known, the IP-tunnelling is utilized for the backbone line to exchange data packet among KNX and system.

3.1 Data rate

The information transmit average is 9,600 bit/s, and the information transfer sequent, one byte at a time, through a synchronous information transmit. When a logical zero is transmitted, the voltage drops briefly and then, after no more than 104 µs, increases again to even out at the original voltage. This is due to the inductor effect of the choke. The transmission of logical ones corresponds to the idle state of the bus. The various media do differ considerably in their data transfer rates, however. In normal data traffic, KNX TP needs around 20 ms to send a telegram. Only during the programming of devices does this increase – to 40 ms. A KNX TP bus can send a maximum of 50 telegrams per second. Whereas KNA-LAN (IP) capacity can reach 10000 Telegram @ 10 Mbps.

As known that the data transfer rate is 9600 bits/second, therefore we can compute the Telegram size as follow:

$$Telegram\ size = Data\ Rate \times Telegram\ Length$$

$$Telegram\ size = 9600\ bits/second \times 0.025\ sec$$

$$Telegram\ size = 192\ bits$$

3.2 KNX transmission protocol

The KNX is adopting a protocol of communication which is:

CSMA/CA stands for Carrier Sense Multiple Access / Collision Avoidance is a network protocol for carrier transmission. While the LAN-Ethernet is complied with CSMA/CD which stands for Carrier Sense Multiple Access/ Collision Detection It is also a network protocol for transmission and operates in the Medium Access Control Layer. In this protocol, each station senses the collision by broadcast sensing. In case of collision, the transmission is stopped, and they send a jam signal and then wait for a random time context before retransmission.

3.3 Group object's flags

Since the main purpose of this paper is to evaluate the efficiency of utilizing IP-Tunnelling for KNX network, hence we should also eliminate the communication bus usage as minimal as possible, and this can be attained by classifying the types of signals exchanged via KNX bus.

The signals in KNX system are as we mentioned earlier called telegrams, while each telegram comprised a certain useful data depends on the device functionality or in other word on the group objects assigned parameters, for example the group objects functions are varies between "Inputs" and "Outputs" (Table. 1), on the other hand these group objects will have activations rate depends on their assigned group address and the selected parameters.

Table. 1

Group object type	Assigned flag	Device example
Output	Read	Visualization, Actuators
Input	Write	Control switches, Sensors

Using the diagnosis tool at ETS5 software it is possible to monitor all bus activities with a statistical data analysis to determine the bus usage percentage of each group object represented of course by the number of generated telegrams over a certain time interval.

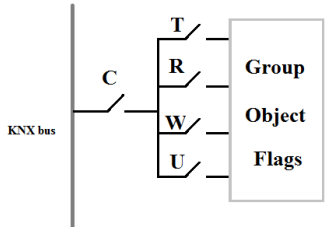


Figure. 7

As known the KNX bus communication parameters is assigned with what so called "Flags" (Fig 7), In that case we can diminish the number of transferred telegrams via bus by adjusting the flags of each group object, for example the update (U) flag can be inhibited in some group functions to provide bus vacancy, similarly the Transmit (T) flag.

Mainly visualisation and sensors are the most devices that generates a high rate of telegrams and respectively increase the bus load.

(IV) Conclusion:

Based on previous KNX literature review on this paper and my methodology in defining the communication Protocol for both T.P & I.P medium, we can conclude this paper with confirming the capability of I.P tunnelling to handle KNX data exchange efficiently, since the data transfer via IP/LAN protocol is fairly secured and has a high baud rate in compared to KNX data transfer rate.

References:

[1]Martin S.Roden."Analog and Digital Communication systems" , 5th Ed.

[2] William Sinnema."Electronic Transmission Technology lines,waves,and antennas", second Ed.

[3] J.A.Nazabal ,J.Gomez F.Falcone, C. Fernandez-valdivielso, P.E.Branchi and I.R Matas, 2012. "Android Application for Accessing KNX Devices via IP connection",

International Journal of Smart Home 6, No.4 , pp 39 – 46.

[4] J.Petnik and J.Vanus , 2018. “Design of smart Home Implementation within IoT with Natural Language Interface’’, International Federation of Automatic Control 51-6 , pp 174-179.

[5] F. Heiny ,Dr. Th.Weinzierl , 2013. “KNX over IP New Solutions for KNX Installations” , Weinzierl Engineering GmbH.

[6] Dipl.Ing. Hans-Joachim Langles , 2008. “KNX IP-using IP Networks as KNX Medium”, KNX scientific conference.

[7] The KNX Standard – the Basics. “Smart Home and Building Solutions. Global Secure Connected”.