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# Zigbee Communications

EB538-80-04

MATRIX

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EB538

# ZigBee

## Course notes

EB538

# ZigBee Student Notes

## About this course

**Aims:** The principal aim of this course is to introduce you to the concepts involved in ZigBee networks.

On completing this course you will have learned about:

- the relationship between IEEE 802.15.4 and ZigBee protocols;
- the electrical principles behind ZigBee transmissions;
- the components that make up a ZigBee network;
- the topologies available to ZigBee networks;
- the addressing schemes;
- ZigBee routing;
- Sleep modes and packet buffering;
- ZigBee security options;
- common AT commands and syntax.

**What you will need:**
To complete this course you will need the following equipment:

- Flowcode software
- E-blocks including:
    - four Multiprogrammers (PIC - EB006, or AVR - EB019) with a suitable microcontroller device fitted in each
    - one ZigBee E-Block ( EB051 C) –co-ordinator;
    - three ZigBee E-Blocks (EB051 R) – router / end-node;
    - an LED E-Block (EB004)
    - a Graphical Colour LCD E-Block (EB043)
    - a Keypad (EB014)
    - two Sensor E-Blocks (EB003)
    - a Switch E-Block (EB007)
    - a USB E_Block (EB039)

**Using this course:**
This course presents you with a number of tasks listed in the exercises in the following text. All the information you need to complete the labs is contained in the notes.

Before starting any exercises, you are advised to spend some time familiarising yourself with the material on this course so that you know where to look when you get stuck.

Time: If you undertake all of the exercises on this course then it will take you around twelve hours.

**Important note**: Information presented here is correct at the time this document was produced. Please check the Matrix Multimedia web site http://www.matrixmultimedia.com for the latest E-Blocks documentation.

## Scheme of work

| Section | | Notes for instructors | Timing (minutes) |
|---|---|---|---|
| **1. Introduction to ZigBee** | | | |
| 1.1 | Overview | Students familiarise themselves with various wireless technologies for WPANs, WLANs and WWANs.<br>They can use websites such as www.ieee802.org/15/, or en.wikipedia.org/wiki/WPAN for more information. | 10 - 30 |
| 1.2 | Comparison of Wireless Technologies | This section compares the characteristics of ZigBee, Bluetooth, UWB, Wi-Fi and Wi-MAX wireless technologies. Students can use an internet Search Engine to find out more information about any of these technologies. | 10 - 30 |
| 1.3 | ZigBee Applications | Two application areas, the Smart home and the Smart Office, are outlined here. There is a wealth of information available on the internet, especially from the ZigBee Alliance website which contains a 'White Papers' area on www.zigbee.org/en/resources/whitepapers1.asp | 10 - 30 |
| 1.4 | ZigBee protocol outline | This section starts with an overview of the standard OSI networking model, and compares it with the three layer model used by the ZigBee Alliance. | 10 - 30 |
| 1.5 | IEEE 802.15.4 Standard | The focus of this standard is outlined, and contrasted with that of the 802.11 and 802.16 standards. The areas covered by the PHY and MAC layer specs are then described. There is a brief outline of the modulation techniques, AM, FM and PSK, including QPSK and O-QPSK, and DSSS. Finally the two 802.15.4. device types, FFD and RFD, are contrasted. | 10 - 30 |

| **2. The ZigBee Network** | | | |
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| 2.1 | ZigBee Logical Devices | After a brief reminder about the two kinds of 802.15.4. physical devices, this section introduces the three kinds of ZigBee logical device, the co-ordinator, the router and the end device. Students should be familiar with these roles, and relate the performance of FFD and RFD devices to them. | 5 |
| 2.2 | ZigBee Network Topologies | This section compares and contrasts the three types of topology recognised by the ZigBee protocol stack – star, cluster tree (sometimes called simply 'tree') and mesh. They should be aware that the size of the proposed ZigBee network will probably dictate which of these is used. The characteristics, in terms of latency, routing and reliability are very different for these three topologies. Students need to aware of the significance of redundancy in leading to increased reliability. | 10 - 30 |
| 2.3 | Multi-Access Networks | ZigBee networks are multi-access because usually there are a number of radio transmitters, one to a node, all vying for use of the air-waves. Only one can transmit at a time, otherwise a collision occurs and the data will be corrupted. The issue is – what decides which radio transmits!<br><br>In a fuller discussion, the distinction between deterministic and non-deterministic networks could be raised, and a comparison drawn with Ethernet vs Token Ring cabled networks.<br><br>Here, the differences between beacon access (deterministic) and non-beacon access (non-deterministic) are explained. In theory, when beacon frames are used, collisions cannot occur. Again, the issue of which type to choose comes down usually to the size of the network. In a small network, non-beacon access probably has the edge in terms of latency.<br><br>A possible advantage of beacon access is that it allows the routing devices to use sleep mode, whereas in the free-for-all atmosphere of non-beacon access, they must be awake at all times to manage any transmissions that take place. | 10 - 30 |
| 2.4 | Creating a ZigBee network | The role of the co-ordinator is paramount in setting up the network. It chooses a quiet transmission channel, and unique PAN ID to ensure as little interference with any neighbouring ZigBee networks. Also configured at this time are the parameters Cm, maximum number of children of a router, Rm the maximum number of child routers a router can have and Lm, the depth of the network. These will determine the addressing strategy used in the network. | 10 - 30 |

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| 2.5 ZigBee Addressing Scheme | This is a major topic and needs to be well understood by the students. The MAC address is permanent and unique to the device, but tells you nothing about the functionality or location of the device. The network address can help to locate the node, but may change if network devices fall over, or if the node is mobile. Name addresses can be used to categorise nodes by their functionality.<br><br>Students should appreciate the differences between unicast and broadcast transmissions, and realise that broadcasts, while an essential part of the network, limit its performance, and should be kept to a minimum. | 10 - 30 |
| 2.6 Routing and route discovery | This section describes two distinct forms of routing – tree routing and AODV routing. Once again, size is all-important in determining which will be used. A small tree will use tree routing. The disadvantage, the possibility that there might be shorter route than climbing up or down the tree structure, is not significant unless the tree is big. A mesh network has no tree, and so must use AODV. | 10 - 30 |
| 2.7 Sleep Mode | There are two modes of sleep used in the XBee modules – pin sleep and cyclic sleep. The former is simply a matter of applying a voltage to a pin on the chip. The latter requires the use of AT commands and a timer.<br><br>The associated issue is that of packet buffering, and the role of the parent device. The child must synchronise with the parent on wakeup to receive any buffered unicast messages that came its way while asleep.<br><br>Students should be aware of the term ‘indirect messaging’ in this context. | 10 - 30 |
| 2.8 Security | ZigBee networks offer three levels of security:<br><br>1. Low level security<br>2. Use of Access Control Lists<br>3. Encryption<br><br>Access Control Lists use the MAC address of devices to decide which nodes should be allowed to join the network, and hence be party to its communications.<br><br>Encryption relies on the 128 bit AES (Advanced Encryption Standard) which uses a private key, shared by participants, to encrypt messages. | 10 - 30 |

| 3. The Matrix Multimedia ZigBee Training Solution | | |
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| 3.1 The ZigBee E-Block | This section starts with a description of the hardware provided in the Matrix Multimedia kit.<br><br>It goes on to introduce the use of AT ("Attention") commands to control the XBee modules. Students do not need to memorise these commands, or worry about the syntax, as Flowcode delivers them through its macros. | 5 |
| 3.2 Installation | Students need to read this while keeping an eye on the hardware itself. They should familiarise themselves with the layout of the Multiprogrammer board, and in particular, identify the position of its various ports.<br><br>Detailed information on all the E-Block hardware is available from the Matrix Multimedia website. Students should be encouraged to read and use this information.<br><br>They can find valuable information about the ZENA ZigBee analyser via a free download from the Microchip website, ww1.microchip.com/downloads/en/DeviceDoc/ZENA%20Analyzer%20User's%20Guide%2051606b.pdf.<br><br>This gives detailed but straightforward instructions on how to install and run the device. | 5 - 20 |

| Section | Notes for instructors | Timing (minutes) |
|---|---|---|
| **4. The ZigBee assignments** | | |
| | This section lists the assignments and gives a brief outline of what each covers. | **5** |