ZigBee RF Module

ZigBee

- ZigBee is a technology standard to design for control and sensor network
- Based on IEEE 802.15.4 standard
- Ad-hoc and Mesh network creation
- Routing (pass messages on) and Self-healing
- Example of WPAN Technology
- Created by ZigBee Alliance
  - Global standards for reliable, cost-effective, low power wireless applications

ZigBee® Alliance

Radio Communication

- Electromagnetic Waves
- No medium required
- Modulation
- Wireless/Airwaves
- Inverse Square Law

$$\rho \propto \frac{1}{r^2}$$

r = distance, ρ= power.

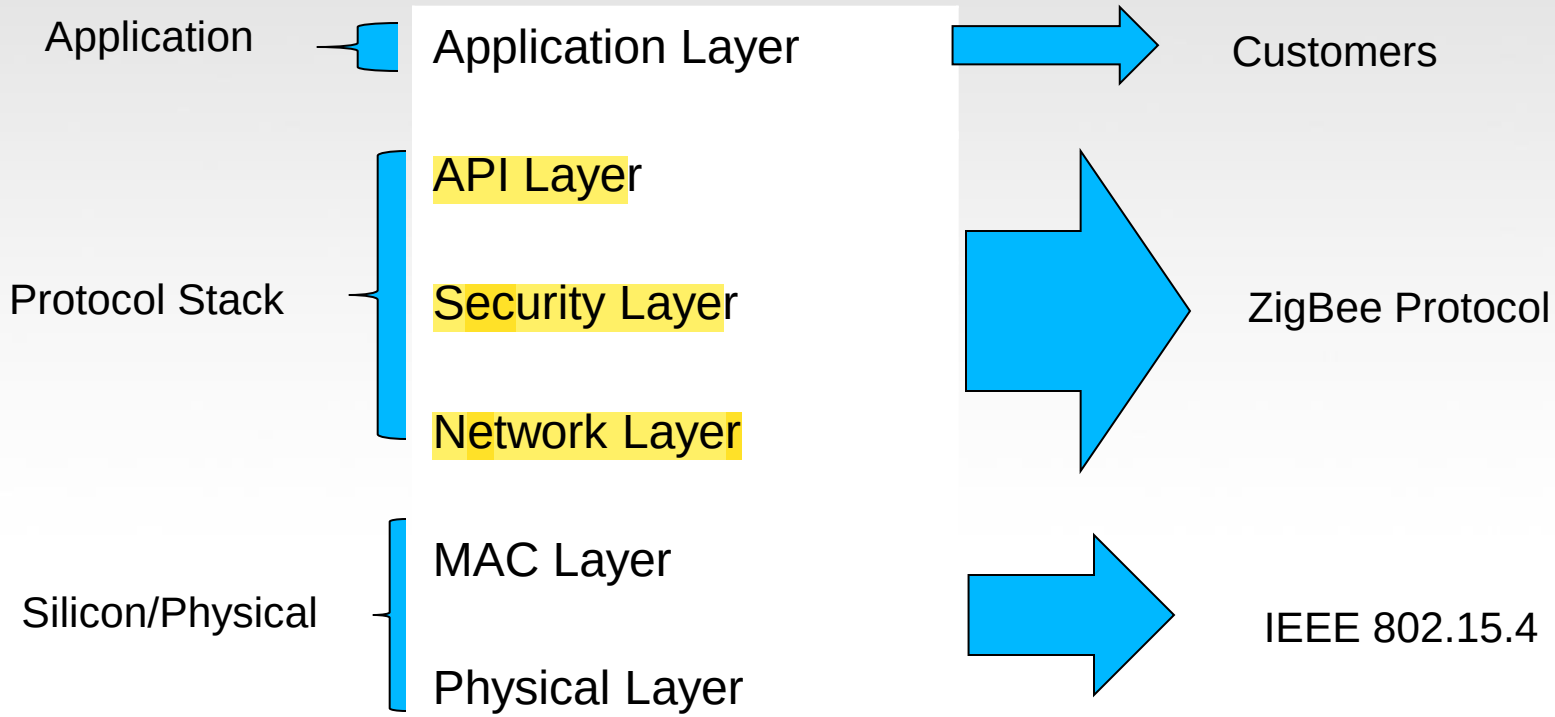
Need of ZigBee?

- Development started 1998, when many engineers realized that Wi-Fi and Bluetooth were going to be unsuitable for many applications as
- Direct /indirect communication between multiple machines
- Non standardized IoT devices
- Low power and small size devices
- Cost effective and security.

IEEE 802.15.4

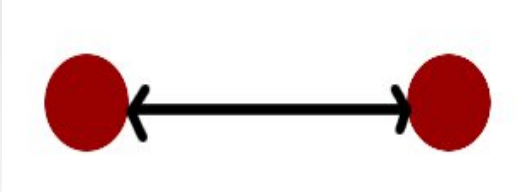
- Low Power consumption
- Low bandwidth
- Affordable
- Small
- Standardized
- Popular

Layering Architecture of ZigBee

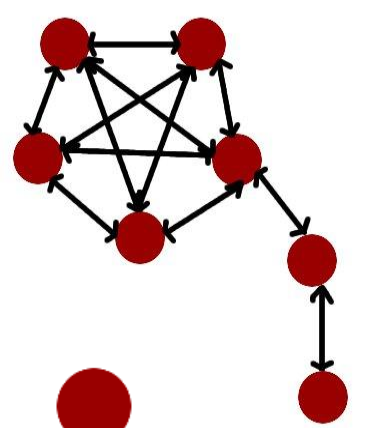


IEEE 802.15.4 Configurations

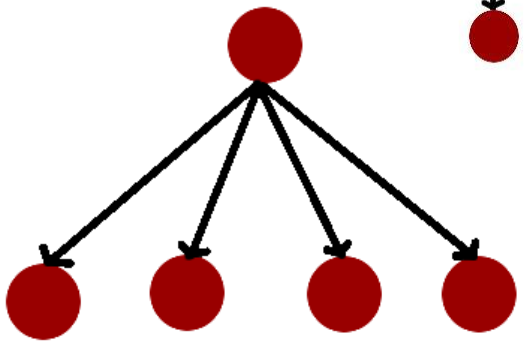
- Single Peer



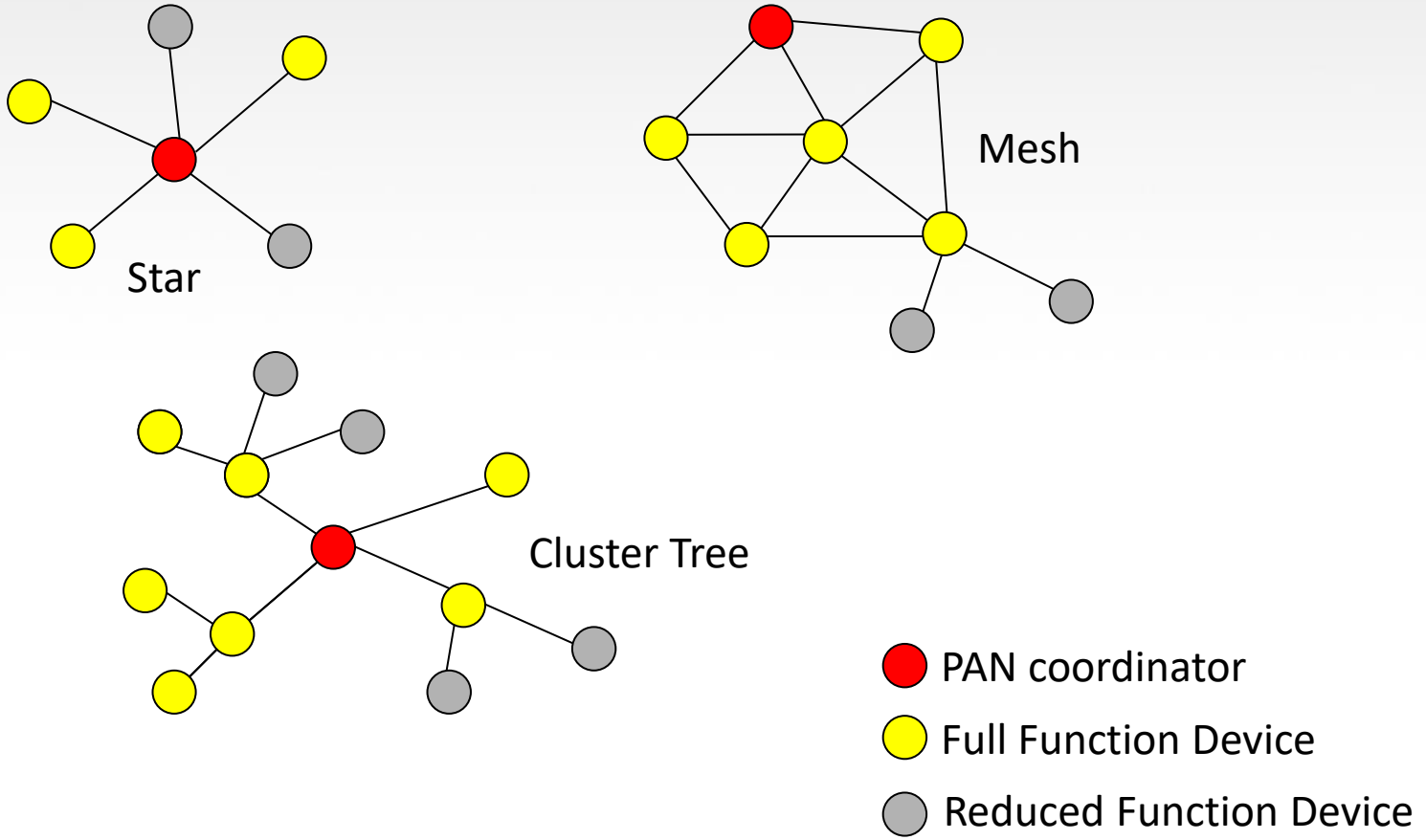
- Multi Peer



- Broadcast

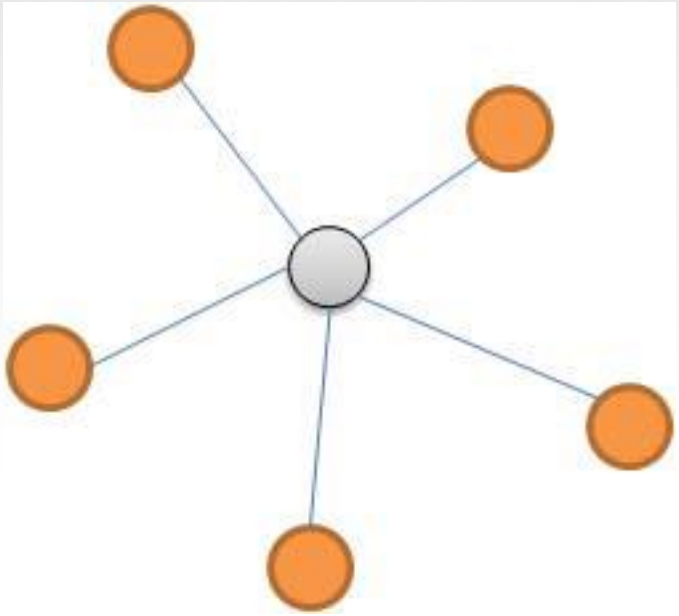


ZigBee Network Topologies



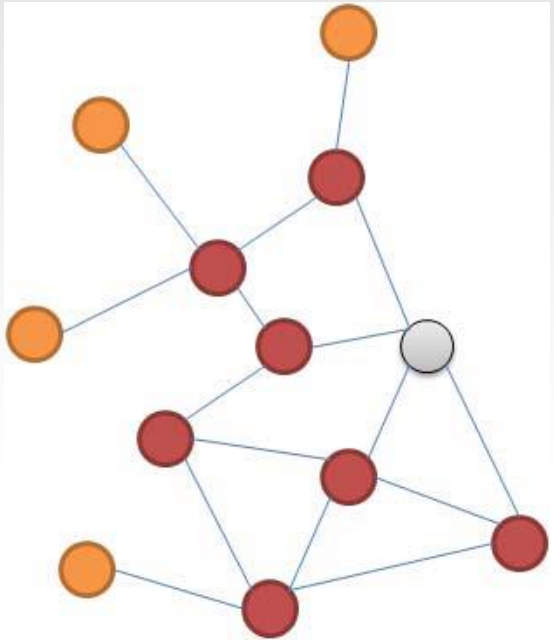
ZigBee Network Topologies

- Star Topology
  - Advantage
    - Easy to synchronize
    - Low latency
  - Disadvantage
    - Small scale



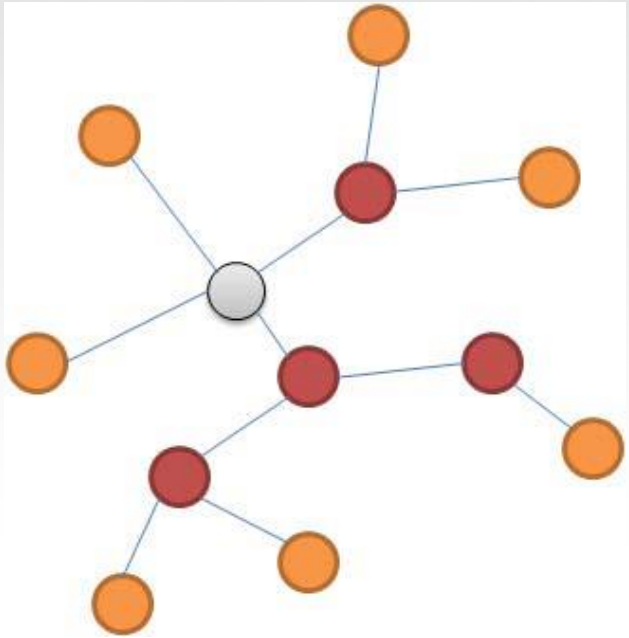
ZigBee Network Topologies

- Mesh Topology
  - Advantage
    - Robust multi-hop communication
    - Network is more flexible
    - Lower latency
  - Disadvantage
    - Route discovery is costly
    - Needs storage for routing table



ZigBee Network Topologies

- Cluster Tree
  - Advantage
    - Low routing cost
    - Allow multihop communication
  - Disadvantage
    - Route reconstruction is costly
    - Latency may be quite long

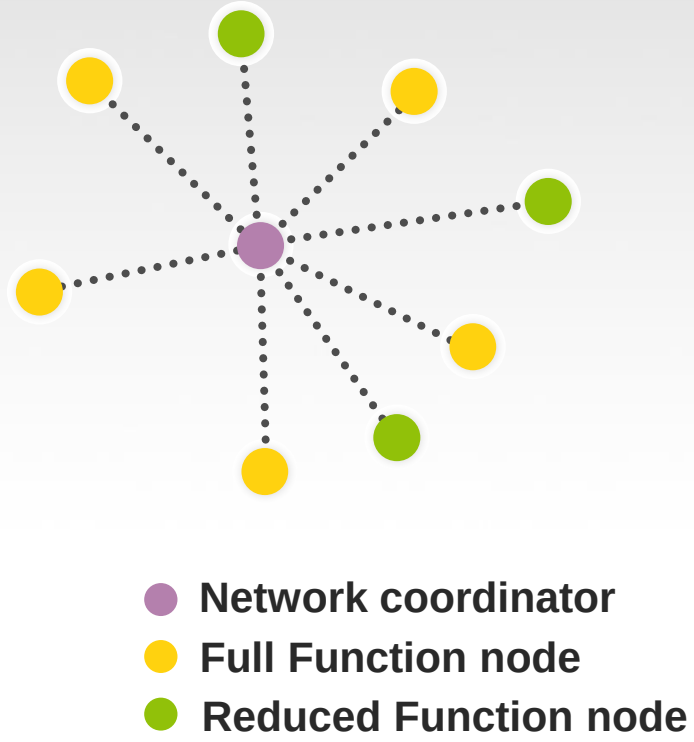


Sensor/Control Network Requirements

- Networks form by themselves, scale to large sizes and operate for years without manual intervention
- Extremely long battery life (years on AA cell),
  - low infrastructure cost (low device & setup costs)
  - low complexity and small size
- Low device data rate and QoS (Quality-of-Service)
- Standardized protocols allow multiple vendors to interoperate.

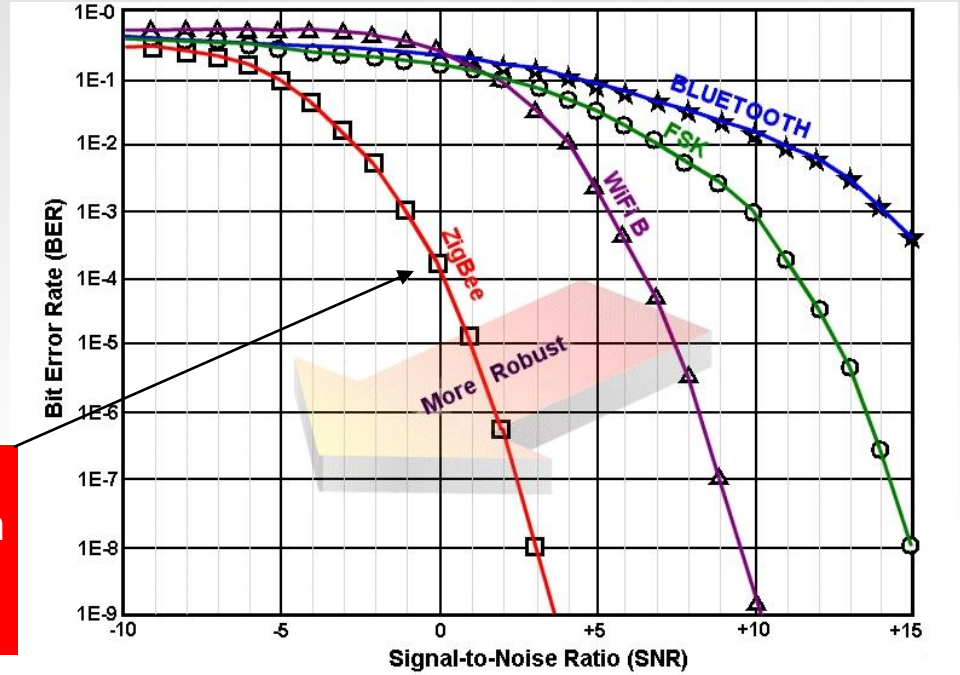
Basic Network Characteristics

- 65,536 network (client) nodes
- 27 channels over 2 bands
- 250Kbps data rate
- Optimized for time-critical applications and power management
- Full mesh networking support



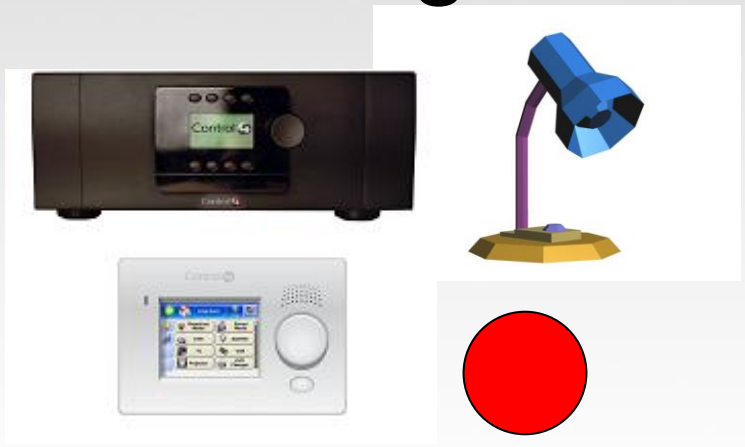
Basic Radio Characteristics

ZigBee technology relies upon IEEE 802.15.4, which has excellent performance in low SNR environments



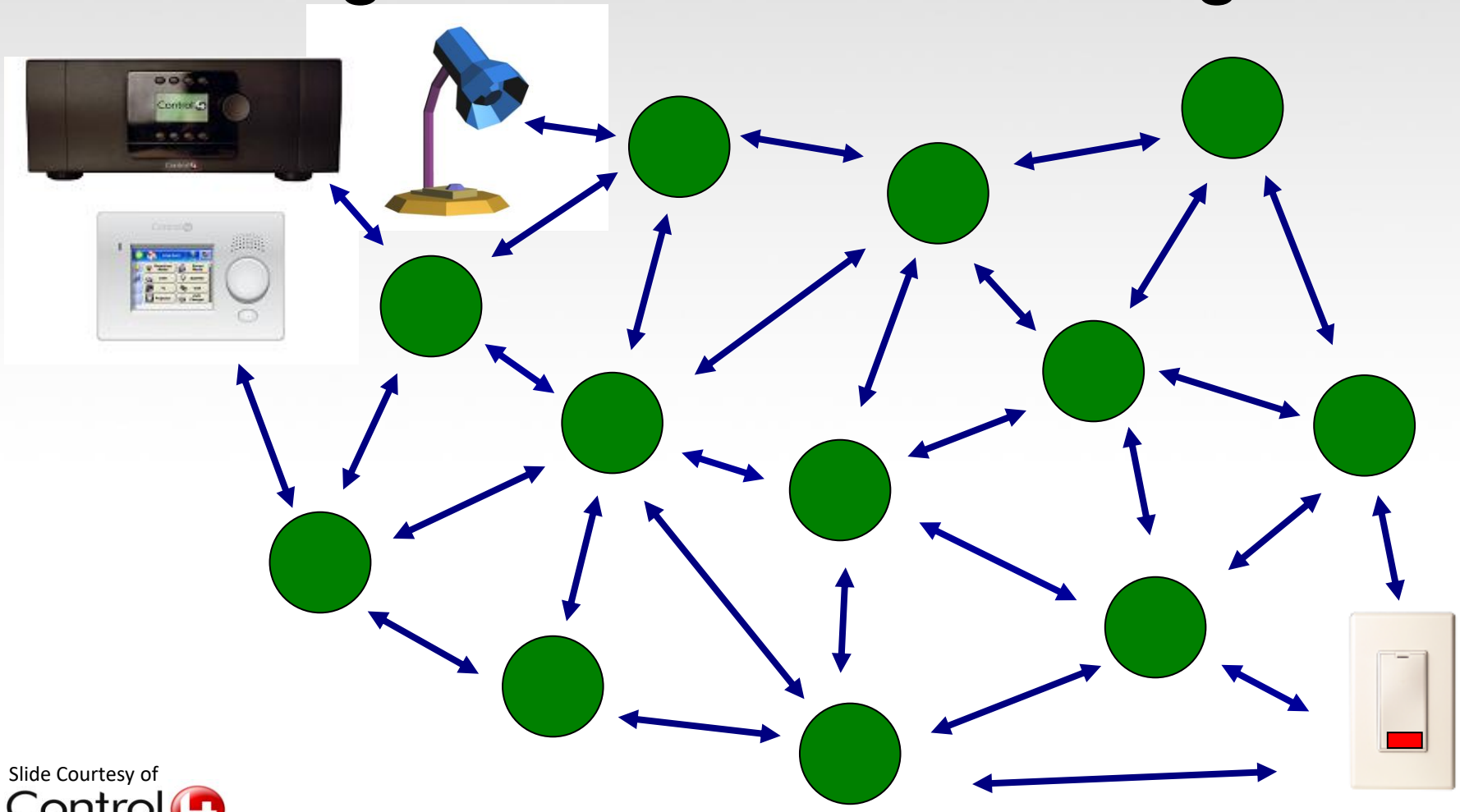
Frequency Band	License Required?	Geographic Region	Data Rate	Channel Number(s)
868.3 MHz	No	Europe	20kbps	0
902-928 MHz	No	Americas	40kbps	1-10
2405-2480 MHz	No	Worldwide	250kbps	11-26

ZigBee Mesh Networking



Slide Courtesy of
Control 4

ZigBee Mesh Networking



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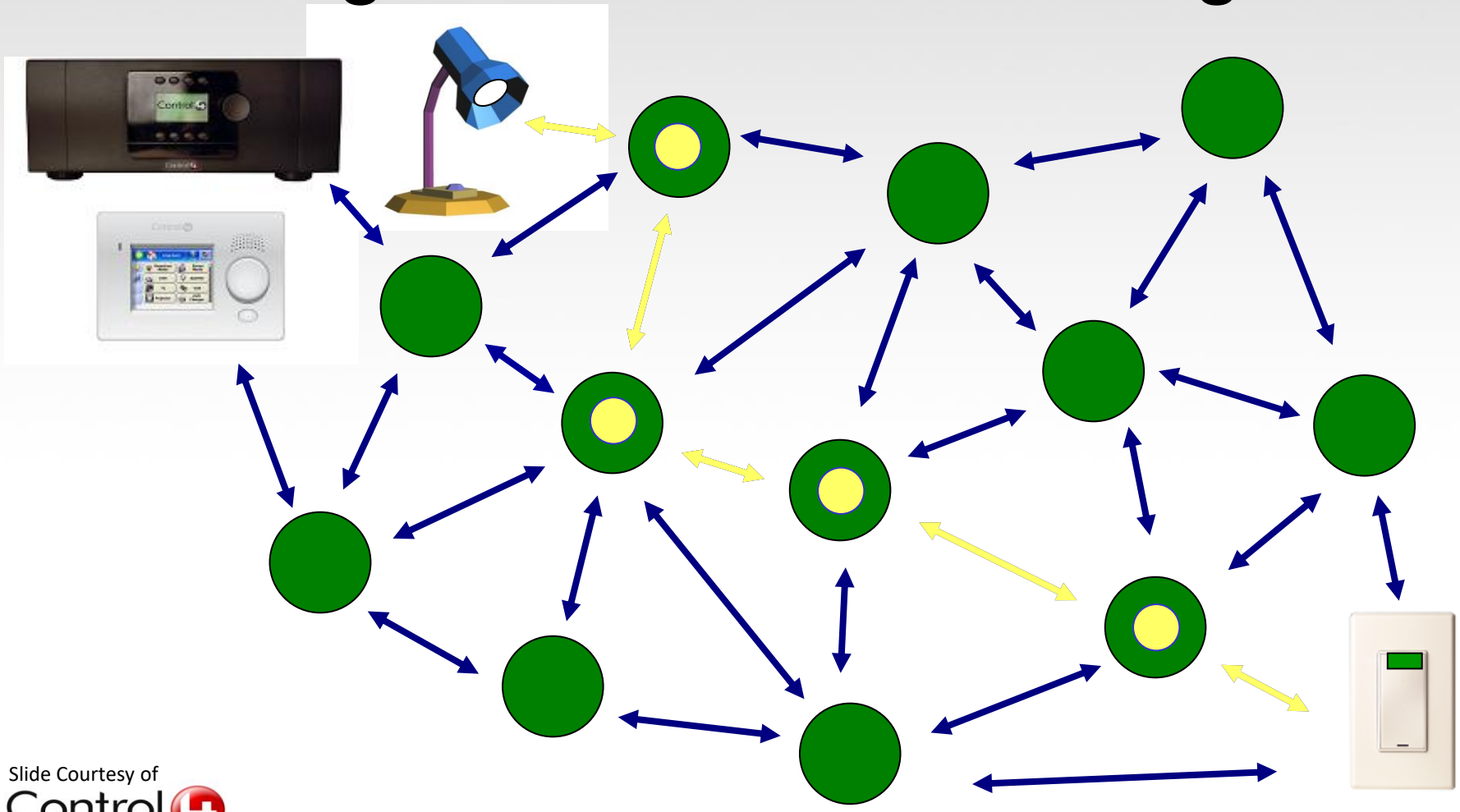
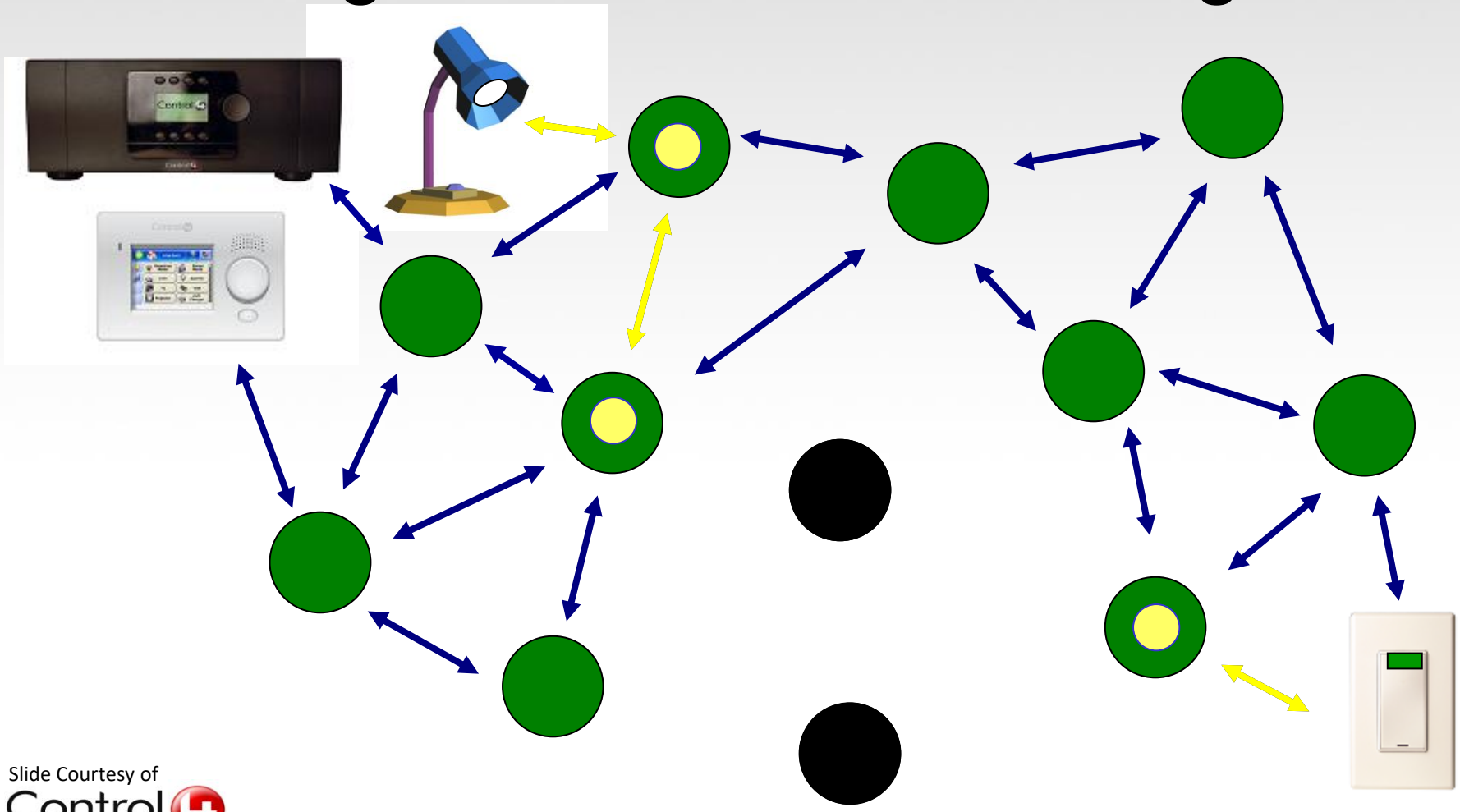
Control 4

ZigBee Mesh Networking



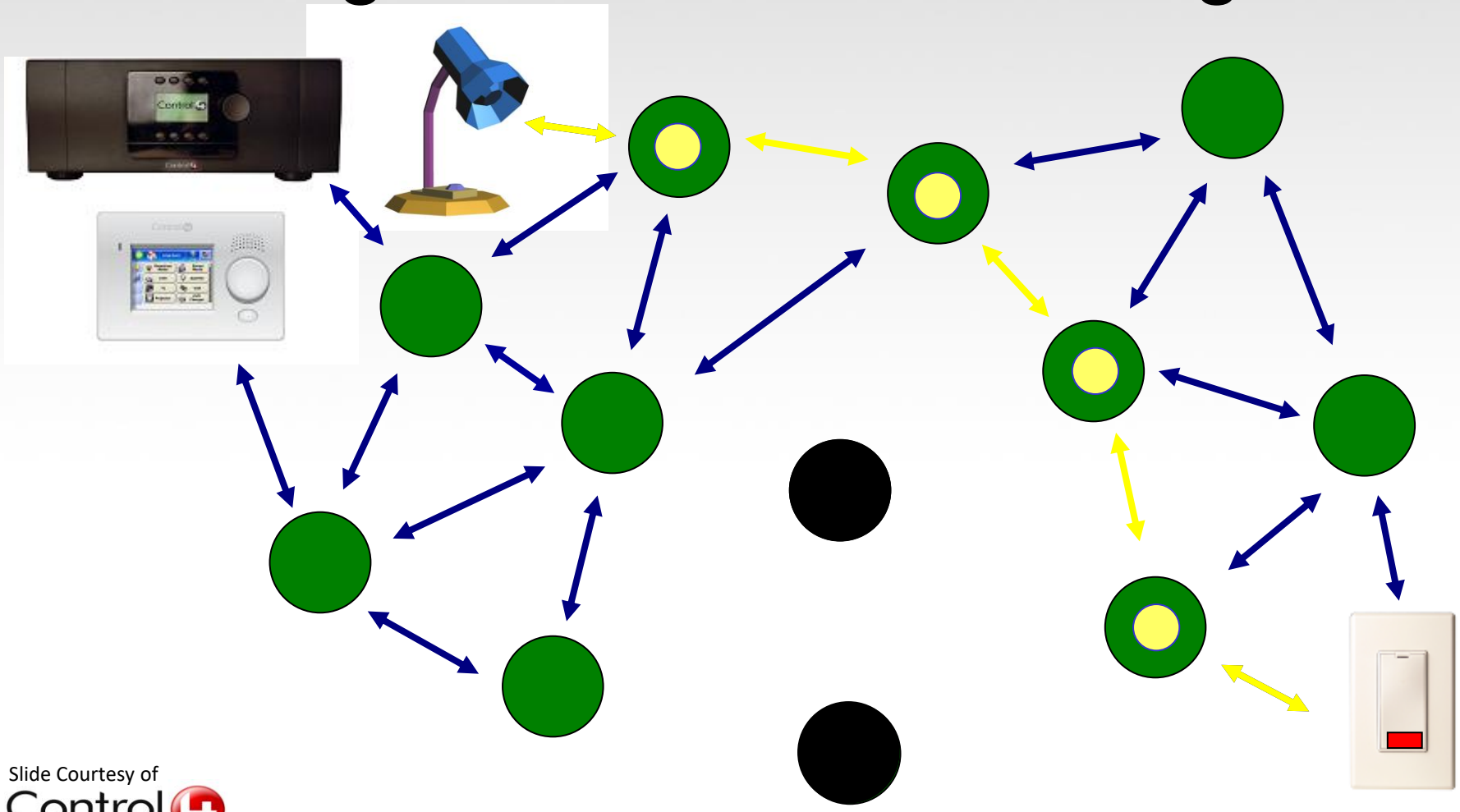
Slide Courtesy of
Control 4

ZigBee Mesh Networking



Slide Courtesy of
Control 4

ZigBee Mesh Networking



Slide Courtesy of
Control 4

Wireless Connectivity Comparison				
Category	**BLE**	**Bluetooth Classic**	**ZIG-BEE**	**Wi-Fi**
				
IEEE Standard	802.15.1	802.15.1	802.15.4	802.11 (a, b, g, n)
Frequency (GHz)	2.4	2.4	0.8, 0.9, 2.4	2.4 to 5
Bandwidth (Mbps)	Low (1)	Medium (1 to 3)	Very low (0.25)	High (54-a, 11-b, 54-g, 600-n)
Power Consumption	Very Low	Medium	Very low	High
Battery Life	Months to Years	Days	Months to Years	Hours
Network Size	Undefined	7	64,000 +	255
Range	Short to Medium	Short	Medium	Medium to Long
Ease of use	Simple to use	Fairly simple to use	Fairly simple to use, but not yet adopted in mobiles and computers	It is more complex and requires configuration of Hardware and Software
Adaptability	High	High	Low	High
Primary Applications	Wearables, Mobile phones	Mobile Phones, mouse, keyboards, office and industrial automation devices	Industrial Automation, Home Automation, Smart metering	Notebook computers, desktop computers, servers.

XBee as a Coordinator

- Each network has 1 coordinator
- Coordinator selects channel and Create PAN ID
- Other devices then join the PAN ID
- Usually powered by something stable
- 16-bit network address is always 0
- Assigns 16-bit address for the router and end devices

XBee as a Routers

- Router as Optional
- Often powered by something stable
- Can have as many as you want
- Issues a request on start to find a coordinator/network so it can join
- Can talk to any device
- Coordinator can act as a “super router”

XBee as End Devices

- End devices as Optional
- Usually, battery powered
- Can have as many as you want
- Issues a request on start to find a network, it can join a parent device (router or coordinator)
- Can only communicate with its parent

XBee ZB S1 Vs XBee ZB S2 Vs XBee s2c

Specification	XBee ZB S1	XBee ZB S2	XBee ZB S2C
Indoor/Urban range	up to 100 ft. (30m)	up to 133 ft. (40m)	up to 200 ft (60 m)
Outdoor RF line-of-sight range	up to 300 ft. (100m)	up to 400 ft. (120m)	up to 4000 ft (1200m)
Transmit Power Output	1 mW (0dbm)	2 mW (+3dbm)	6.3mW (+8dBm) Boost mode
			3.1mW (+ddBm) Normal mode
RF Data Rate	250 Kbps	250 Kbps	250 Kbps
Receiver Sensitivity	-92dBm (1% PER)	-98dBm (1% PER)	-102dBm (1% PER) Boost mode
			-100dBm (1% PER) Normal Mode

XBee ZB S1 Vs XBee ZB S2 Vs XBee s2c

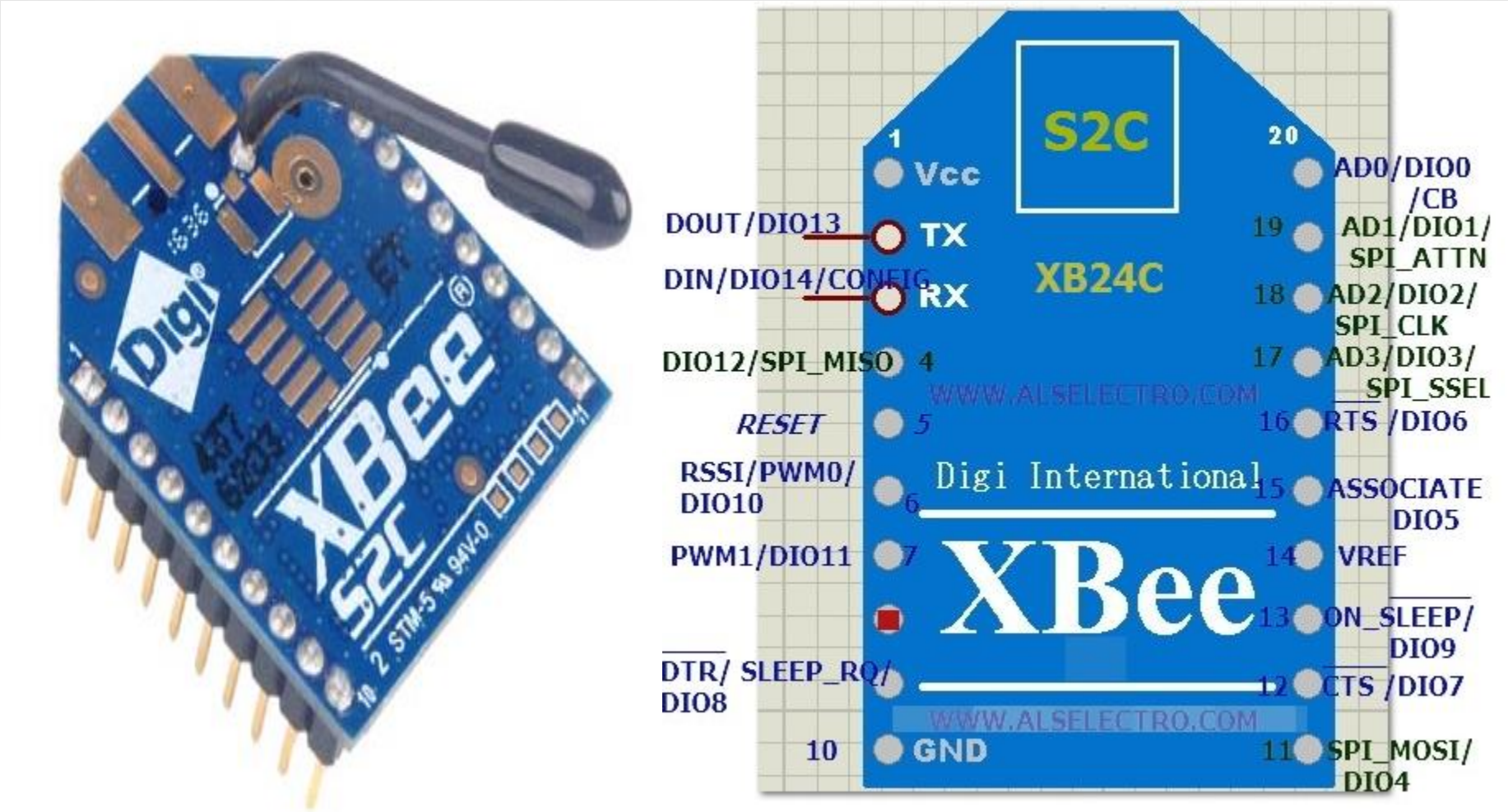
Supply Voltage	2.8 - 3.4 V	2.8 - 3.6 V	2.1 - 3.6V
Transmit Current (typical)	45 mA (@ 3.3 V)	40 mA (@ 3.3 V)	45 mA (+8dBm) Boost Mode
			33 mA (+5dBm) Normal Mode
Idle/Receive Current (typical)	50 mA (@ 3.3 V)	40 mA (@ 3.3 V)	31 mA (+8dBm) Boost Mode
			28 mA (+5dBm) Normal Mode
Power-down Current	10 uA	1 uA	<1uA
Frequency	ISM 2.4 GHz	ISM 2.4 GHz	ISM 2.4 GHz

XBee ZB S1 Vs XBee ZB S2 Vs XBee s2c

Network Topologies	Point to point, Star, Mesh (with DigiMesh firmware)	Point to point, Star, Mesh	Point to point, Star, Mesh
Number of Channels	16 Direct Sequence Channels	16 Direct Sequence Channels	16 Direct Sequence Channels
Filtration Options	PAN ID, Channel & Source/Destination	PAN ID, Channel & Source/Destination	PAN ID, Channel & Source/Destination

https://www.digi.com/support/knowledge-base/the-major-differences-in-the-xbee-series-1-vs-the

XBee s2c Pin out Diagram



Pin signals for XBee s2c

Pin	Name	Direction	Description
1	VCC		Power supply
2	DOUT	Output	UART data out
3	DIN/CONFIG	Input	UART data In
4	DIO12/SPI_MISO	Both	Digital I/O 12 / Serial Peripheral Interface (SPI) Data Out
5	RESET	Input	Module reset (reset pulse must be at least 200 ns). This must be driven as an open drain/collector. The device drives this line low when a reset occurs. Never drive this line high.
6	DIO10/PWM0/RSSI PWM	Both	Digital I/O 10 / PWM output 0 / RX signal strength indicator
7	DIO11/PWM1	Both	Digital I/O 11 / PWM output 1
8	[Reserved] - Do not connect		
9	DIO8/SLEEP_ RQ/DTR	Both	Digital I/O 8 / Pin sleep control line
10	GND		Ground
11	DIO4/SPI_MOSI	Both	Digital I/O 4 / SPI Data In
12	DIO7/CTS	Both	Digital I/O 7 / Clear-to-send flow control
13	ON/SLEEP	Output	Device sleep status indicator
14	VREF		Feature not supported on this device. Used on other XBee devices for analog voltage reference.

Pin signals for XBee s2c Cont..

Pin	Name	Direction	Description
15	DIO5/ASSOC	Both	Digital I/O 5 / Associated indicator
16	DIO6/RTS	Both	Digital I/O 6 / Request-to-send flow control
17	DIO3/AD3/SPI_ SSEL	Both	Digital I/O 3 / Analog input 3 / SPI select
18	DIO2/AD2/SPI_CLK	Both	Digital I/O 2 / Analog input 2 / SPI clock
19	DIO1/AD1/SPI_ ATTN	Both	Digital I/O 1 / Analog input 1 / SPI Attention
20	DIO0/AD0	Both	Digital I/O 0 / Analog input 0

Troubleshooting

- Only use 3.3V, more than 5V will release magic smoke
- Use decoupling capacitors with a voltage regulator
- TX->RX
- RX->TX
- Don't overwhelm them, try putting in a small delay

Firmware

- Must install with X-CTU (on Windows)
- API firmware
- Coordinator, Router, End Device
- Each Firmware has different settings

Thank You

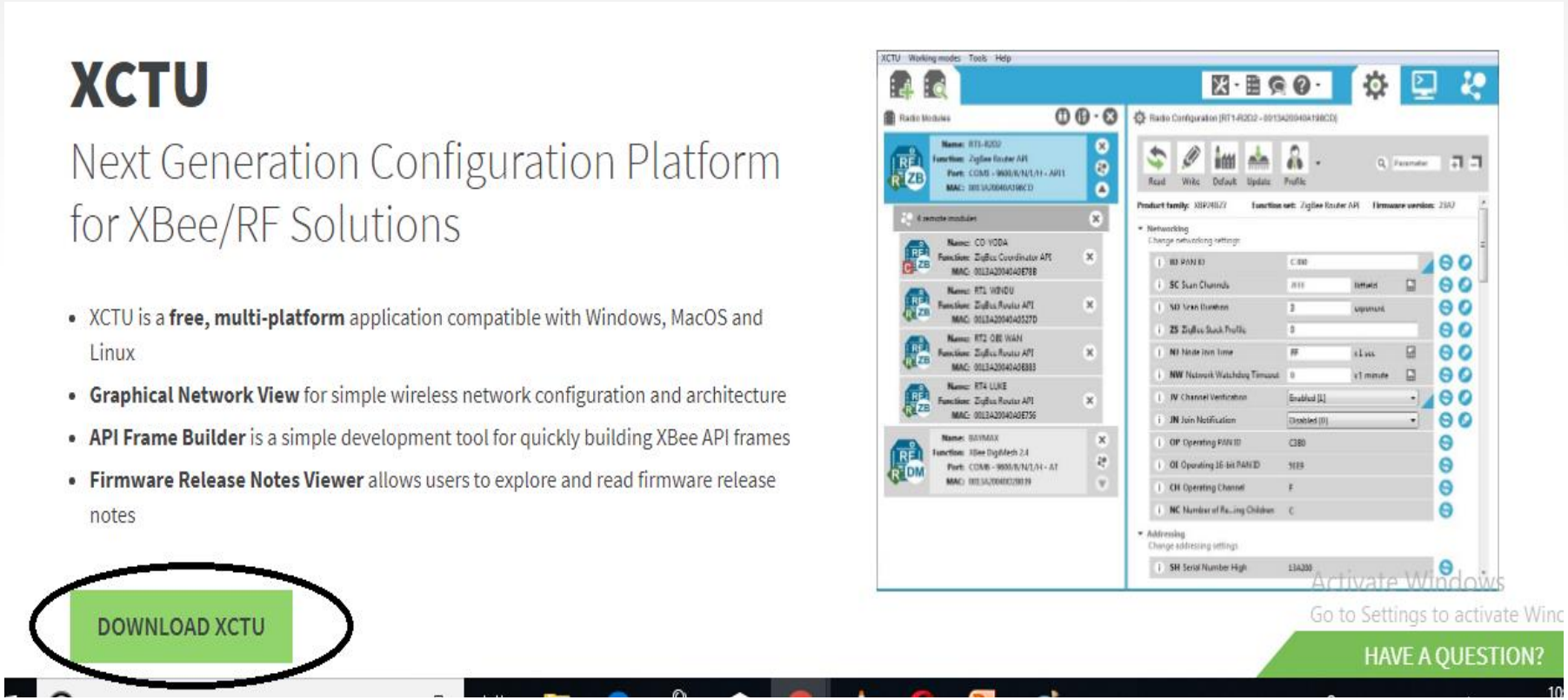
https://www.robolab.in/zigbee-xbee-s2c-how-to-configure-as-coordinator-router-end-device/

Getting Started With XCTU

Installation of XCTU

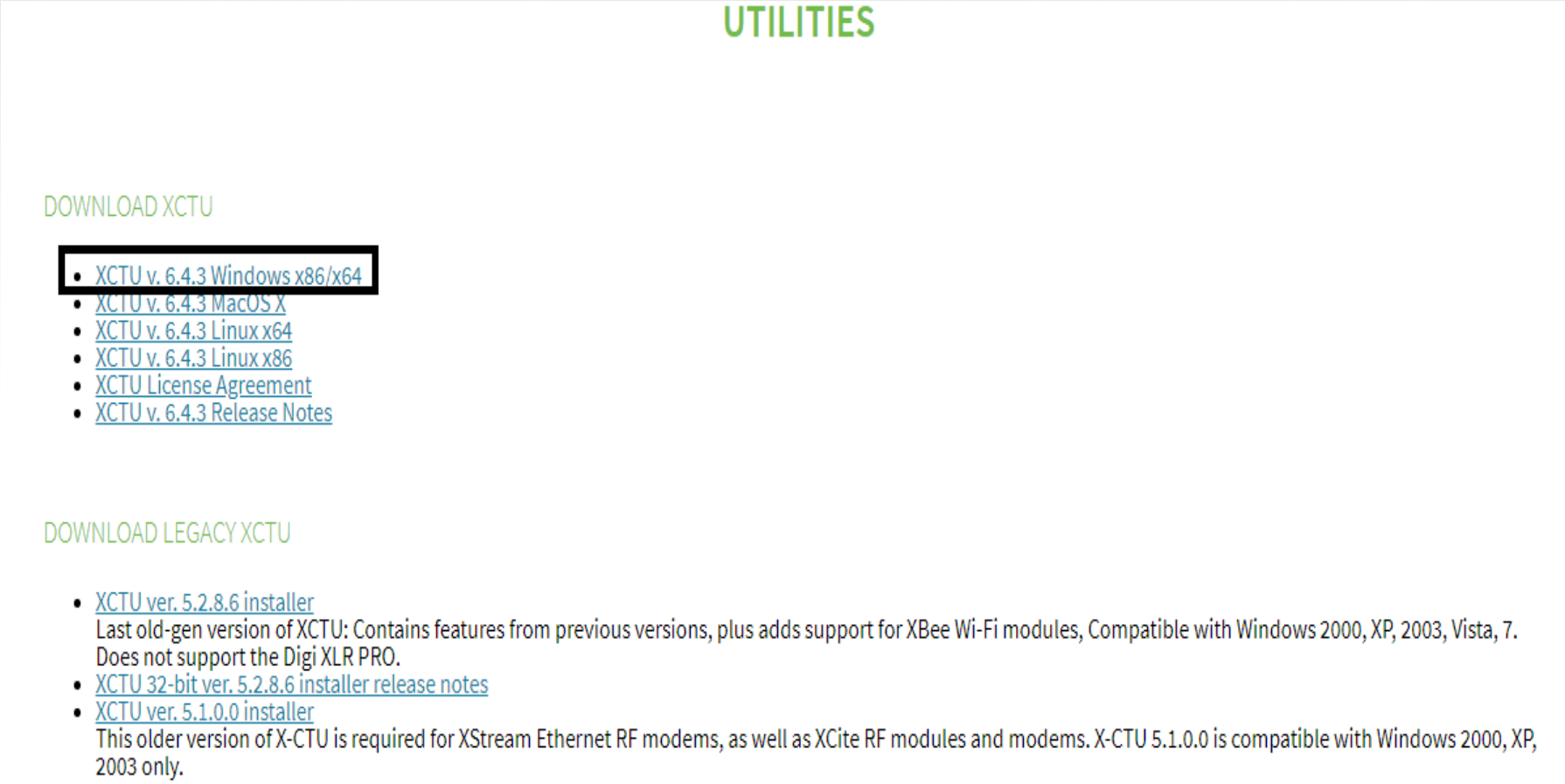
- Step 1: Click on the link :

  https://www.digi.com/products/embedded-systems/digi-xbee-tools/xctu
- Click on Download XCTU



Installation of XCTU Cont..

Step 2: You can download XCTU software for windows x86/x64, Linux x64/x86 and mac os x. Click on XCTUv6.4.3 windows x86/x64.

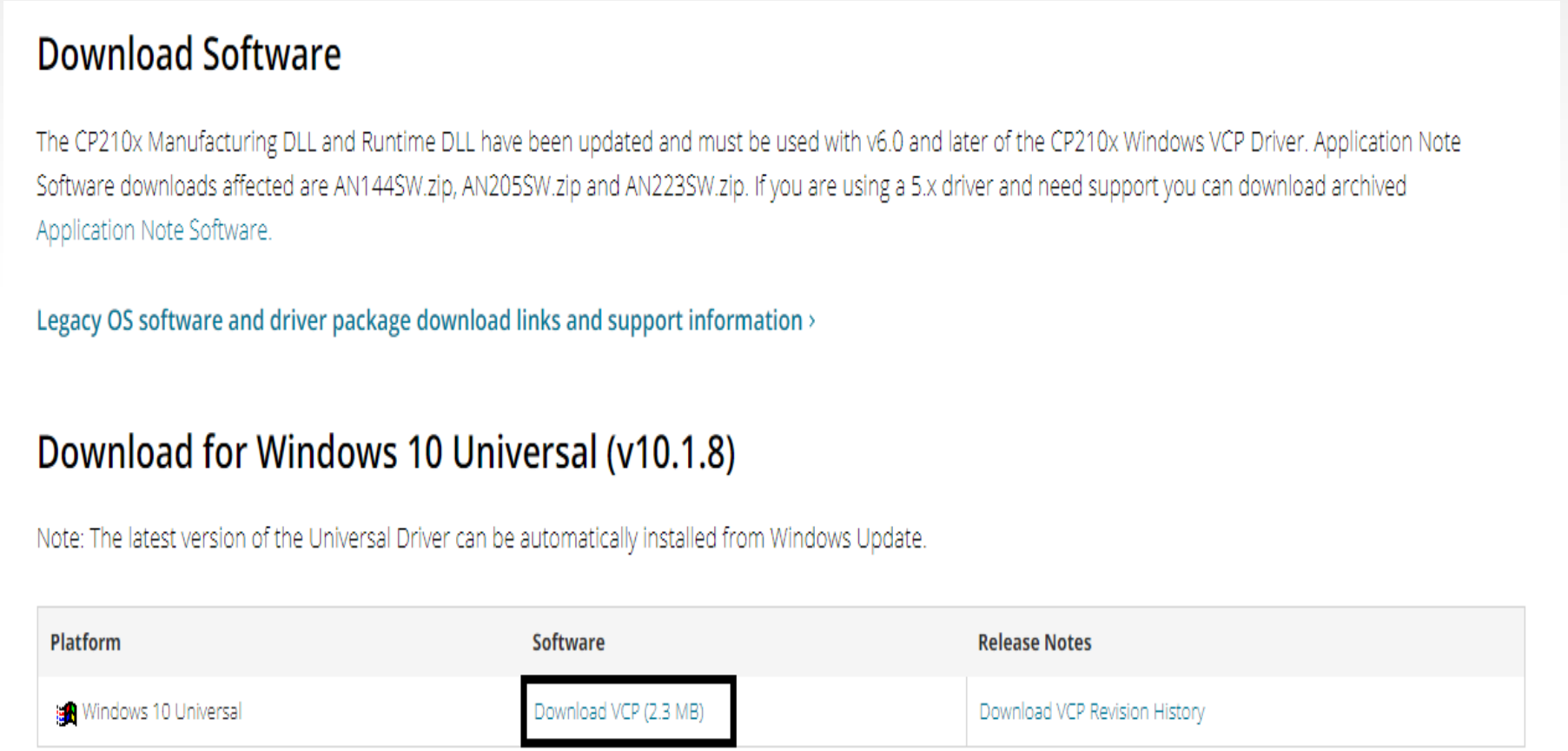


Installation of USB driver for XBee Cont..

- Step 1: Click on link

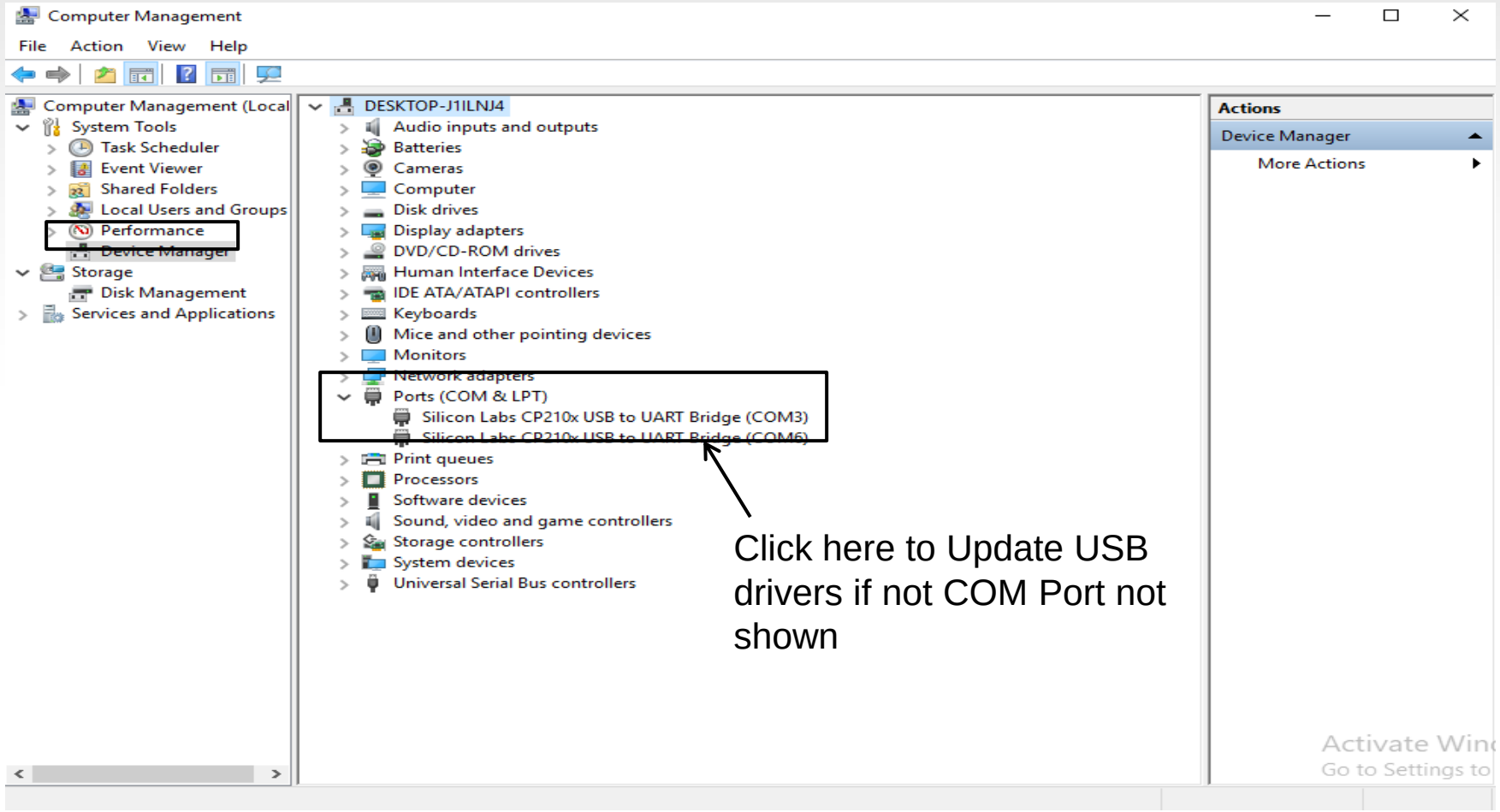
https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers

- To download USB drivers-→ Clink on Download VCP(23MB)



Update USB driver for XBee

- Step 2: Check USB drivers for XBee. Go to Right click on My Computer--> open computer Management → click on Device Manager → and check here for USB driver for XBEE i.e. CP210x USB to UART Bridge VCP Drivers



Communication Between Two XBee’s

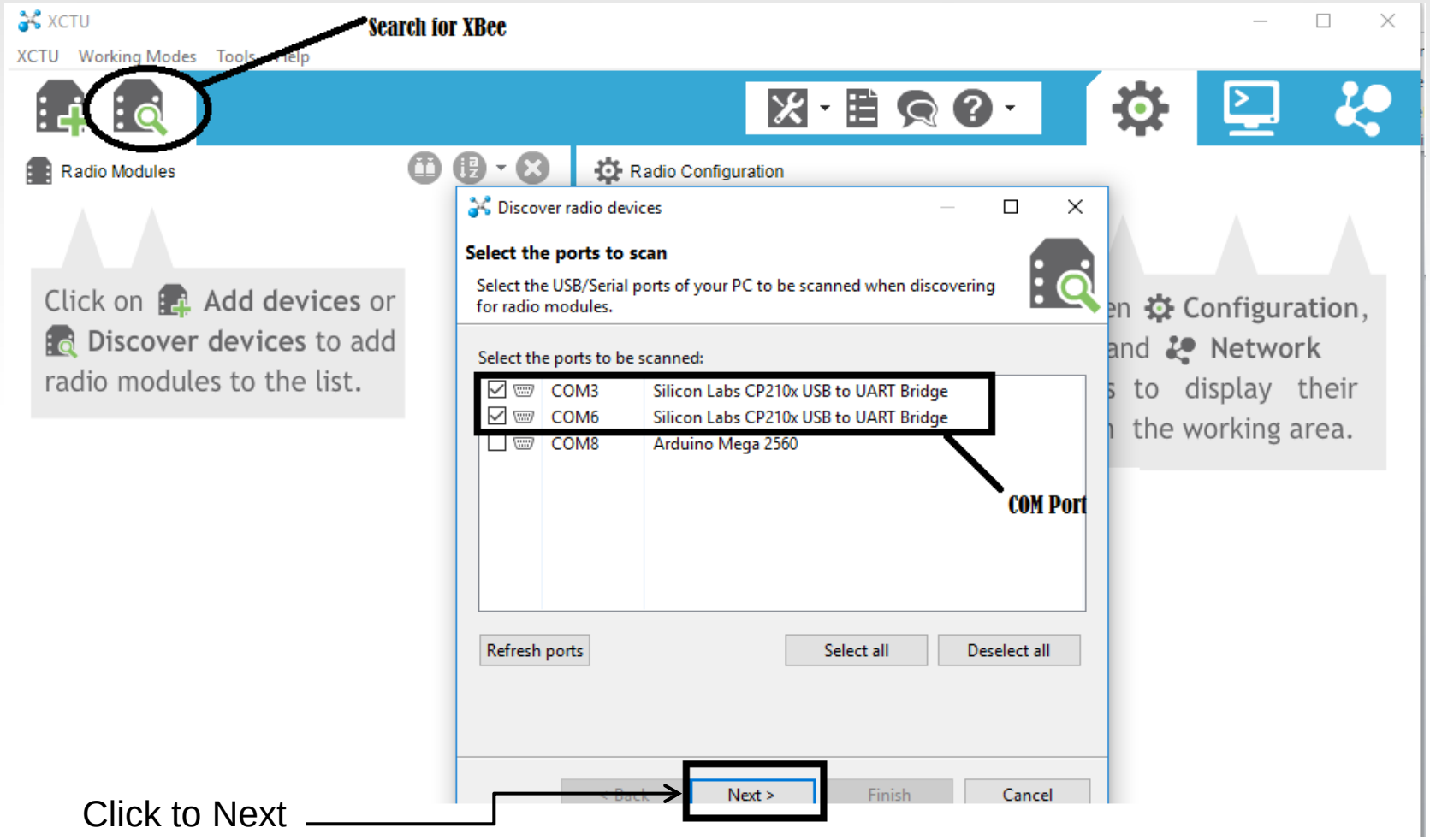
Components Required

- Two XBee s2c with breakout board
- Two USB cables
- One or Two laptop/computer system

Configuration for Coordinator XBee

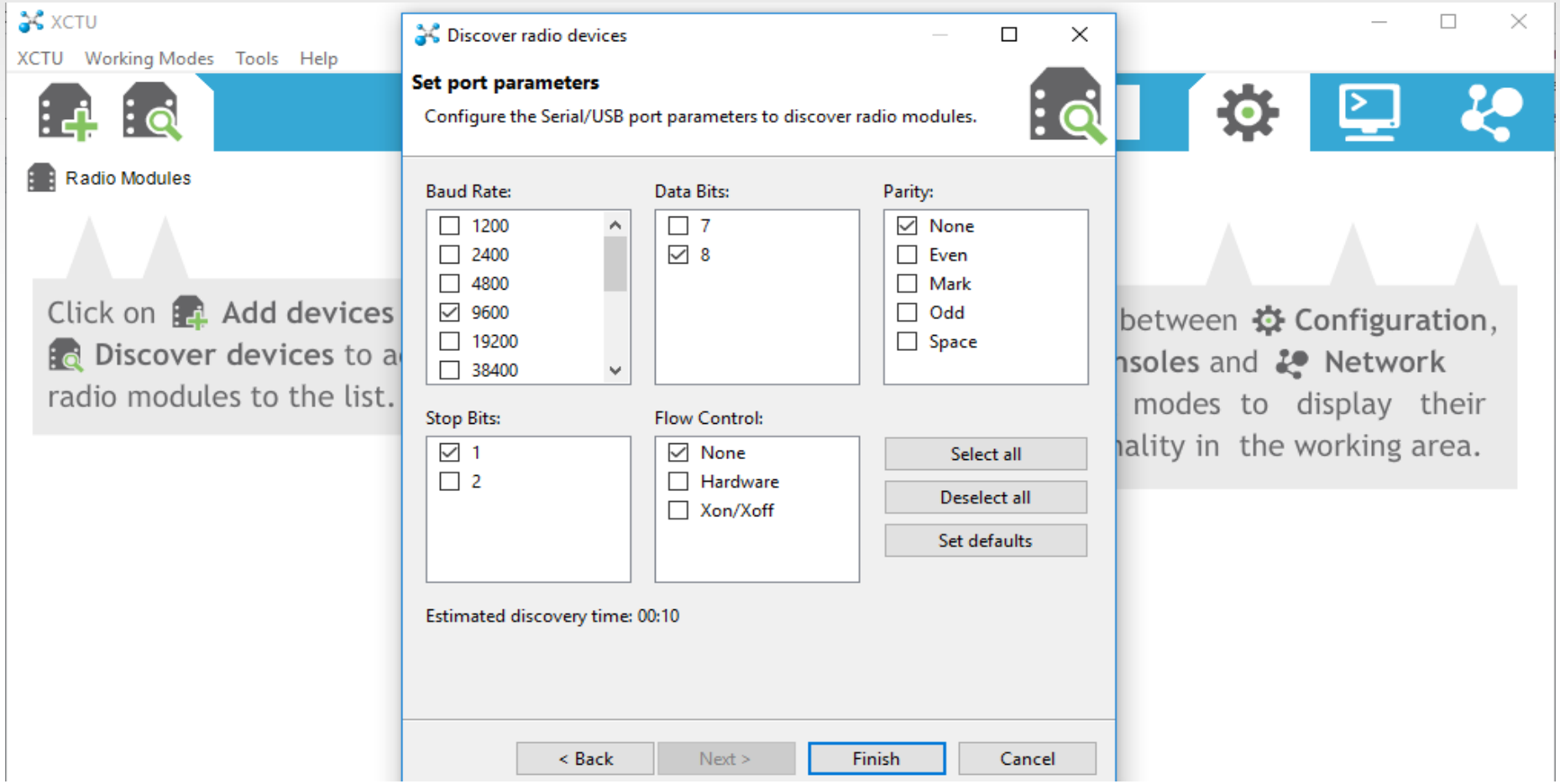
Steps:

1. Open the XCTU software and Click on the SEARCH icon on top to detect the USB ports.



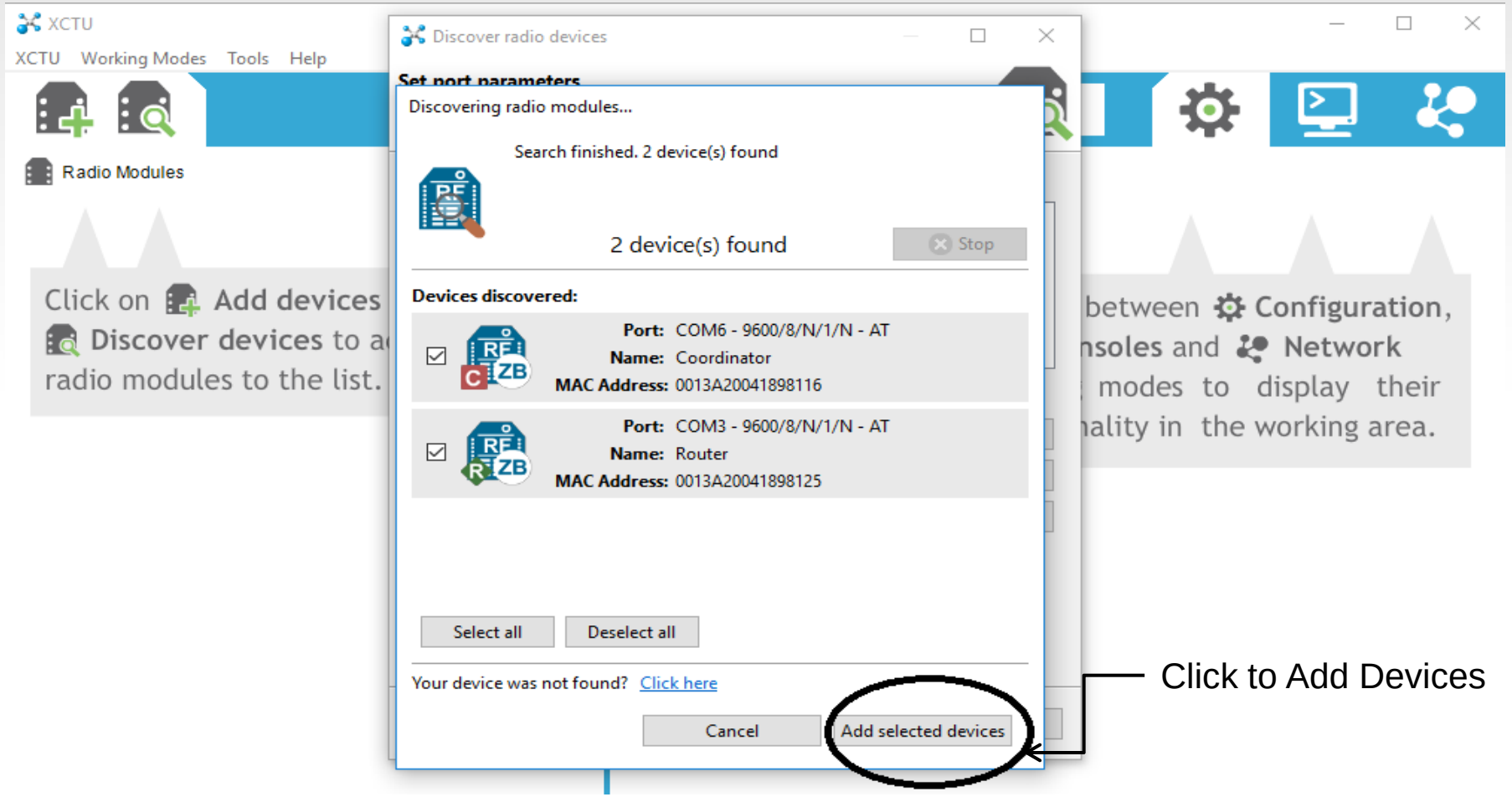
Configuration for Coordinator XBee Cont..

2. Click on NEXT & accept the default PORT PARAMETERS, 9600 is the BAUD RATE, 8 Data Bits, No Parity, Stop bit 1 and Flow Control None. Then Finish.



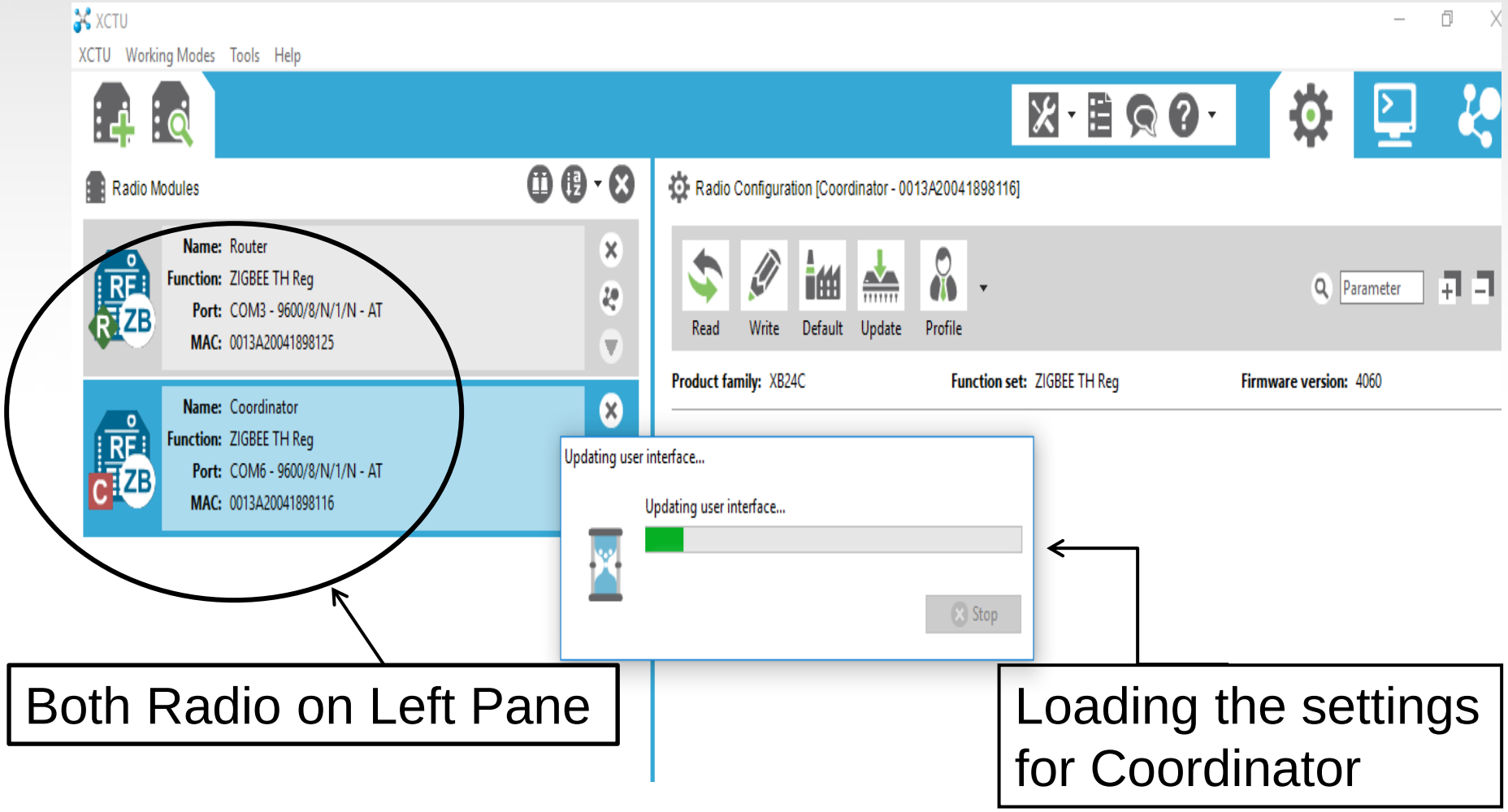
Configuration for Coordinator XBee Cont..

3. The XCTU scans the USB ports selected & lists the RADIOs found with their unique 64-bit address and Select both the devices & click ADD SELECTED DEVICES.



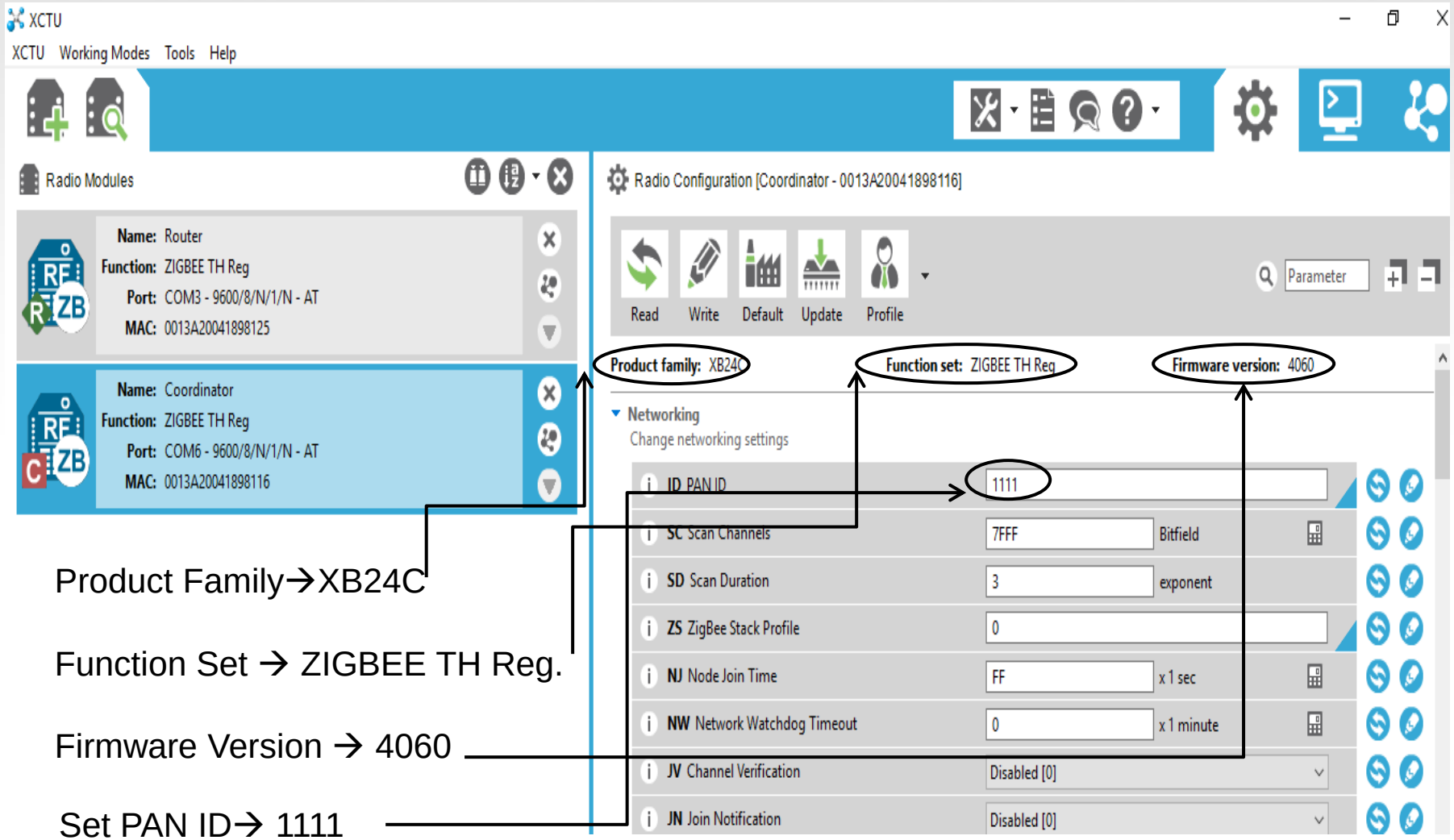
Configuration for Coordinator XBee Cont..

4. Now both the Radios appear on the left pane. Let us configure the RADIO at COM6 as COORDINATOR first and Load the Settings by Clicking on it.

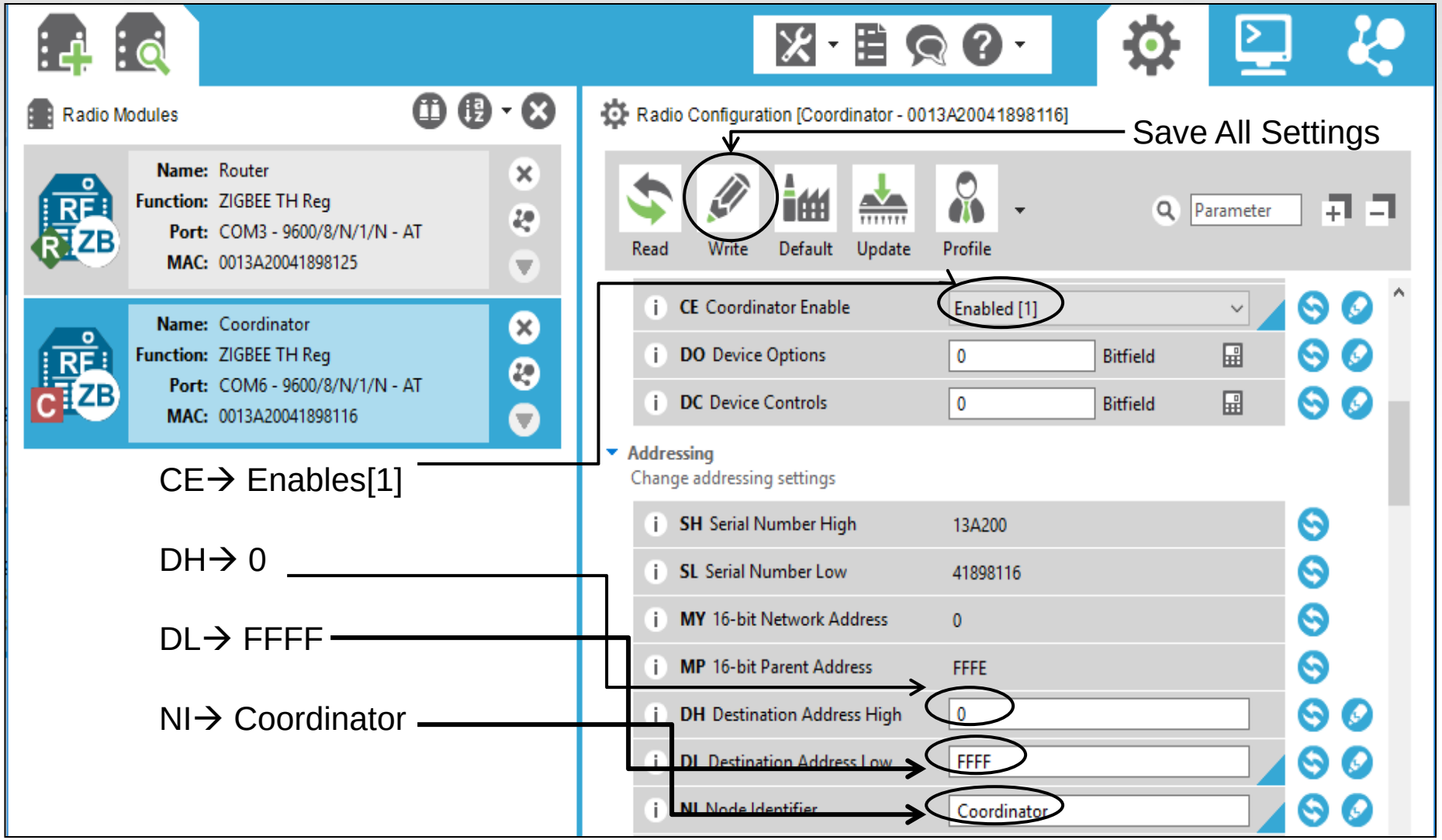


Configuration for Coordinator XBee Cont..

5. 1st thing to set PAN ID of the network, this can be from 0 to FFFF Hex. In my case, it is 1111.

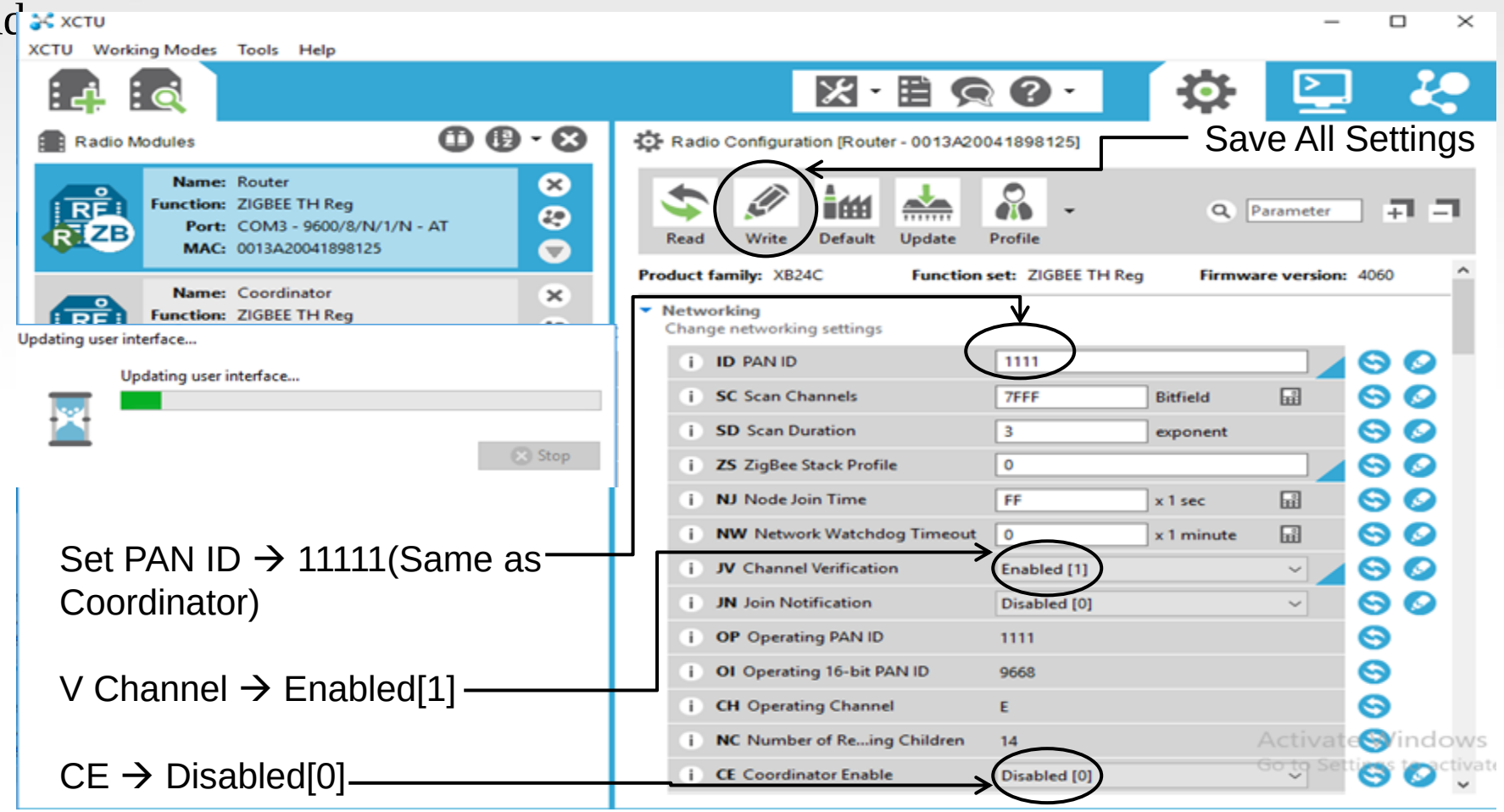


Configuration for Coordinator XBee Cont..



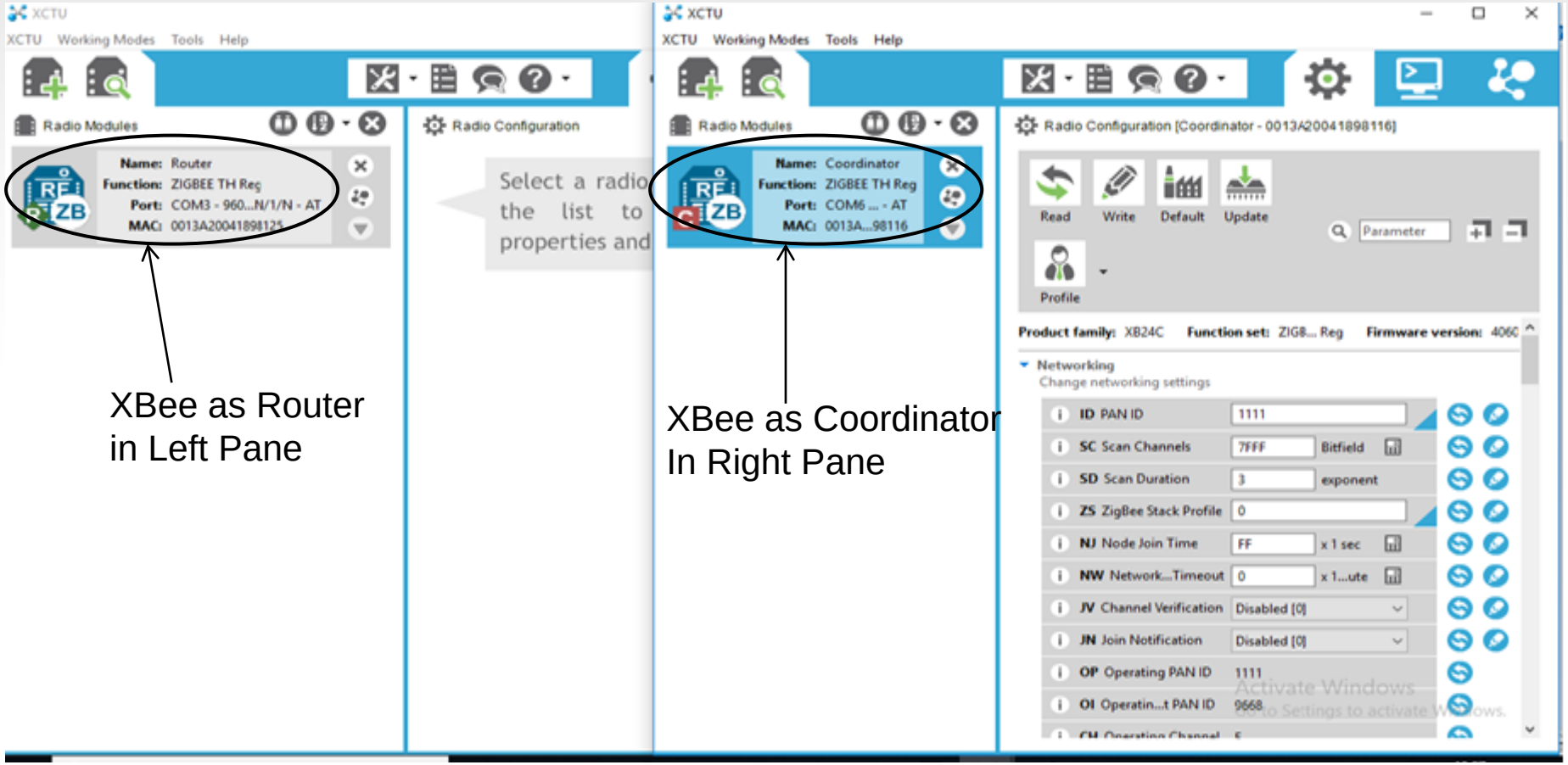
Configuration for Router XBee

Click on the 2nd radio on the left pane to load the setting and then Enter the PANID as 1111 , same as that of Coordinator. JV CHANNEL VERIFICATION is Enabled, CE Coordinator is DISABLED, Destination Address DL is left to default 0, and NI (Node Identifier) as " ROUTER". Now Click on WRITE button to save the changes mad



Communication Between Coordinator and Router

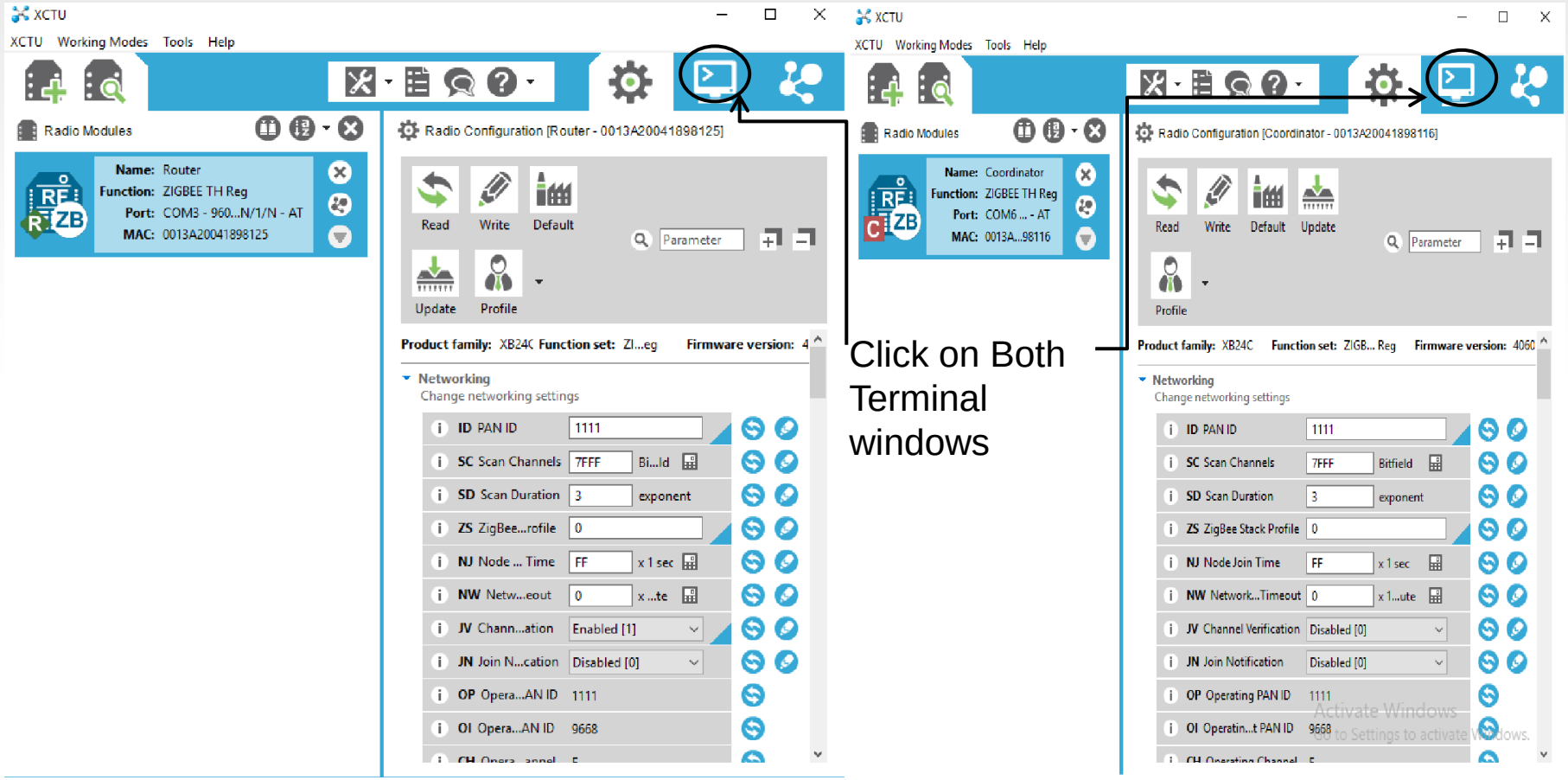
1. The modules are paired and ready for communication. Now let us test the communication on the XCTU window delete the second Radio. Click on the first Radio to load the settings.



Communication Between Coordinator and Router

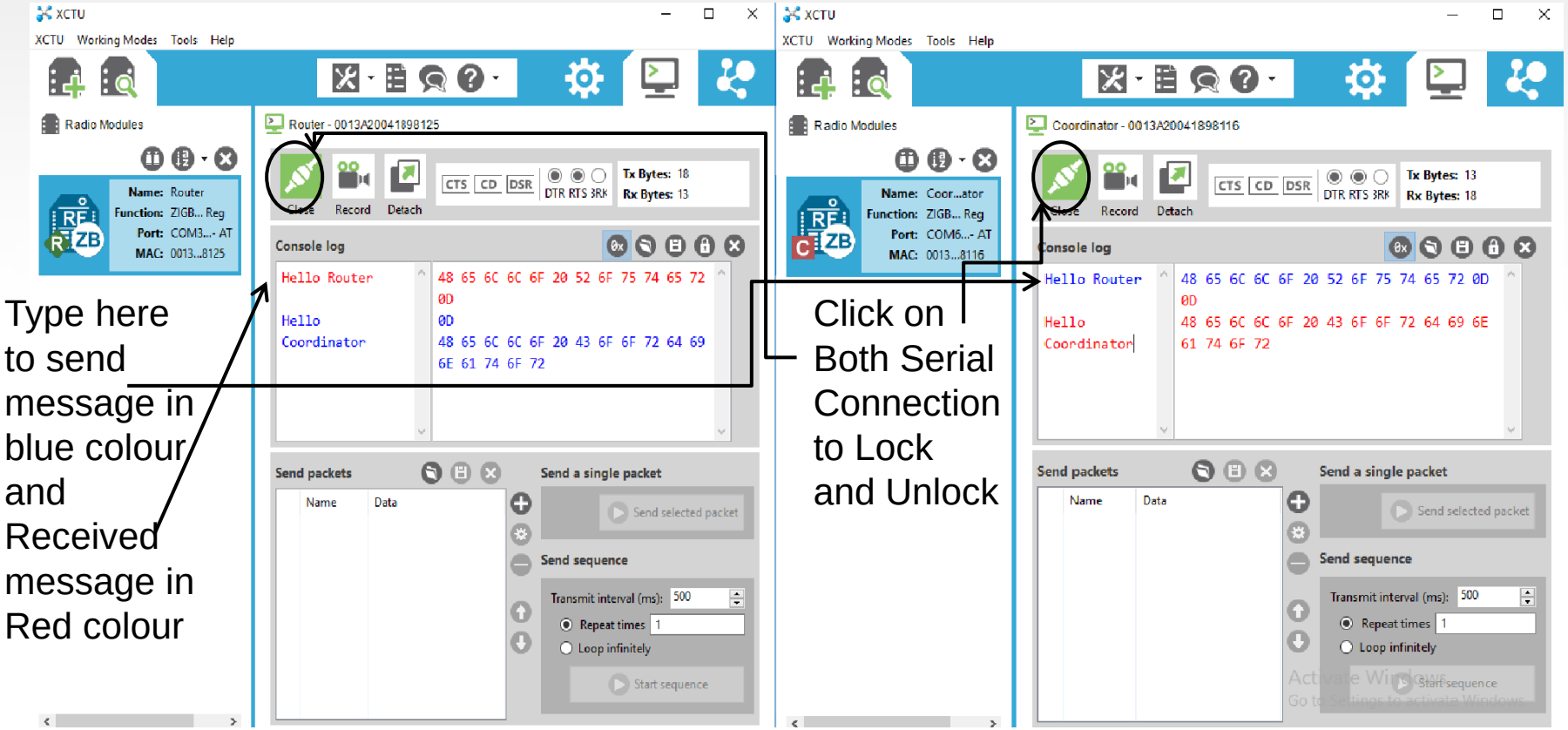
2. Click the TERMINAL icon on both the windows to enter Terminal mode. Click on the SERIAL CONNECTION icon on both the windows to enter the serial connection mode.

.



Communication Between Coordinator and Router

3. You can see the SERIAL Icon in LOCK mode & the AT CONSOLE Status changes to CONNECTED. Now you can type any message inside console log window & see that received on the other Radio. The transmit message is in BLUE & received message in RED.



Communication Between XBee and Ultrasonic Sensor Using Arduino

Component Required

- Two XBee s2c with breakout board
- Two USB cables
- One Arduino Mega-2560 board
- Jumper wires
- One/Two laptops/computer systems
- One Ultrasonic sensor

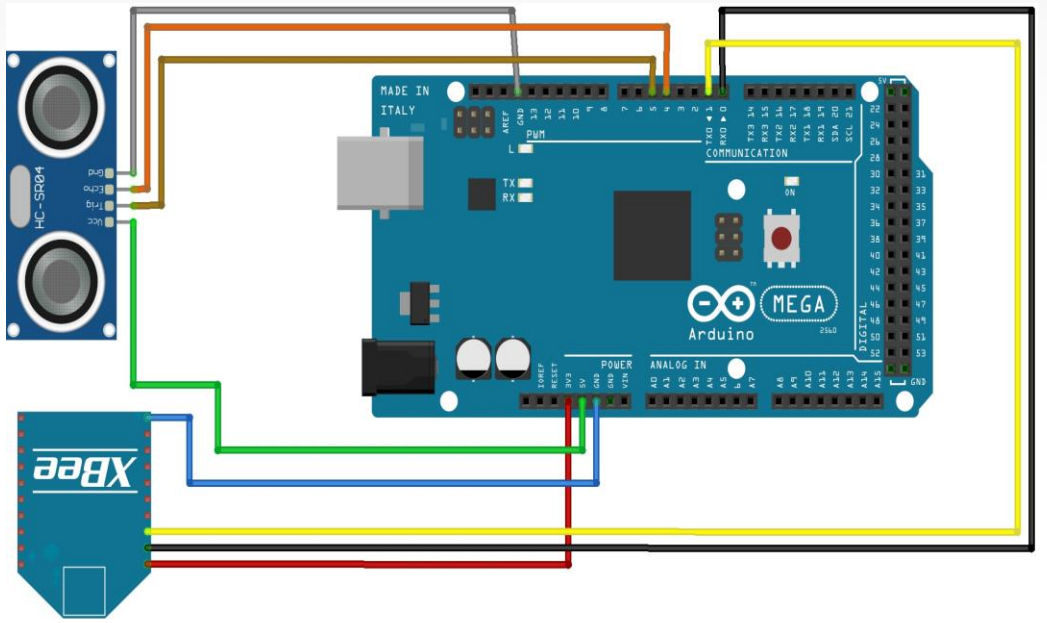
Installation of Arduino IDE

- Must installed XCTU software for configuration of XBee.
- Must installed Arduino IDE for configuration of Arduino mega- 2560 board and also programmed it.

  https://www.arduino.cc/en/main/software

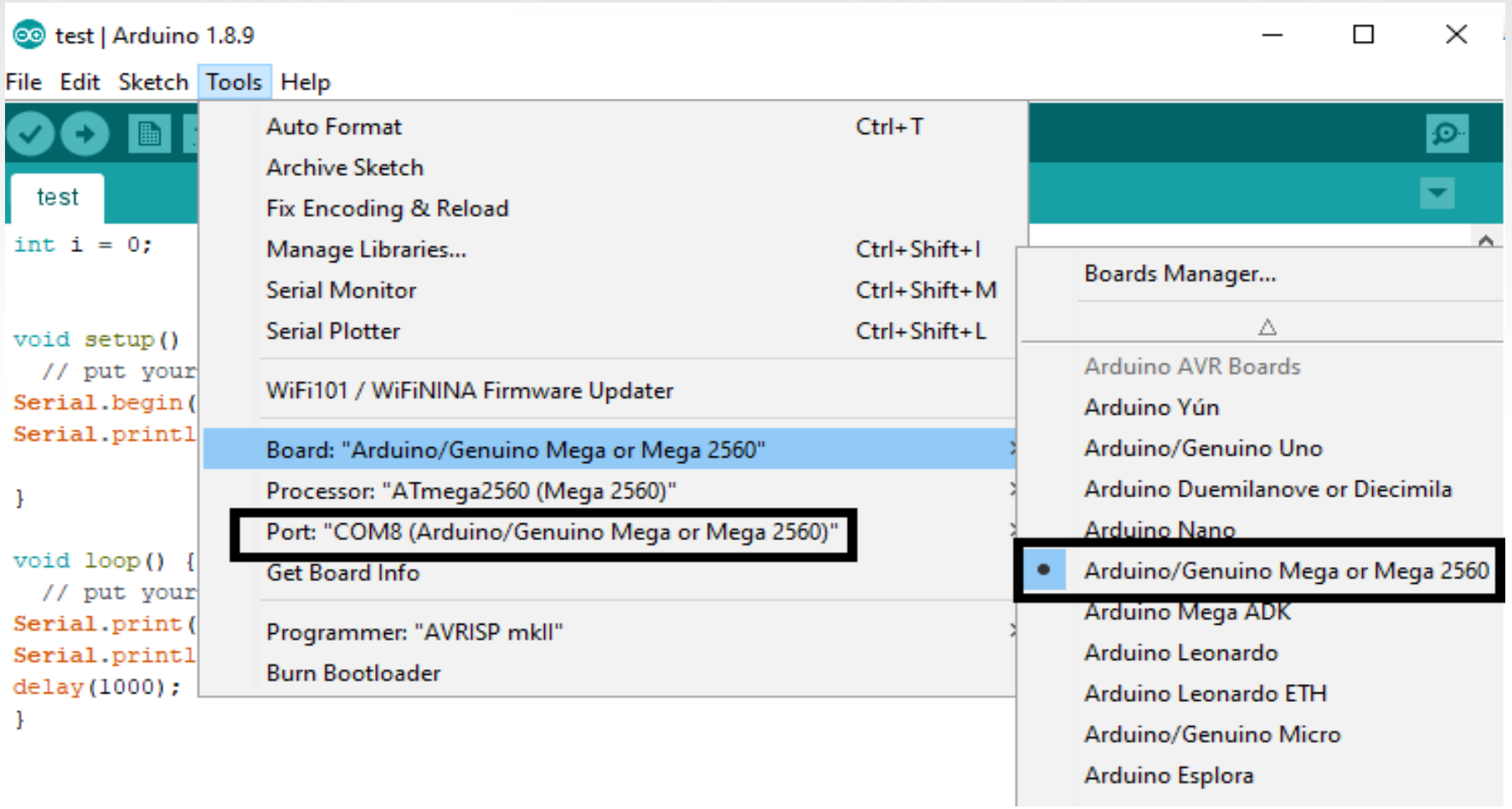
Connections Between XBee, Arduino Mega and Ultrasonic Sensor

- After installation XTCU software and Arduino ide
- Now make the connections between XBee, Arduino mega and ultrasonic sensor.
- 3vcc of XBee to 3vcc of Arduino mega
- Pin 2-TX , Pin 3-RX of XBee to RX0-0,
  TX0-1 of Arduino Mega
- GND- XBee to GND -AM
- 5VCC of Ultrasonic sensor to 5vcc-AM
- GND- US to GND-AM
- TRIG and Echo to Pin 5 and 4 resp.



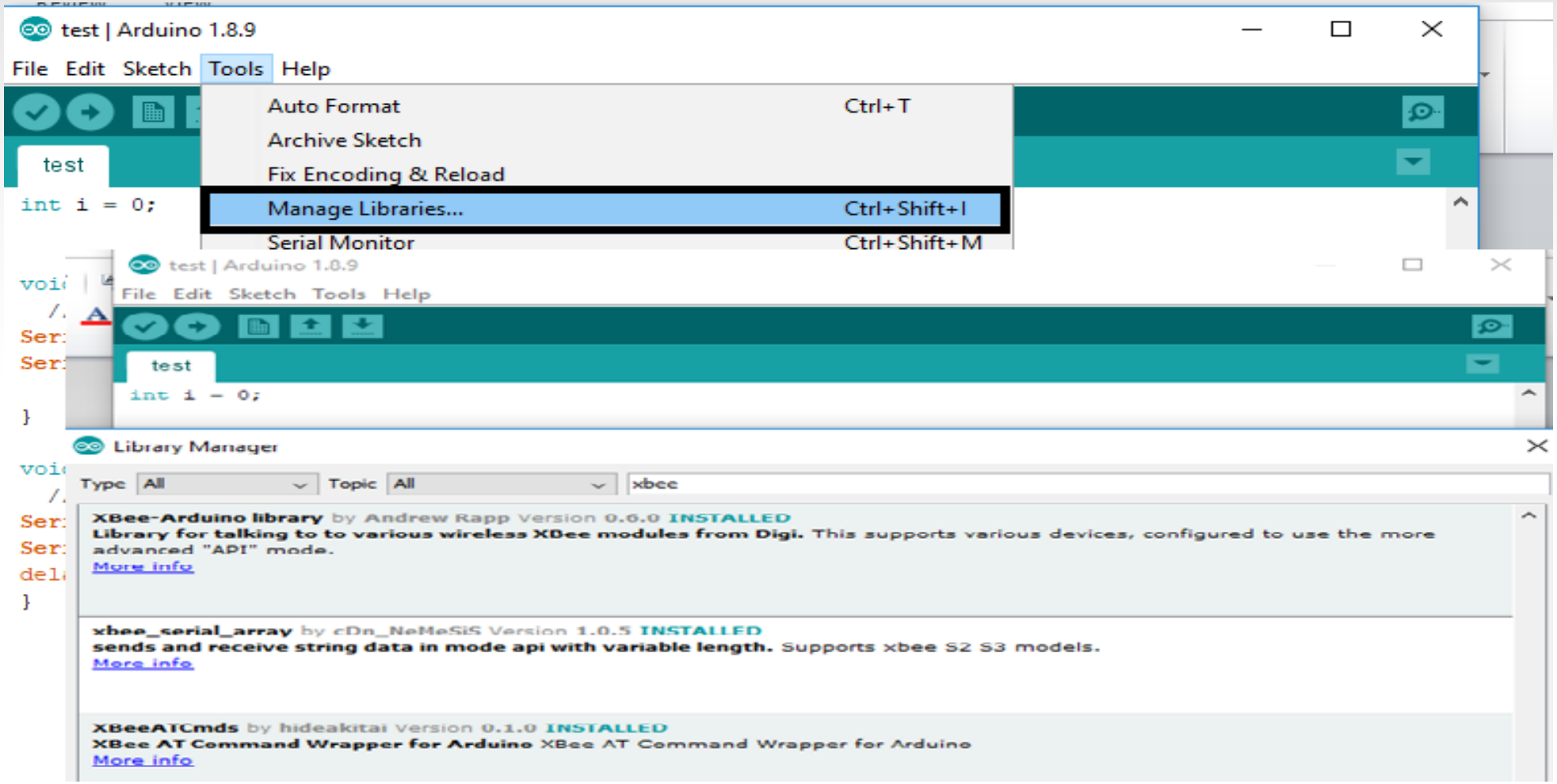
Configuration on Arduino IDE

- Click on tool → board → Arduino Mega 2560 and port -→COM8



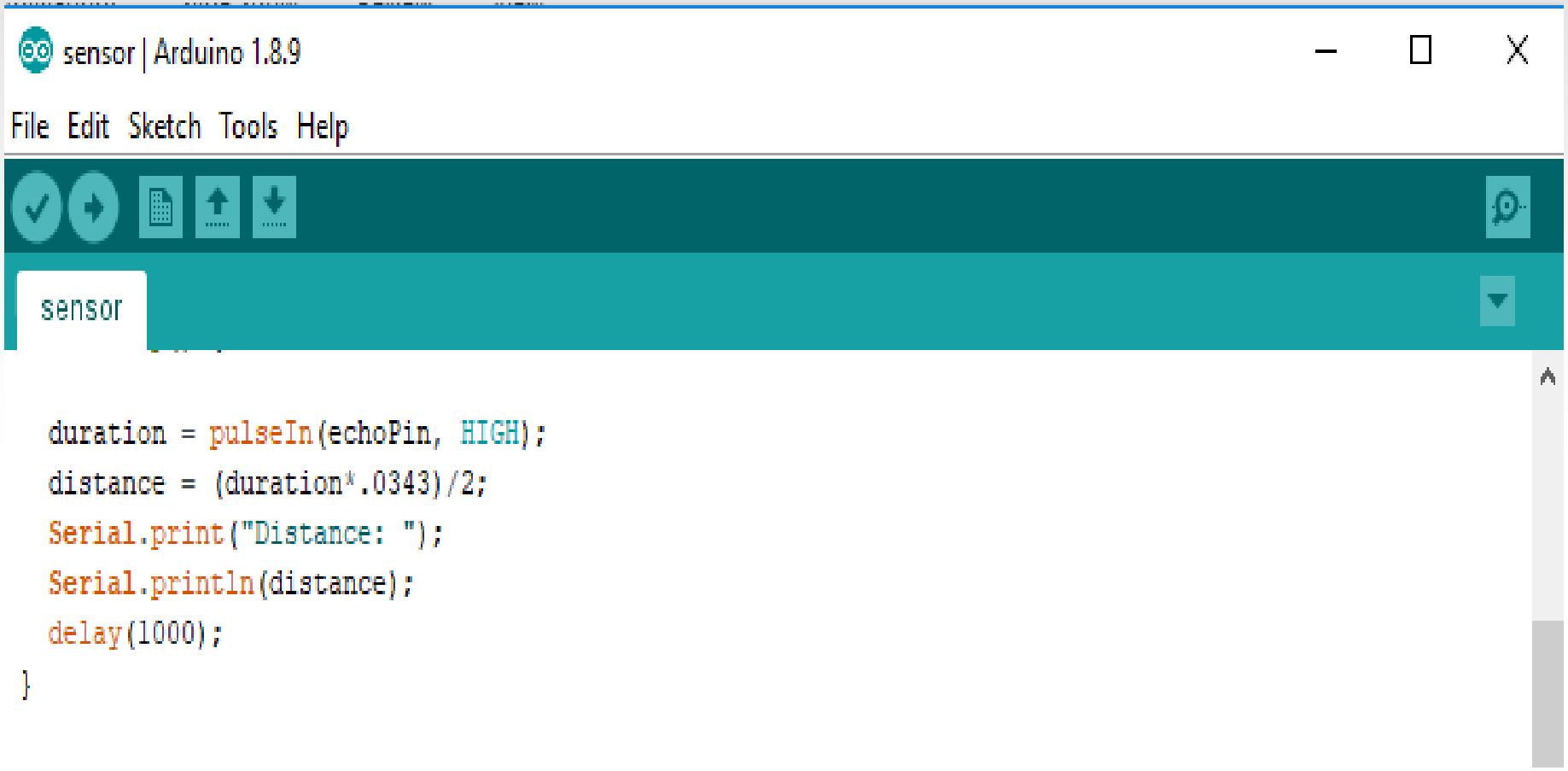
Manage Libraries on Arduino IDE

- Then install XBee library by click on tool -→ manage library → search XBee library → XBee – Arduino library by Andrew Rapp, xbee_serial_array by cDn_NeMesis and XBeeATCmds by hideakitai .



Code for Communication with Ultrasonic sensor

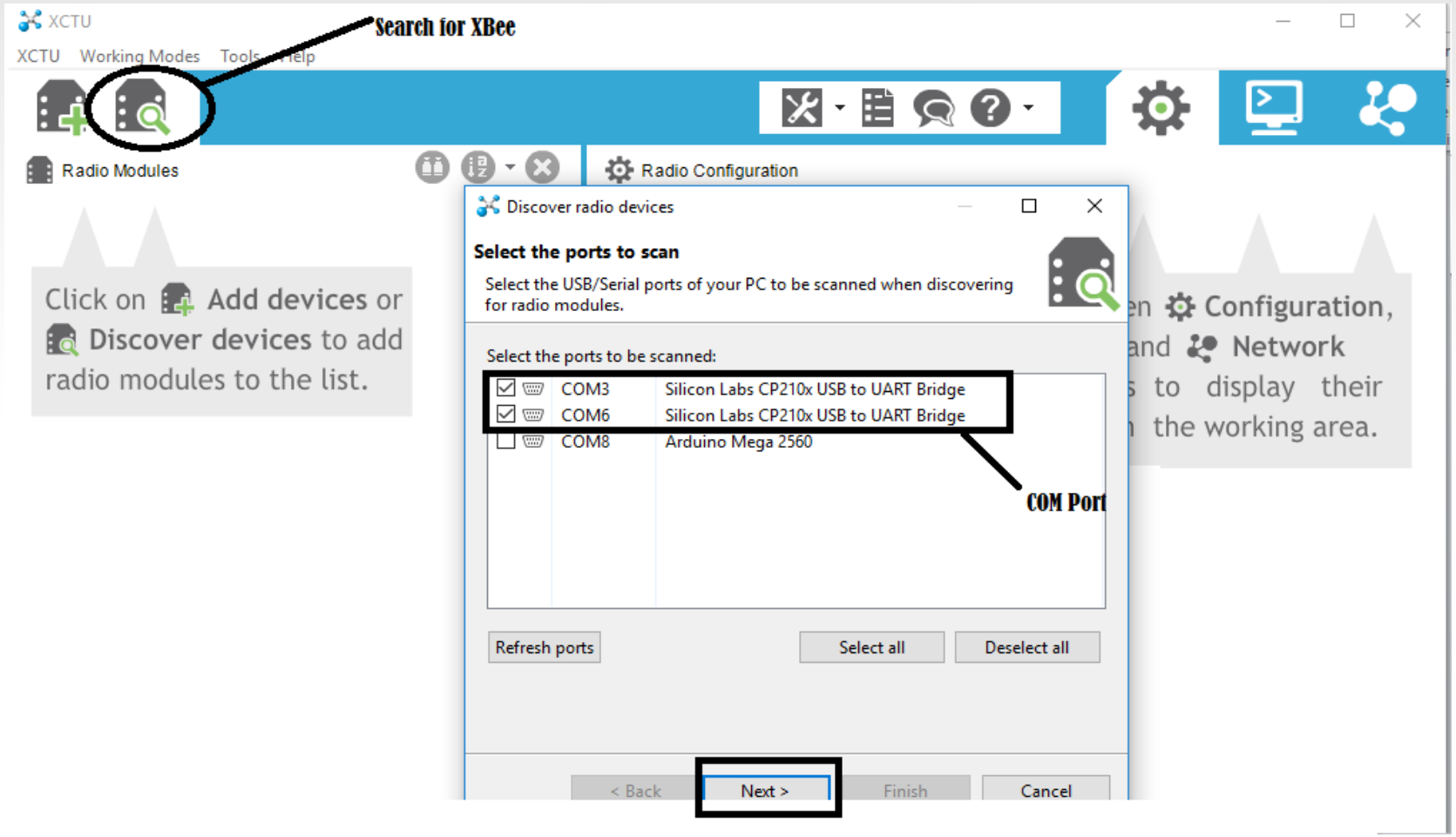
Code for Communication with Ultrasonic Sensor Cont..



Configuration of XBee using XCTU

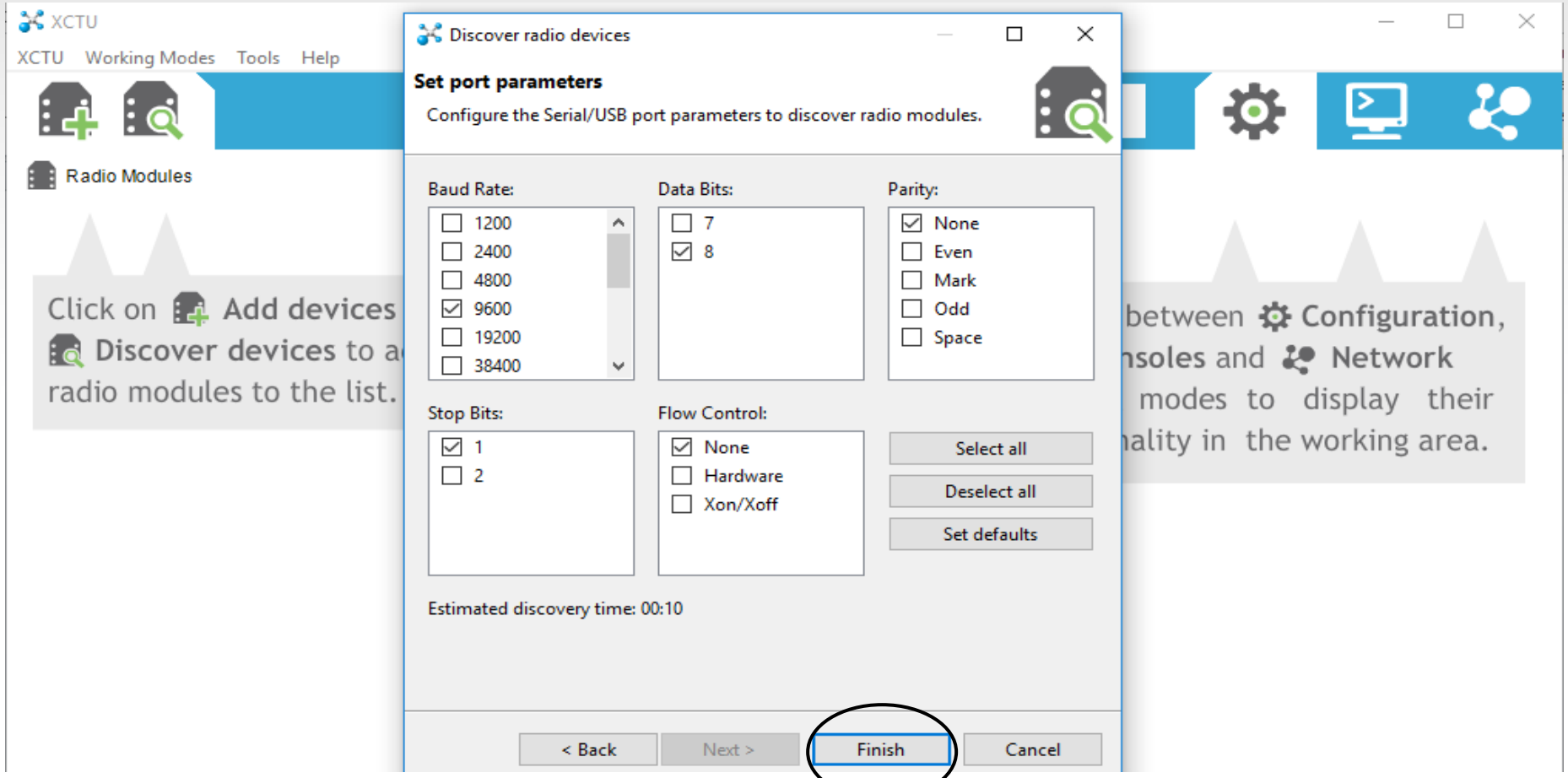
Steps:

1. Open the XCTU software and Click on the SEARCH icon on top to detect the USB ports.



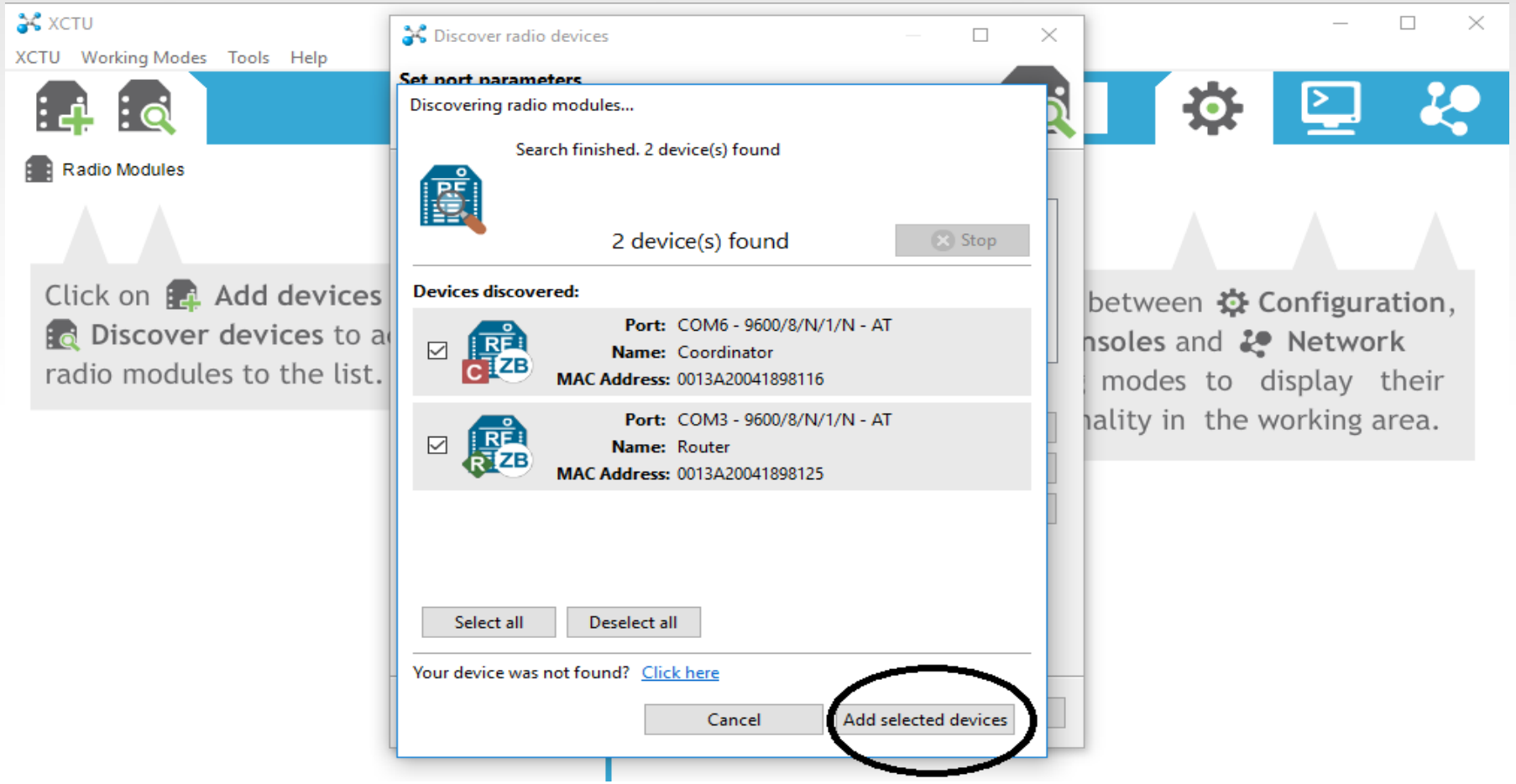
Configuration of XBee using XCTU Cont..

2. Click on NEXT & accept the default PORT PARAMETERS, 9600 is the BAUD RATE, 8 Data Bits, No Parity, Stop bit 1 and Flow Control None and then Finish.



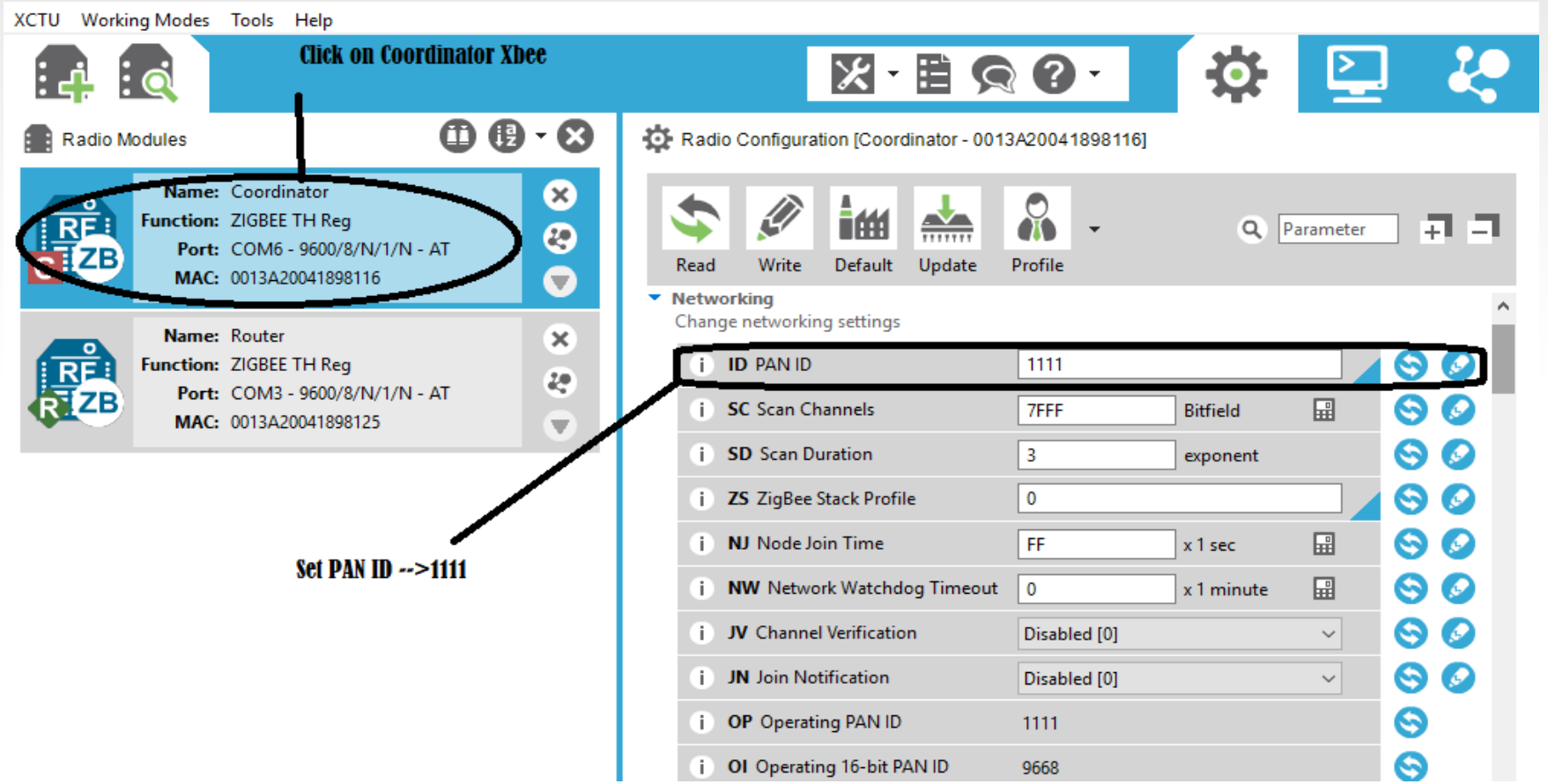
Configuration of XBee using XCTU Cont..

3. The XCTU scans the USB ports selected & lists the RADIOs found with their unique 64-bit address and Select both the devices & click ADD SELECTED DEVICES.



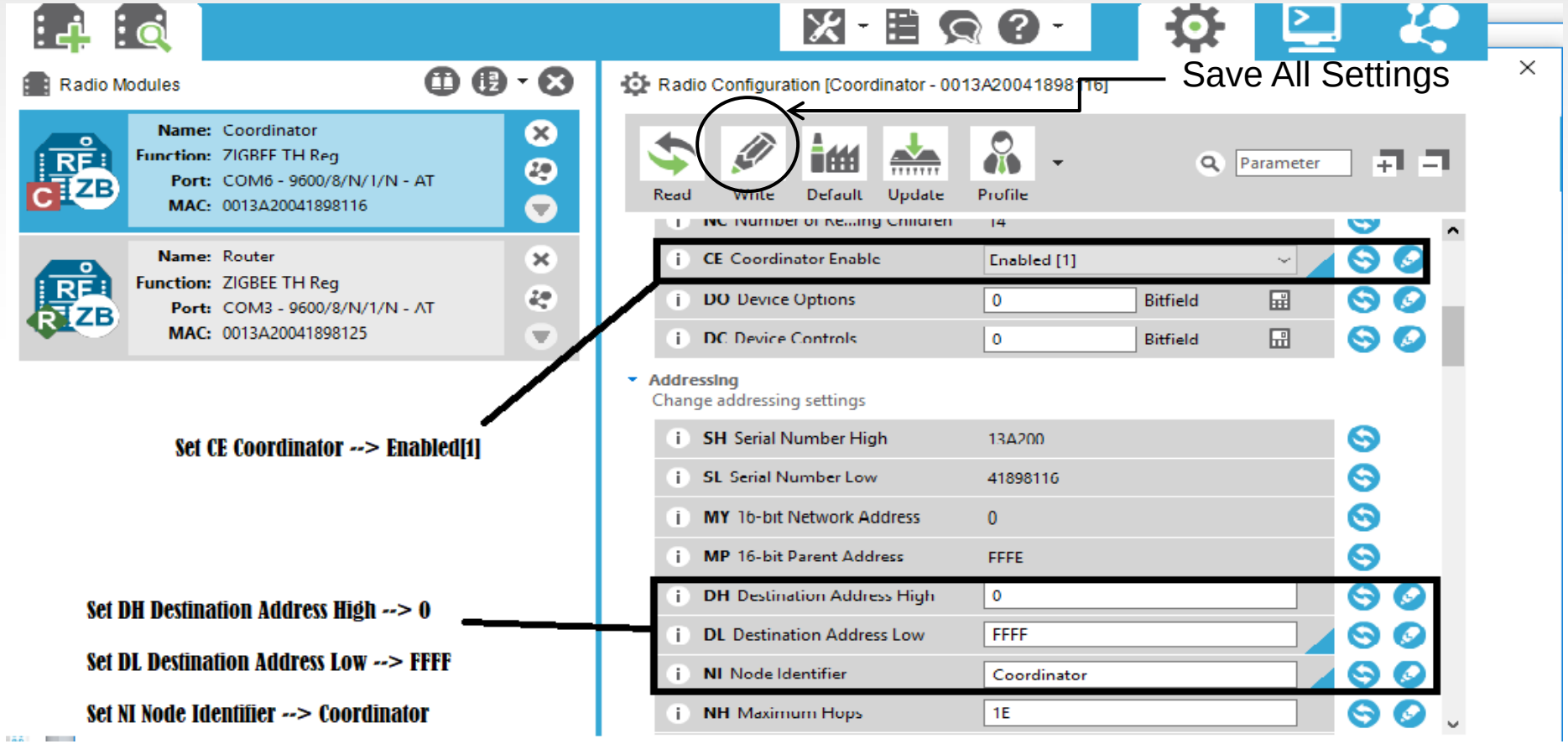
Configuration of Coordinator XBee using XCTU

4. Now both the Radios appear on the left pane. Let us configure the RADIO at COM6 as COORDINATOR first and Load the Settings by Clicking on it and then set the PAN ID -→ 1111



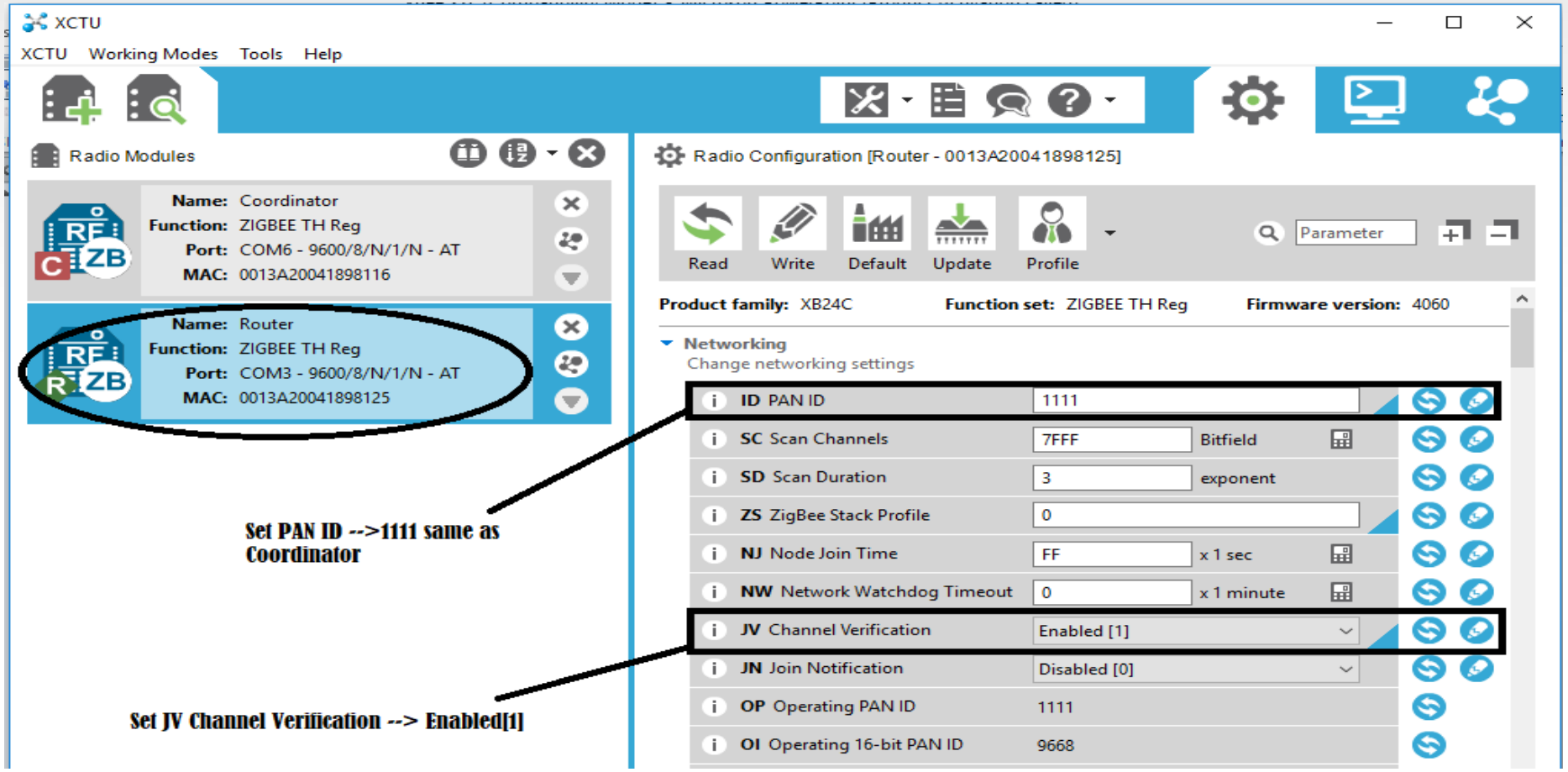
Configuration of Coordinator XBee using XCTU Cont..

5. Scroll Down and set CE → Enabled[1], Set DH, DL →0,FFFF and Set NI → Coordinator and then Click on the PENCIL icon on top to WRITE the changes made. This is done with Coordinator configuration.



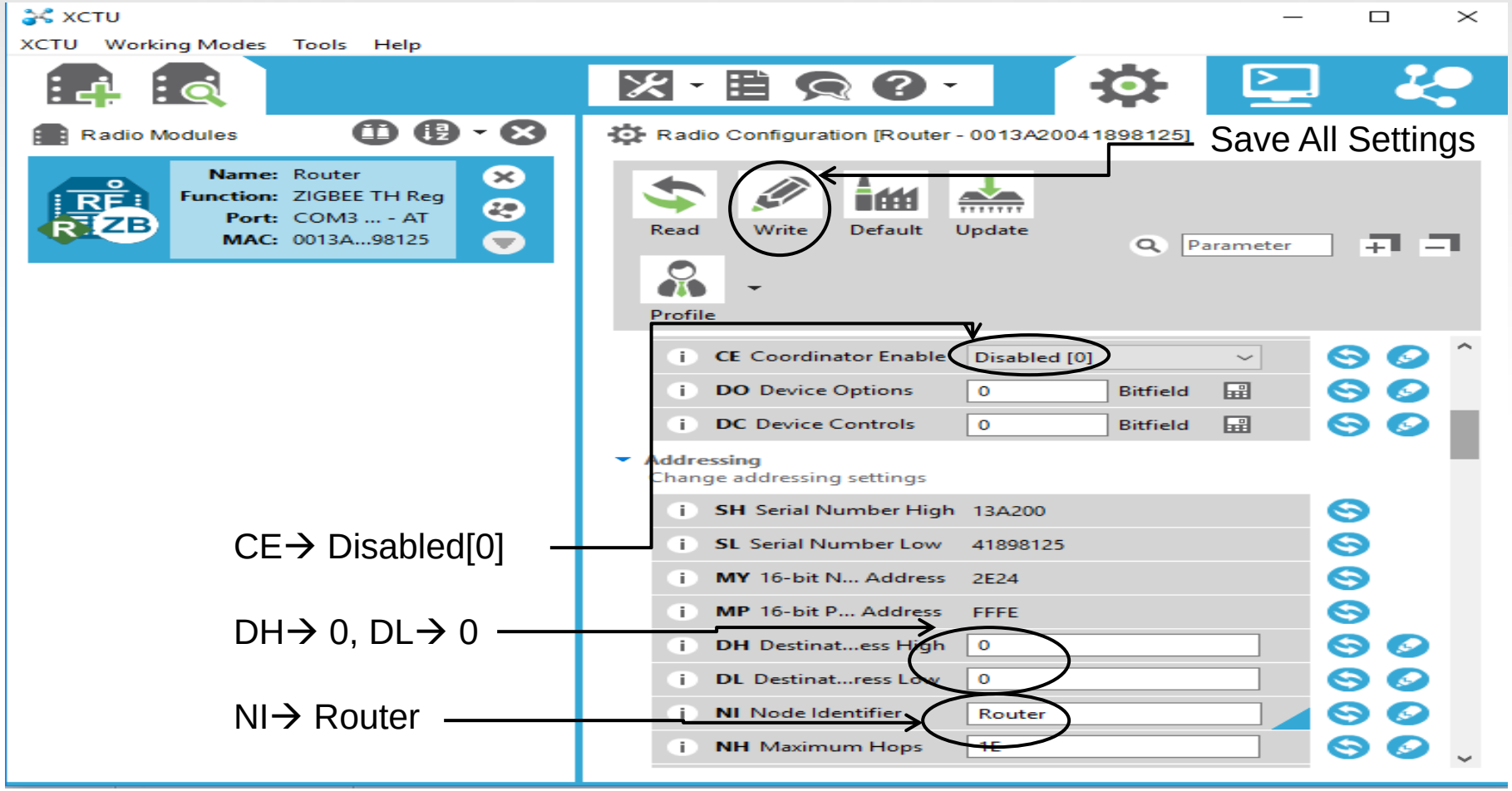
Configuration for Router XBee

1. Click on the 2nd radio on the left pane to load the setting and then Enter the PAN ID as 1111 , same as that of Coordinator. JV CHANNEL VERIFICATION is Enabled and rest settings are same as default and then Click on the PENCIL icon on top to WRITE the changes made. This is done with Router configuration.



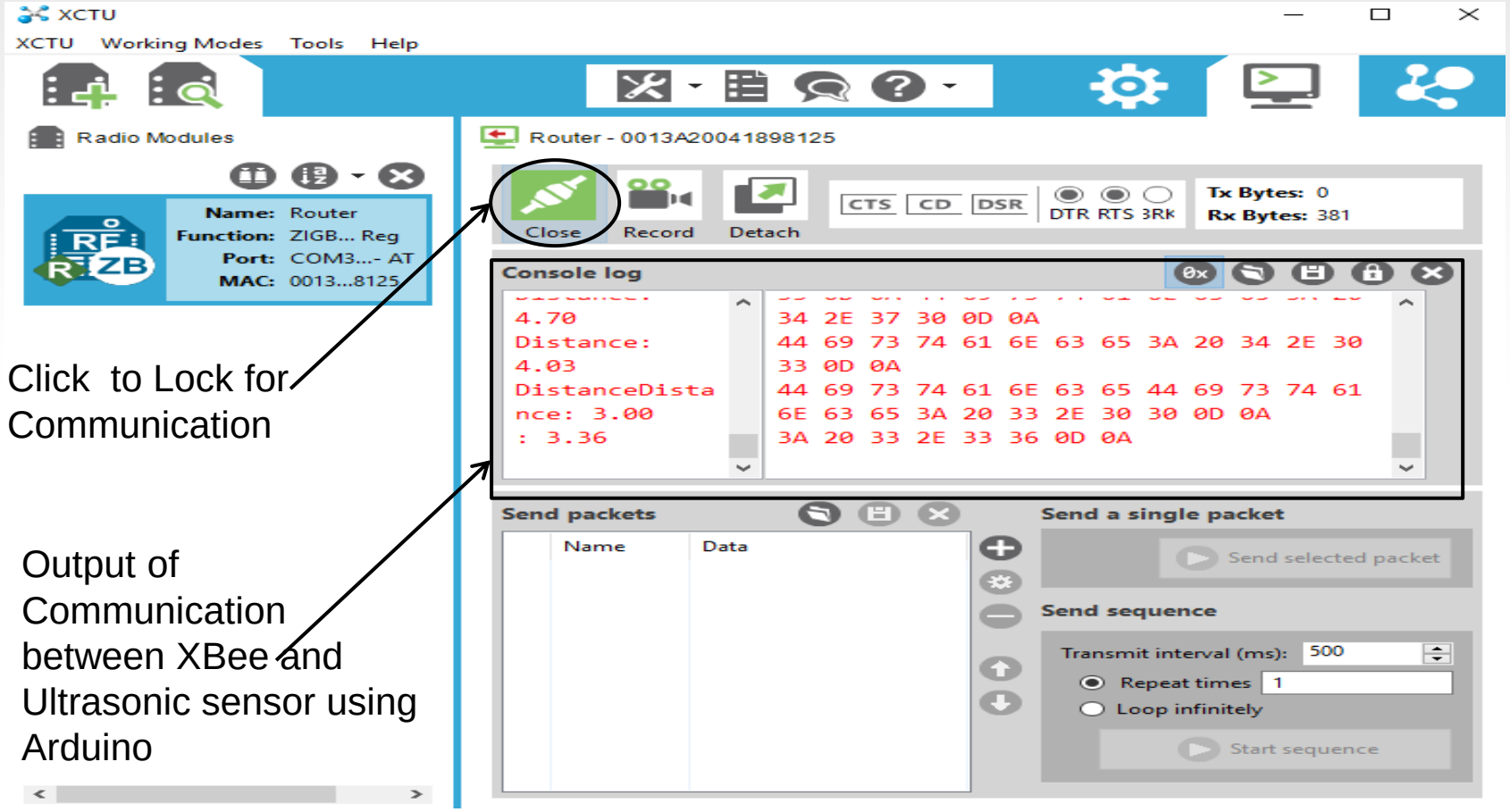
Configuration for Router XBee Cont..

2. CE Coordinator is DISABLED, Destination Address DL is left to default 0. and NI Node Identifier as " ROUTER". Now Click on WRITE button to save the changes made.



Communication Between XBee and Ultrasonic Sensor using Arduino

3. The modules are paired and ready for communication. Now let us test the communication on the XCTU Router Window as:



Thank You