2013 Taiwan RTC Bluetooth Training

BT001

Adding Bluetooth Dalalink to Embedded Systems

December, 2013

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Agenda

- Bluetooth Overview
- Microchip Bluetooth Products
- Lab 1 Command mode and Data mode
- Lab 2 Discovering and connecting from PC
- Lab 3 Cable Replacement Mode
- Lab 4 APP1632-7 PIC32 MCU board with RN-42
- Real world issues and tricks to put RN Bluetooth modules in customer's design
- New on RN Product Support
- Summary

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Objectives

- **Develops an understanding of Bluetooth® technology and uses**
- **Understands Microchip's Bluetooth solution offering and its capabilities**
- **Hands on experience with RN-42-EK board**
  - Configure the RN42 module
  - Link to RN42 on the EK board and create a Bluetooth virtual COM port on PC to see data going back and forth on the Bluetooth link
  - Link a RN42 to another RN42 to do a wireless cable replacement
- **Writes code to send data from a PIC32 to a PC or Android phone via Bluetooth**
- **Knows how to integrate RN42 with your host system**

© 2012 Microchip Technology Incorporated. All Rights Reserved.

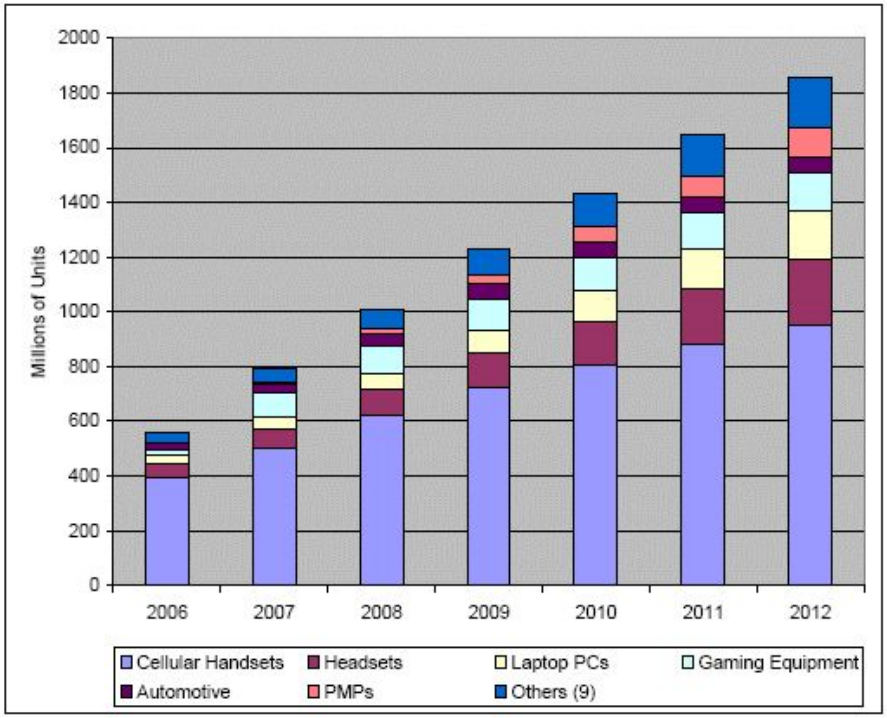
Bluetooth™ Overview

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth™ Adoption

Bluetooth…, Why should you consider it for your design?

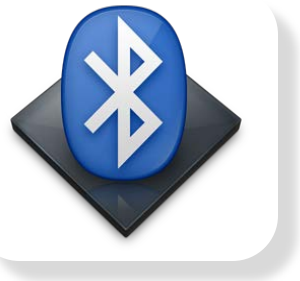
- No cost:
  unlicensed ISM band
- Millions of smartphones
  - You only need to design one side of the link
  - User interface available on phone
- Bluetooth enabled devices shipment expected to exceed 2 Billion in 2013



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth Applications

- **Simple Cable Replacement**
  - What BT was originally designed for!
  - Easily make legacy wired devices – wireless
    - **Barcode scanners**
    - **RS232 cable replacement**
    - **Industrial controllers**
- **Smartphone and Tablet Apps**
  - Lots of products can use a smartphone as the UIF
  - Apple has the‘cool’ factor
  - Becoming a lifestyle hub
    - **Health/fitness**
    - **Automotive**
    - **Industrial control**
    - **Home automation**
- **And NOW audio**
  - Speakers and intercom system
  - Not hands free headsets



© 2012 Microchip Technology Incorporated. All Rights Reserved.

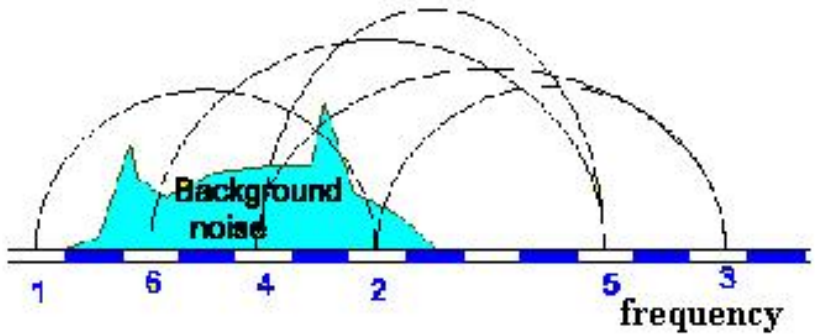
Bluetooth™ Overview

- Wireless Data Exchange Technology operating within the ISM 2.4 to 2.48 Ghz Band
- Created by Ericsson in 1994 to replace RS-232 cabling
- Managed by Bluetooth Special Interest Group (SIG)
- Over 16,000 member companies in Bluetooth SIG
- Must be a member (no cost) of Bluetooth SIG to use Bluetooth logo

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth™ Implementation

- **Frequency Band**
  - 2.4 to 2.48 Ghz ISM Band
  - 79 Channels
  - Pseudo-Random Hopping Among 79 Channels, 1600 hops/sec
  - Frequency Hopping Spread Spectrum (FHSS)
- **Architecture**
  - Typically 1 Master Talking to 1 Slave
  - Data Transferred between Master & Slave
- **Connection Process**
  - Discovery
  - Pairing
  - Authentication (optional)



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth™ Nomenclature

- **Range / Class**

Class	Maximum Power		Range (m)	Roving Module
	(mW)	(dBm)		
Class 1	100	20	~100	RN-41
Class 2	2.5	4	~30	RN-42
Class 3	1	0	~10	RN-42 (dial down tx power)

- **Version / Standard**

Version	Data Rate	Maximum Application Throughput
Version 1.2	1 Mbit/s	0.7 Mbit/s
Version 2.1 + EDR	3 Mbit/s	2.1 Mbit/s

© 2012 Microchip Technology Incorporated. All Rights Reserved.

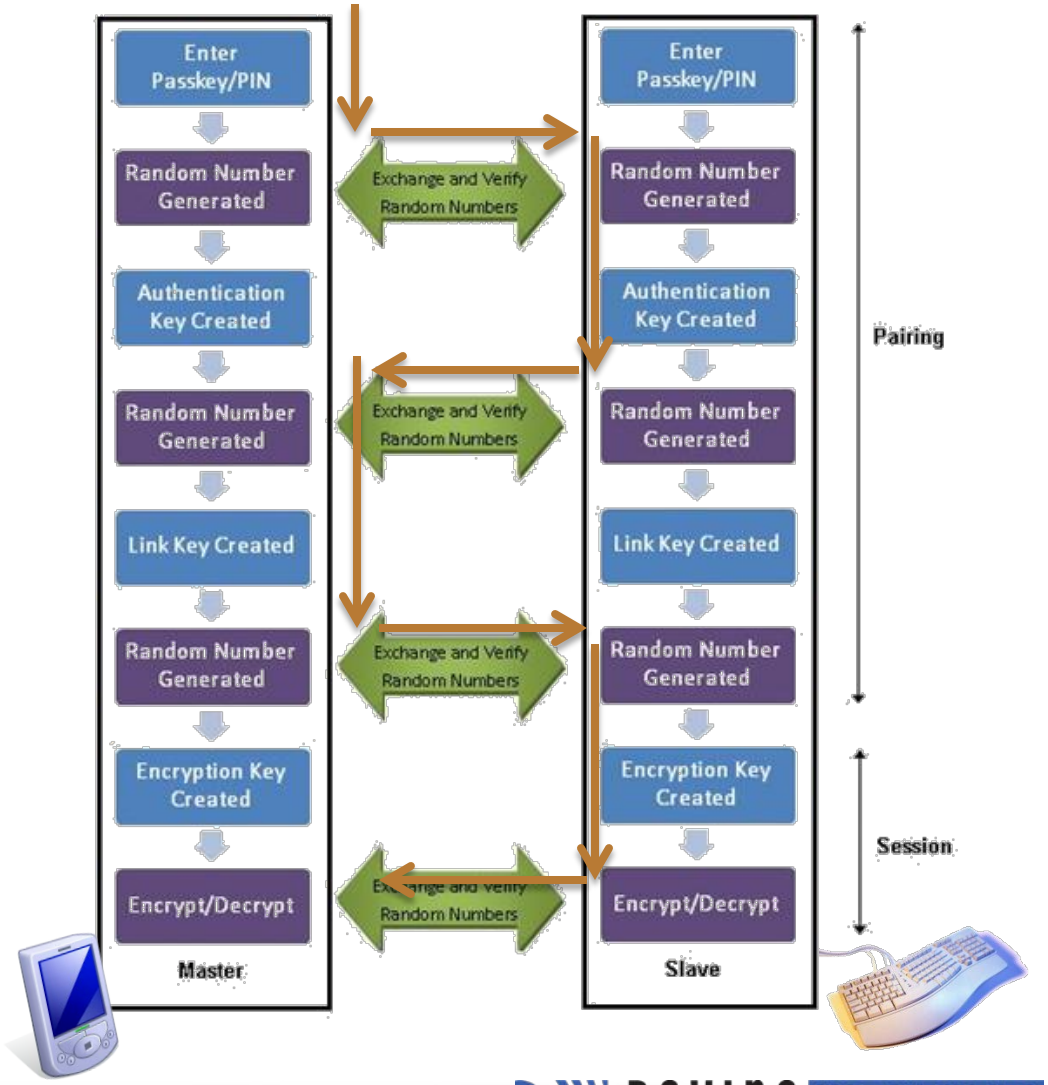
Why the name Bluetooth®

- King Harald Gormsson was the king of Denmark and Norway.
- He ordered many public works projects which brought the two countries together.
- He loved to eat blueberries and had stained teeth. Hence Bluetooth.

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Connection Process

- Bluetooth employs a 128-bit Secure and Fast Encryption Routine, (SAFER)
- Bluetooth connection is a three step process
  - Device discovery
  - Pairing
  - Authentication
    - Optional
    - Required if any one of the two devices demands authentication



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Authentication modes

Authentication modes supported by Microchip Bluetooth products

- **No pin**
  - Just pairs
- **Pin code**
  - Requires pin to connect
- **Keyboard I/O**
  - User must verify a 6-digit code on device
  - Supports the “Just Works” mode in Android devices
- **Secure Simple Pairing (SSP)**
  - Does not require pin code exchange
  - Supported in Bluetooth 2.1 + EDR

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth® Profile???

- Bluetooth is a common radio platform designed to be used by many different types of end product
- By design : Bluetooth devices won't talk to other Bluetooth devices unless they are supposed to
  - Pairing
  - Profiles
- Bluetooth announces its profile/service capability during the pairing process
- To support a service, the Profile needs to be supported by both ends of a link

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Built-in Bluetooth™ Profiles

- **Profiles define a application protocol**
  - Runs on top of Bluetooth transport level (RFCOM)
  - Both Host and Client must support profile
- **Roving modules have the Bluetooth stack and profiles on-board**
- **Field tested profiles**
  - iPhones, iPads, and Android devices
  - Windows, Linux, Macs

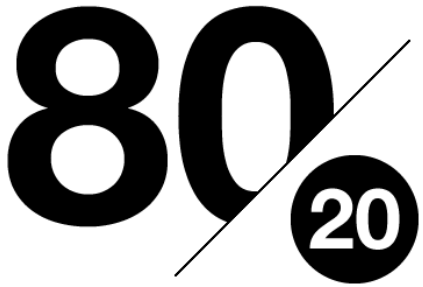
	Standard Bluetooth Profiles
Supported	**Serial Port Profile (SPP)**
Supported	**Human Interface Device Profile (HID)**
Supported	**Advanced Audio Distribution Profile (A2DP)**
Supported	**Audio/Video Remote Control Profile (AVRCP)**
Supported	**Hands-Free Profile (HFP)**
Supported	**Headset Profile (HSP)**
	Attribute Profile (ATT)
	Basic Imaging Profile (BIP)
	Basic Printing Profile (BPP)
	Common ISDN Access Profile (CIP)
	Cordless Telephony Profile (CTP)
	Device ID Profile (DIP)
	Dial-up Networking Profile (DUN)
	Fax Profile (FAX)
	File Transfer Profile (FTP)
	Generic Audio/Video Distribution Profile (GAVDP)
	Generic Access Profile (GAP)
	Generic Attribute Profile (GATT)
	Generic Object Exchange Profile (GOEP)
	Hard Copy Cable Replacement Profile (HCRP)
	Health Device Profile (HDP)
	Intercom Profile (ICP)
	LAN Access Profile (LAP)
	Message Access Profile (MAP)
	Object Push Profile (OPP)
	Personal Area Networking Profile (PAN)
	Phone Book Access Profile (PBAP, PBA)
	Service Discovery Application Profile (SDAP)
	SIM Access Profile (SAP, SIM, rSAP)
	Synchronization Profile (SYNCH)
	Video Distribution Profile (VDP)
	Wireless Application Protocol Bearer (WAPB)

	Other Profiles
Supported	**iAP for Apple**

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth – Which profiles do I need?

- How do we fit all the profiles into our module(s) cost effectively?
  - We don't!
  - Instead we follow the 80/20 rule……
    - 80% of the customers only need 20% of the profiles
    - 80% of *data* customers only need
      - ***HID*** *: Human Interface Device*
      - ***SPP*** *: Serial Port Profile*
      - ***iAP*** *: iPhone Accessory Profile*
    - 80% of *audio* customers only need
      - ***AVCRP*** *: Audio Video Remote Control Profile*
      - ***A2DP*** *: Advanced Audio Distribution Profile*
      - ***HSP*** *: Head Set Profile*
      - ***HFP*** *: Hands Free Profile*
    - The other 20% are addressed via HCI (Host Controller Interface)



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth – Which profiles are where?

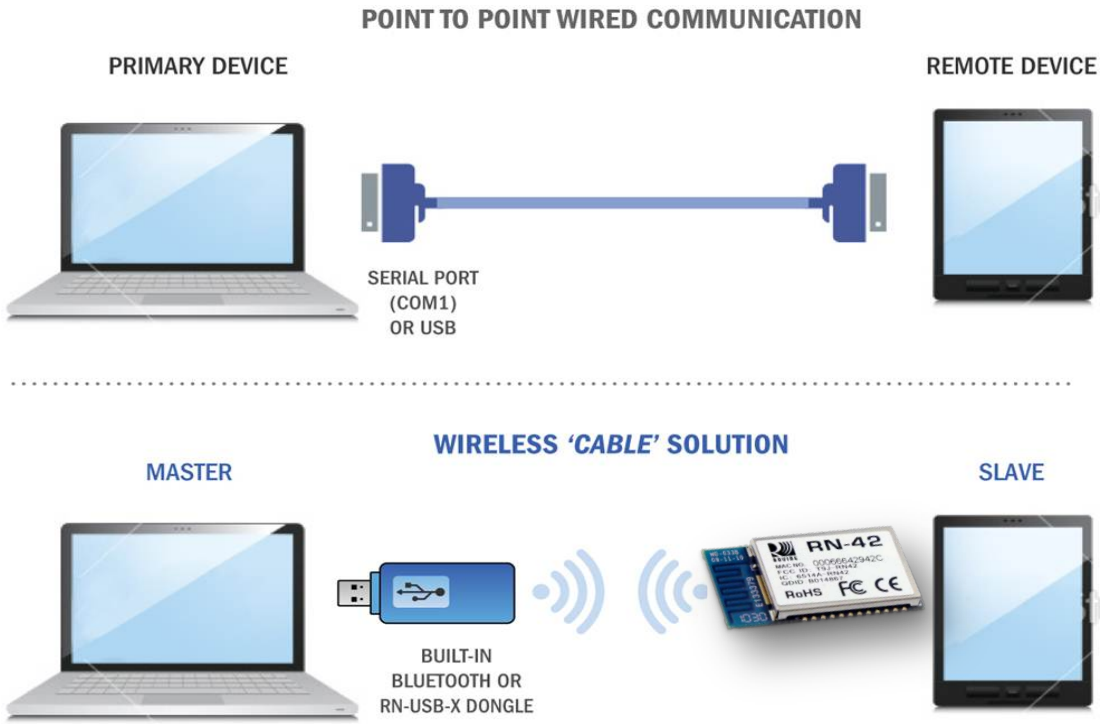
Key Profile	Use Case	RN52	RN42	RN41	General Platform	iOS Platform	Apple Auth Required	Description & Notes
HID	DATA	✗	✓	✓	✓	✓	✗	Effectively a one way data profile but locks out onscreen keyboards when used
SPP	DATA	COMING SOON	✓	✓	✓	✗		A serial cable over BT but NOT supported by iOS
iAP*	DATA	COMING SOON	✓	✓	✗	✓	✓	Apple's proprietary SPP. Needs an Apple licence to use (* APL firmware version required)
AVRCP	DATA	✓	✗	✗	✓	✓	✗	Media only profile. Play, Pause, Next Track, etc.
A2DP	Audio	✓	✗	✗	✓	✓	✗	Standard Audio streaming profile
HSP	Audio	✓	✗	✗	✓	✓	✗	Designed for phones and has basic audio control capabilities.
HFP	Audio	✓	✗	✗	✓	✓	✗	Designed for the phone. Adds Call Waiting, last number redial and so forth
HCI	SPECIAL	✓	✓	✓				Allows an external microcontroller to run additional profiles though incurs time, engineering and cost

- 80% of all customer applications can be addressed by these few profiles
- The other 20% by HCI

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth™ Profiles: Serial Port Profile (SPP)

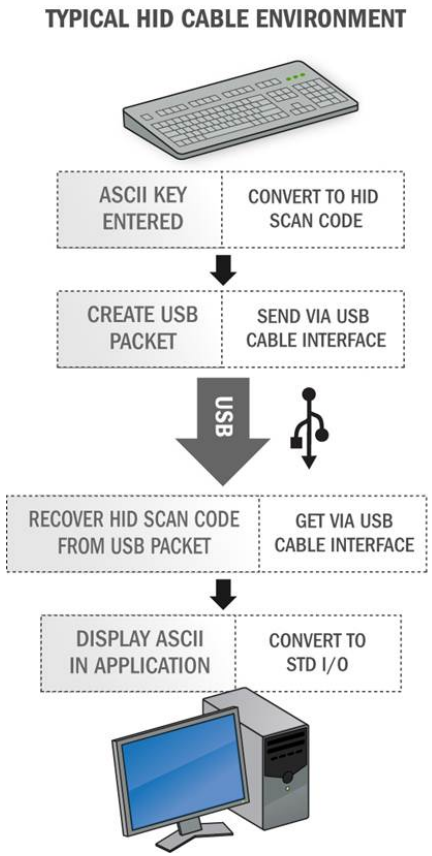
- **Emulates COM Port over Bluetooth**
  - Cable Replacement Applications
  - Bluetooth driver on host computer creates a virtual COM port after successful pairing
  - When COM port is open the Bluetooth connection to the slave is opened

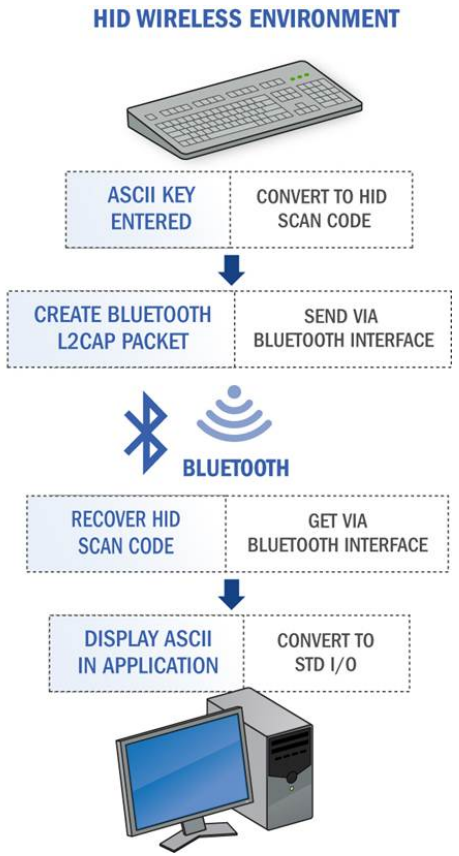


© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth™ Profiles: Human Interface Device (HID)

- **Typically used for keyboard and mouse applications**
  - Host computer loads HID driver when pairing is successful
  - Ubiquitous, standard interface across platforms
- **Single direction connection**
  - Use SPP for bidirectional requirements
- **Roving module has several extended features**
  - ASCII translation
  - Consumer reports
  - Apple virtual keyboard control
  - Programmable scan codes linked to PIO





© 2012 Microchip Technology Incorporated. All Rights Reserved.

Apple & Bluetooth

- **Apple controls proprietary data links to the iPhone / iPad / iPod**
  - Physical cables
    - 8/30 pin Apple connector
  - Bluetooth
    - Exceptions are HID and Headset profiles
  - WiFi is also a wireless link. However, it is not considered as a “direct” wireless link since it is running network protocol

- **‘Made for iPod’ program**
  - All accessory connections MUST have an Apple Authentication chip
  - MFI requires project plan to be approved
    - Ensure quality customer experience
    - Self test for interoperability & compatibility

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Microchip Apple Ready Modules

- **SIMPLY works with iPad, iPhone, iPod**
  - Fully tested and qualified with Apple MFI
  - Saves customer development time & money
  - Tried & tested in real-life volume applications
  - Same module works with PCs & Android

- **Customers must be part of MFI program**
  - To buy Roving development kit
  - To buy authentication chips

Made for iPod iPhone iPad

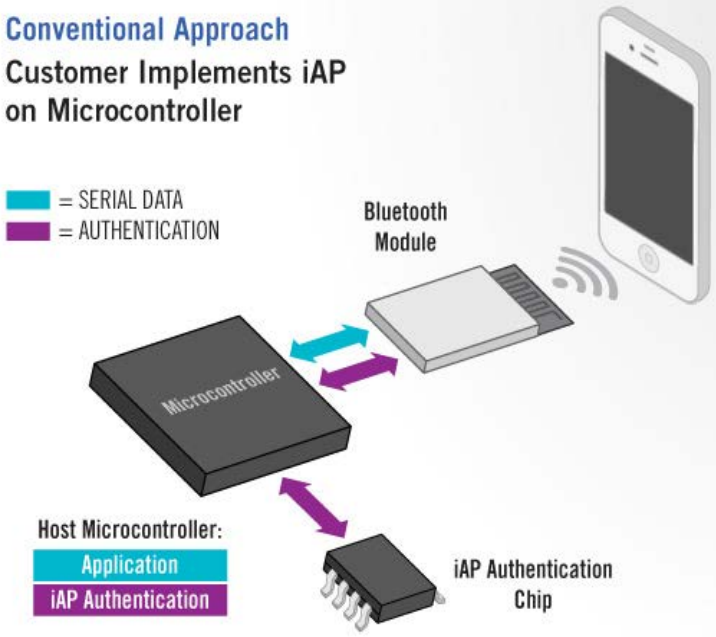
ROVING networks

© 2012 Microchip Technology Incorporated. All Rights Reserved.

iAP: Apple Authentication System Architectures

Conventional Approach

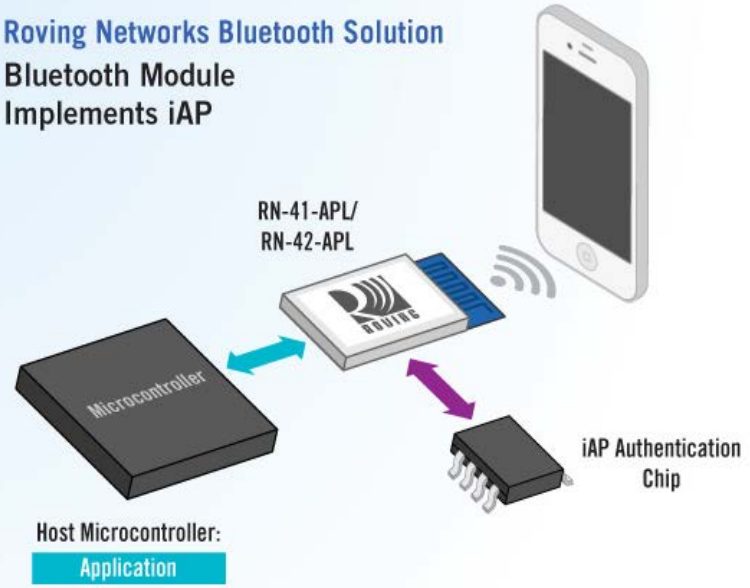
Customer Implements iAP on Microcontroller



- High-end host microcontroller
- Adds complexity to firmware and hardware design
- Longer development cycles and learning curves
- Increases power consumption
- Difficult to port code across microcontroller platforms

Roving Networks Bluetooth Solution

Bluetooth Module Implements iAP



- Low-cost host microcontroller
- Simple host interface
- iAP transparent to user
- Developers focus on their design, not iAP protocols
- Same interface for other smart phones and computing platforms

© 2012 Microchip Technology Incorporated. All Rights Reserved.

What is BT4.0?

- BT4.0
  - Is a stack version ONLY
  - It has added functionality on previous version
  - It is ONLY required if you need BTLE
    - It is NOT required for BTC data or audio

Version	Data Rate	Max. Application Throughput & Notes	Ratified	Status
1.2	1Mbit/s	0.7 Mbit/s	2002	Obsolete
2.0 EDR	3Mbit/s	2.1 Mbit/s	2004	Obsolete
2.1 EDR	3Mbit/s	2.1 Mbit/s + Security	2007	Current
3.0 HS	24Mbit/s	Co-location to Wi-Fi	2009	Current
4.0	Depends if used for BTLE, HS or Classic Applications		2010	Current

© 2012 Microchip Technology Incorporated. All Rights Reserved.

BTLE
AN alternative to SPP / iAP?

- Can BTLE replace SPP/iAP?
  - Not exactly….
    - BTLE cannot do everything iAP or SPP do
      - Apple doesn't try to lay MFi on top – BTLE is too limiting to add it!
    - BTLE has a very small payload so it is NOT a 'serial port'
    - BTLE has a LOW throughput
    - BTLE does not allow for streaming or FTP type protocols

- Can BTLE get me around Apple auth/MFi stuff?
    - In addition the issues above
    - Apple still wants to control your app!
    - The still validate all apps before they are put in the App Store

© 2012 Microchip Technology Incorporated. All Rights Reserved.

So what is BTLE?

- The Bluetooth SIG identified a market not addressed by BTC (BT Classic)
  - E.g. Health and Wellness & Sport Fitness
    - Low power requirements
      - Months or years from a button cell
    - Small size and low cost
    - Compatibility to mobile phones

© 2012 Microchip Technology Incorporated. All Rights Reserved.

BTLE Effective Markets

- Proximity
- Time
- Emergency
- Personal User Interface
- Simple remote control
- Temperature Sensor
- Humidity Sensor

- HVAC
- Generic I/O (automation)
- Battery status
- Heart rate monitor
- Physical activity monitor
- Blood glucose monitor
- Cycling sensors
- Pulse Oximeter
- Body thermometer

© 2012 Microchip Technology Incorporated. All Rights Reserved.

BTLE compared to BTC

Technical Specification	BT Classic	BTLE
Frequency	2.4GHz	2.4GHz
Range	10-100m	10m
Data-rate (Over-the-air)	1-3Mbps	1Mbps
Through-put (Reality)	0.7 – 2.1Mbps	25kbs
Max Nodes	7	No limit
Security	56-128 bit	128 bit
Robustness	FHSS	FHSS
Latency (time between pkts)	2.5mS (Data) +100ms (Conn.)	BIGmS (Data) <6ms (Conn.)
Audio	Yes	No
Profile Support	Yes	VERY limited

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Microchip Wireless Portfolio

Microchip has a corporate-wide commitment to wireless

Technology	Protocol	Markets	Market Driver	Network Stack	Freq.
Embedded Wi-Fi	IEEE 802.11	Widespread Commercial Industrial	Internet	TCP/IP	2.4GHz
Embedded Bluetooth	IEEE 802.15.1	Widespread Commercial Industrial	Smartphone	BT v2.1, BT Audio, BTLE	2.4GHz
Wireless One Way	Proprietary	Vertical Security, Sensors, Remotes	Cost	MiWi + Keeloq	Sub-1GHz
Wireless Two Way	Proprietary or IEEE 802.15.4	Vertical HA, SEP, Sensors	Cost Local Network	MiWi, BT, ZigBee, RF4CE,	Sub-1GHz and 2.4GHz

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth, WiFi, or MiWi/Zigbee

	WiFi	Bluetooth	MiWi/Zigbee
Embedded Connected Clients	Best fit	Doable but not as straight-forward as WiFi. Needs a Gateway.	Needs a Gateway device to connect to Ethernet or WiFi to get on internet
Smartphone accessories	1. Can connect to both internet and smart phone 2. Can get around iAP	Lowest integration effort to connect to any smart phone	Need a gateway to go to smart phone
Simple cable replacement / Serial port emulation	Doable but not as straight-forward as Bluetooth	This is what Bluetooth is designed for	1. Can easily do cable replacement 2. Can not do serial port emulation on PC/Smart Phone
Wireless sensor	The data are on internet as soon as the WiFi is connected. Perfect for Cloud application.	1. 7 nodes in the network in ideal condition 2. Need middle ware to get data on to internet	1. Needs a gateway to be on internet 2. Can support a lot of nodes
No. of nodes	20-30 nodes for an AP. Up to 253 in a subnet. No limit for general IP network.	Usually 1 to 1. Could be up to 7 if the host device is powerful enough and data rate is low.	8k on MiWi Pro; 64k on Zigbee
Noise immunity	Good	Excellent	Good. Can be improved by user
Cost	Reasonable	Medium	Low
Range	180m for RN-171 and 200m for RN-131	30m for RN-42 and 100m for RN-41	30-50m without PA; 100m+ with PA

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Microchip Stack-on-module Bluetooth™ Products

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth Modules

	RN-41 / RN-41-N	RN-42 / RN-42-N	RN-52
Type	Class 1 Bluetooth 2.1	Class 2 Bluetooth 2.1	Class 2 Bluetooth 3.0
Interfaces	UART / USB	UART / USB	Analog speaker and mic, i2S, SPDIF, PCM, UART
Profiles	SPP / HID / iAP / HCI	SPP / HID / iAP / HCI	A2DP / ARVCP / HSP / HFP / SPP / iAP
Power	3.3 VDC	3.3 VDC	3.3 VDC
Antenna	ceramic on board	PCB	PCB
Size	13.4mm x 25.8mm x 2mm	13.4mm x 25.8mm x 2mm	13.4mm x 30mm x 3mm
Certification	FCC / CE / ICS	FCC / CE / ICS	FCC / CE / ICS
Chip	CSR BC04	CSR BC04	CSR BC05

© 2012 Microchip Technology Incorporated. All Rights Reserved.

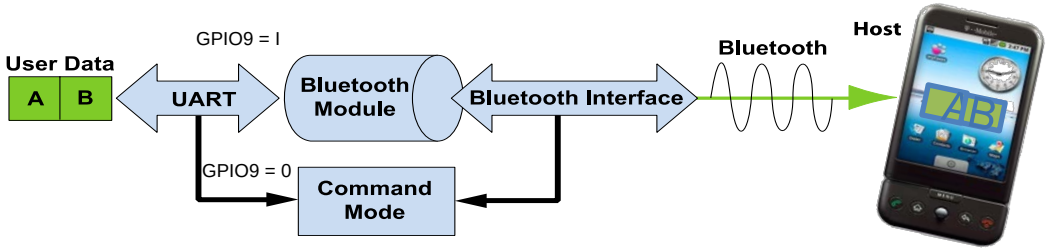
RN-52 Bluetooth Audio Module

- On-board Bluetooth 3.0 stack
  - Designed for glitch free audio in noisy Digital RF environments
  - Compatible with ALL earlier version Bluetooth stacks
  - Profile support *(A2DP, AVRCP, HSP, HFP, SSP, iAP*)*
- Analog and Digital Audio interfaces
- Command interface and GPIO
- Compact Footprint
  - 15 x 30 x 3mm
  - Integrated antenna
- Fully Certified
  - FCC, IC, CE, Bluetooth SIG, RoHS

*Note: iAP support subject to MFi membership

© 2012 Microchip Technology Incorporated. All Rights Reserved.

RN-52 BT Audio Module



- ASCII Command Console
  - Serial interface for configuration by external MCU
    - Bluetooth connection management & profile settings
    - Optional CODEC support
    - Alternate audio channels (I^2C, SPDIF)
  - Audio commands
    - Play, Pause, FFwD, etc.)
    - HSP/HFP initiate, accept and call drop
- iPhone Accessory Profile (iAP) and SPP Support
  - Low Baudrate, parallel data channel for command and control
  - Integrated or external iAP connection management

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Audio Codec Support

- Onboard Codec support
  - SBC: Low Complexity Subband Coding
    - Bluetooth SIG default
    - Required for every device using A2DP profile
  - aptX: High fidelity & low latency
    - Licensed by CSR
    - Customer must sign and pay for license agreement
    - Backward Compatibility: when aptX is not available target device will pair down to SBC
    - Per module royalty, Special MCHP part number
  - AAC: Advanced Audio Coding
    - Apple proprietary
    - Licensed by VIA
    - Per module royalty, Special MCHP part number
- Off Board
  - Up to customer

© 2012 Microchip Technology Incorporated. All Rights Reserved.

RN-52 Part Numbers

Part Number	Description
RN52-I/RM	Standard part, SBC CODEC
RN52APT-I/RM	Aptx CODEC, customer must be CSR licensee
RN52AAC-I/RM	Acc CODEC, customer must be Via licensee
RN-52-EK	Evaluation Kit, SBC CODEC
RN52APL-I/RM	Support Apple Bluetooth (iAP)

- Standard firmware supports all profiles and function
- New firmware can be uploaded in the field
  - ONLY true for RN-52

© 2012 Microchip Technology Incorporated. All Rights Reserved.

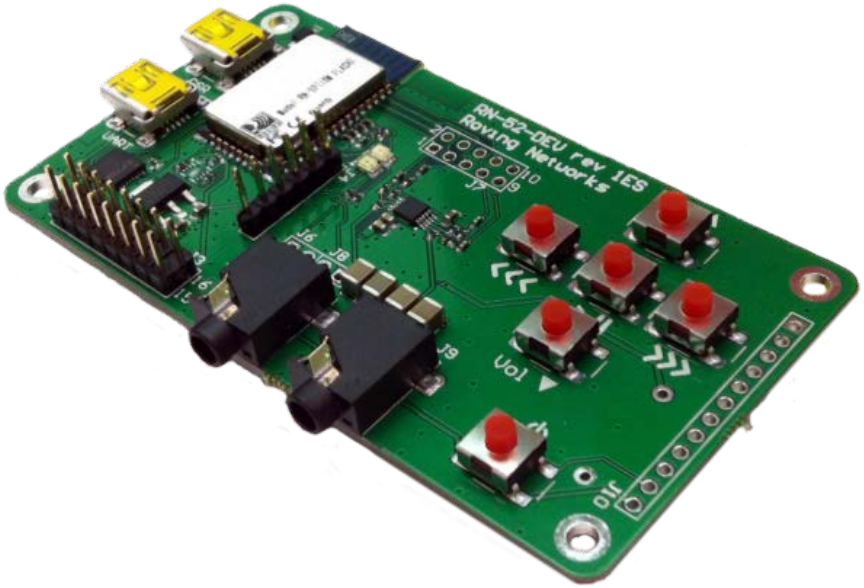
RN52 Evaluation Kit

Features

- RN-52 Audio module
- Status LEDs
- Basic track control buttons
- Stereo Mic. in / Speaker out ports

HW Interfaces

- Analog Audio I/O
- Digital Audio i2s, SPDIF
- PCM port – use with external codec's
- External PA
- GPIO Interface
- USB power and Console
- iAP auth. chip footprint



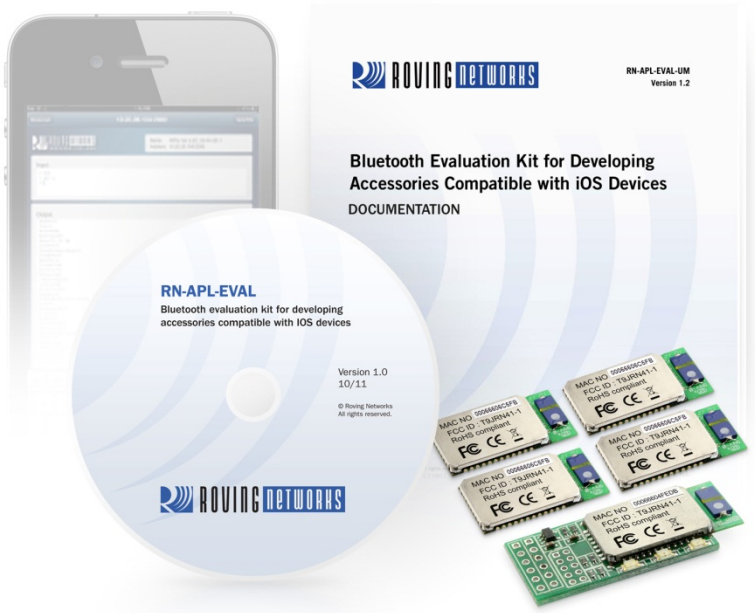
Firmware Capabilities

- In the field Firmware upgrade
  - Device Firmware Update (DFU)
- ASCII command Interface

© 2012 Microchip Technology Incorporated. All Rights Reserved.

iAP: Roving Networks Development Kit

- **Main Development Board**
  - RN-4x-APL module
  - Apple authentication co-processor
  - Status LEDs
  - Power regulation
  - RS-232 & TTL signals
- **Four RN-4x-APL Modules**
  - Used with custom prototype PCBs
- **Complete Design Documents**
  - Schematics
  - Integration guidelines
- **Source Code for Roving Networks Diagnostic Application**



© 2012 Microchip Technology Incorporated. All Rights Reserved.

RN-42-SM Bluetooth Evaluation Kit Hardware for SPP profile

- **RN-4x-SM is still a recommended ref design**
- **RN-4x-SM Evaluation Board**
  - Contains RN-4x module
  - RS-232 converter
  - Status LEDs

Mode	Green LED Status
Configuration Mode	Fast (10/sec)
Boot / Remote Config	Medium (2/sec)
Discoverable / Idle	Slow (1/sec)
Connected	ON (Solid)

  - Config Jumpers
    - Auto-connect modes
    - Factory reset
    - Baud rate (9600 or 115,200)
  - Voltage regulator

RN-41-SM

RN-42-SM

© 2012 Microchip Technology Incorporated. All Rights Reserved.

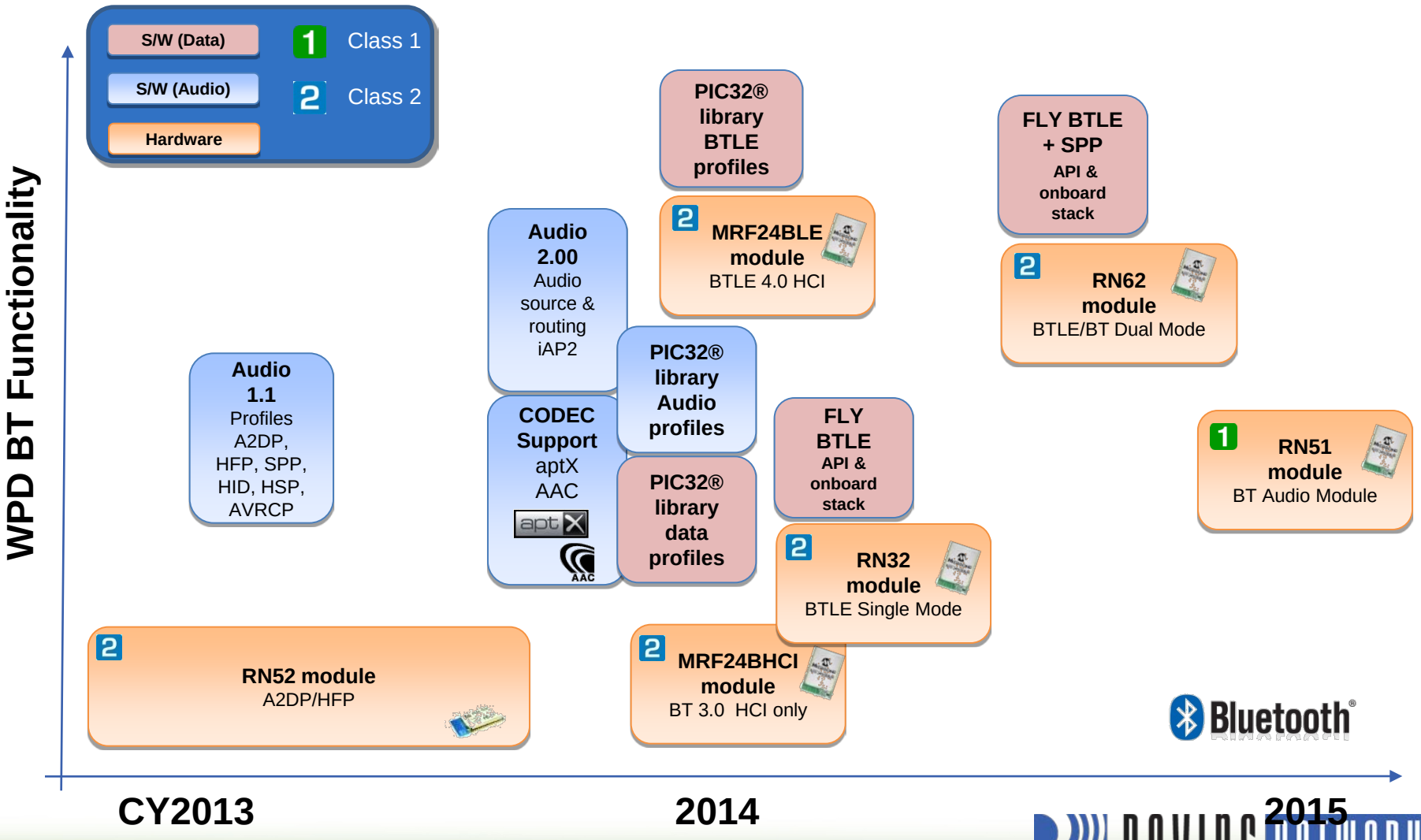
RN42-EK Bluetooth Evaluation Kit Hardware for SPP/HID profile

- **This is the new std RN4x module evaluation platform**
- **RN4x-EK Evaluation Board**
  - **No soldering/wiring required!!!**
  - Contains RN-42 module
  - On Board USB to UART
  - Powered by 5VDC on USB
  - Status LEDs
  - Dip Switches for setting
    - Auto-connect mode
    - Master/Slave select
    - Factory reset
    - Baud rate (9600 or 115,200)
  - Voltage regulator

RN42-EK

© 2012 Microchip Technology Incorporated. All Rights Reserved.

BT Roadmap



© 2012 Microchip Technology Incorporated. All Rights Reserved.

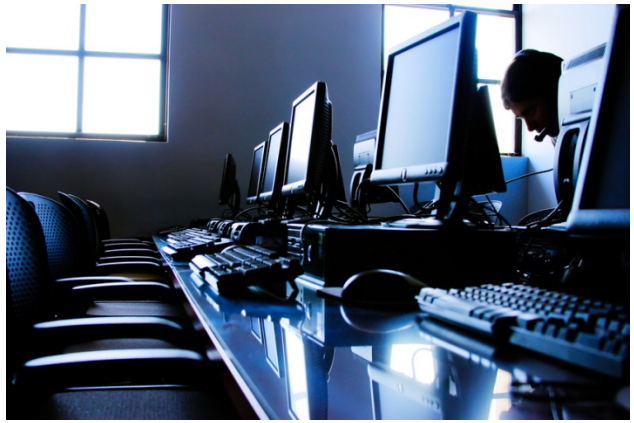
Microchip Bluetooth Strength

- World's most MCU friendly Bluetooth solution – works with any MCU even PIC10
- On module user friendly flexible configurable robust profiles
  - Customer can focus on product design
  - Fast design cycles
- Entire Bluetooth portfolio is footprint and API compatible (Class1/2, Antenna, iAP)
- Field proven, a lot of design references
- Industrial temperature range (v.s. ISSC)
- Flexible antenna options: Antenna (eg. RN-42) and Antenna-less versions (eg. RN-42N)
- Full FCC and other certifications

© 2012 Microchip Technology Incorporated. All Rights Reserved.

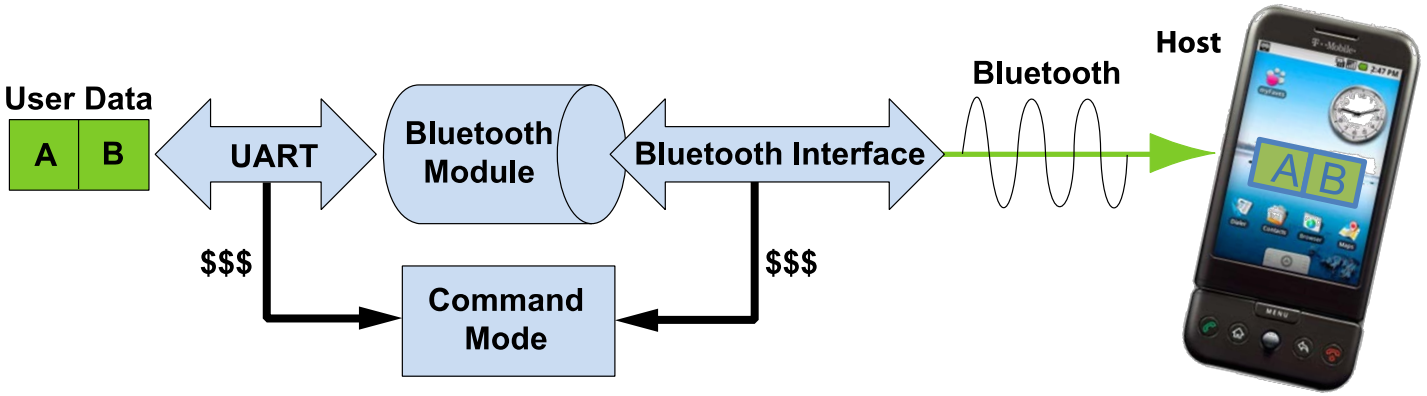
Hands-On Bluetooth Lab

- **Lab 1:** Command Mode vs. Data Mode
- **Lab 2:** Device Discovery & Connection
- **Lab 3:** Cable Replacement Mode
- **Lab 4:** APP1632-7 Development Board



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Data & Command Modes



- **Data Mode (Default State)**
  - Data pipe UART <> COM port
  - Bluetooth protocol header stripped or added, transparent to user
  - Data written to UART sent out over Bluetooth
  - Data received over Bluetooth read from UART
- **Command Mode ($$$)**
  - Special configuration mode entered using $$$
  - Used to configure parameters e.g., baud rate, device name, pin code, etc.
  - Always configurable from UART
  - 60 sec config timer disables command mode on Bluetooth side

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab Prerequisites

- **Hardware**
  - RN42-EK
  - Or RN-42-SM evaluation kit (RN-42-SM + USB to UART cable)
  - PC with USB port and Bluetooth
  - APP1632-7 Bluetooth PIC32 development board
- **Utility Software**
  - Available from http://www.rovingnetworks.com support page
  - TeraTerm (terminal emulator)
  - Prolific and FTDI chipset drivers

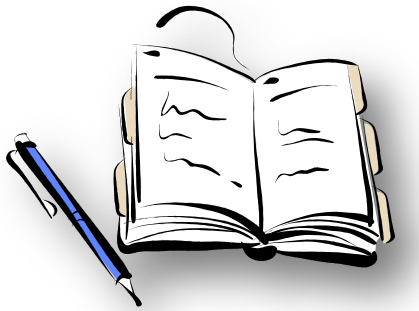
© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 1: Command mode and Data mode

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 1: Learning objectives

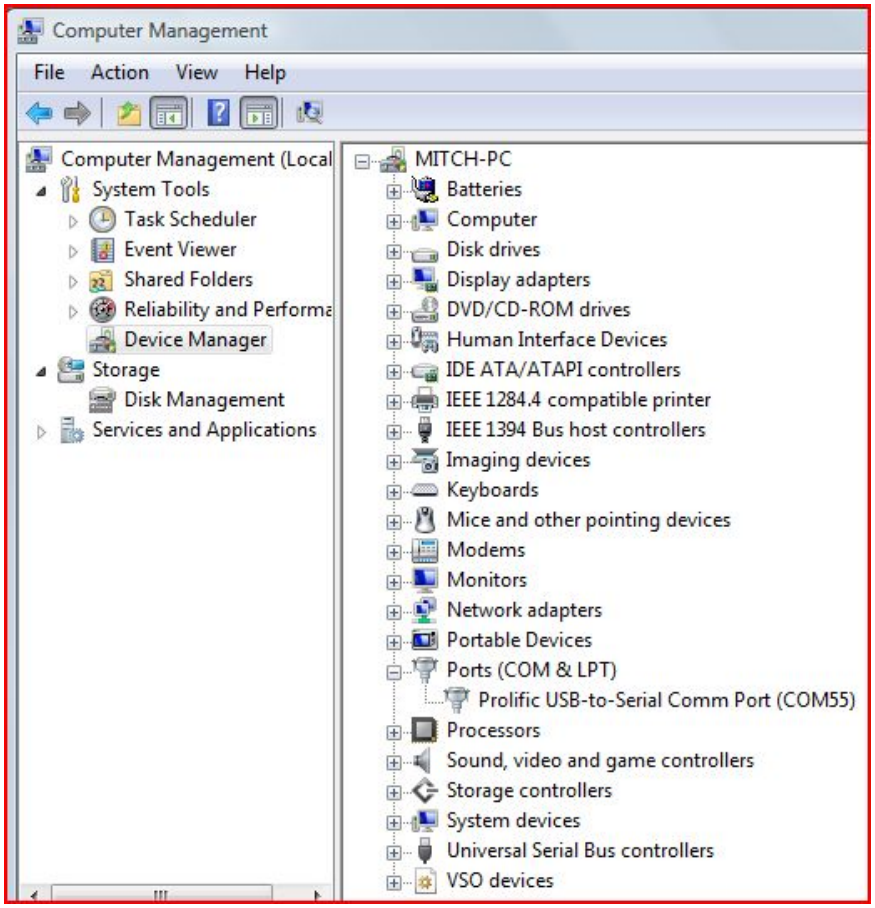
- **By the end of this lab you will be able to:**
  - Connect the evaluation kit hardware to you PC
  - Switch between command mode and data mode
  - View the current settings on the module
  - Check firmware version running on the module
  - Configure module for master and slave modes



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 1: Hardware Setup

- **Connect Evaluation Board**
  - Connect board to your computer
    - Green LED will blink at 1Hz
  - Use device manager to find the COM port
  - Look under Ports (COM & LPT)
    - Prolific USB-to-Serial
  - Serial port default settings:
    - Baud = 115200
    - Data = 8 bits
    - Stop = 1 bit
    - Parity = none
    - Flow Control = none



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 1: Command Mode

- **Send escape sequence to enter command mode**
  - $$$ // notice the Green LED blinks faster
  - D // display module basic settings
  - E // displays extended settings
  - O // displays other settings
  - V // displays firmware version on module
  - SF,1 // resets module to factory default settings
  - H // displays help: list of all commands

TIP: Enable local echo by sending the plus sign (+)

- **To exit command mode, send the sequence of three minus signs, '- - -'**

  // notice the Green LED blinks slower

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 1: Command Mode

- **Changing device Bluetooth name**
  - The Bluetooth device name is advertised by the module during device discovery process.
  - The default name is *RN42-ABCD*
    (where *ABCD* = last 2 bytes of MAC address)
  - To change the device name, the commands are
    - SN,my_device_name // sets device name
    - R,1 // reboot the module
  - Verify the change by:
    - Going into command mode
    - Display basic setting

© 2012 Microchip Technology Incorporated. All Rights Reserved.

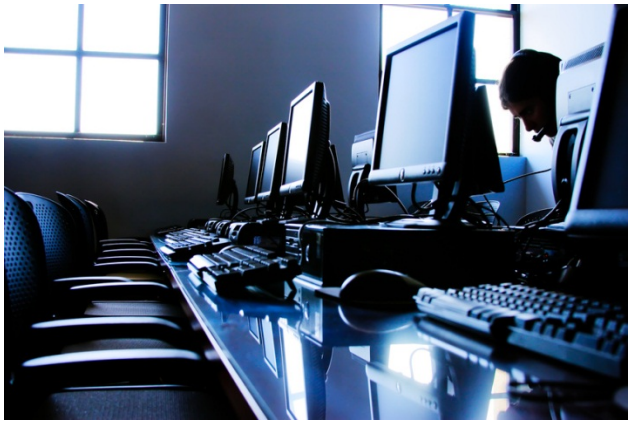
Lab 1: Command Mode

- **Master and slave modes**
  - Default mode is slave mode and discoverable
  - In master mode, the module is not discoverable
- **Setting the module in Master mode**
  - Go into command mode
  - SM,1 // enables master mode
  - D // verify that mode = Mstr
  - R,1 // reboot module for settings to take effect

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 1: Summary

- In this lab, we explored the ASCII command set
- Configured module parameters
- Switched the module in master and slave mode



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 2: Discovering and connecting from PC

© 2012 Microchip Technology Incorporated. All Rights Reserved.

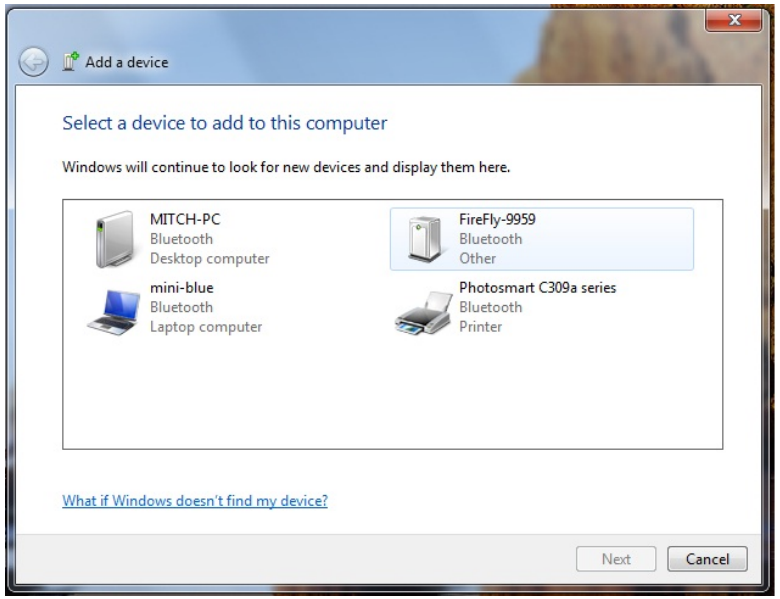
Lab 2: Learning objectives

- **By the end of this lab you will be able to:**
  - Discover the module from a PC
  - Establish a Bluetooth connection from the PC to the module
  - Send data over the Bluetooth link between PC and module

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 2: Discovering and connecting from PC

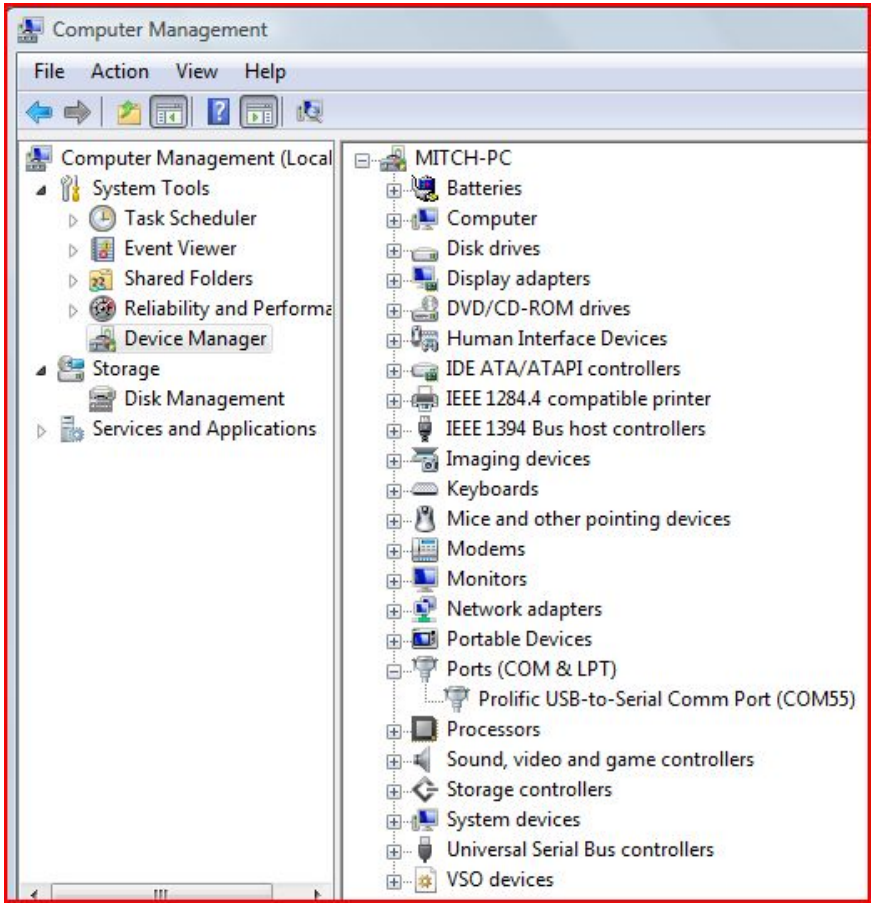
- **Connect evaluation kit to USB port of PC**
- **Go into command mode and factory reset the module, exit command mode**
- **On your PC, go to Bluetooth manager on and click “Add new device”**
  - The device will show up as *RN42-ABCD*
  - When prompted, enter the default PIN code 1234
  - A virtual COM port will be created by Windows



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 2: Discovering and connecting from PC

- **Check the COM port created in device manager**
- **Navigate to Ports (COM & LPT)**
  - Look for “Standard Serial over Bluetooth Link”

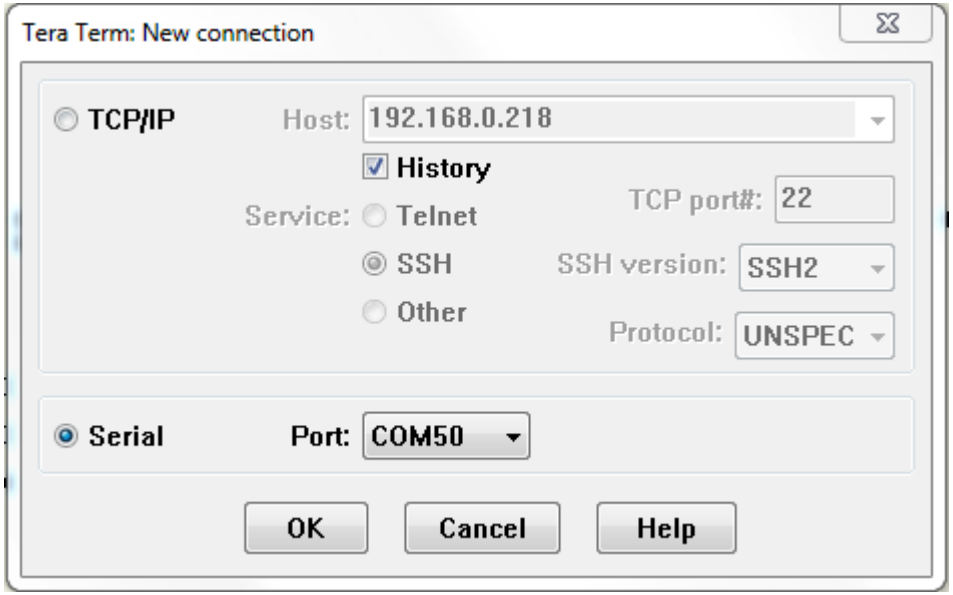


NOTE: Sometimes Windows will create two COM ports and label them “incoming” and “outgoing”. In this case, use the “outgoing port”

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 2: Discovering and connecting from PC

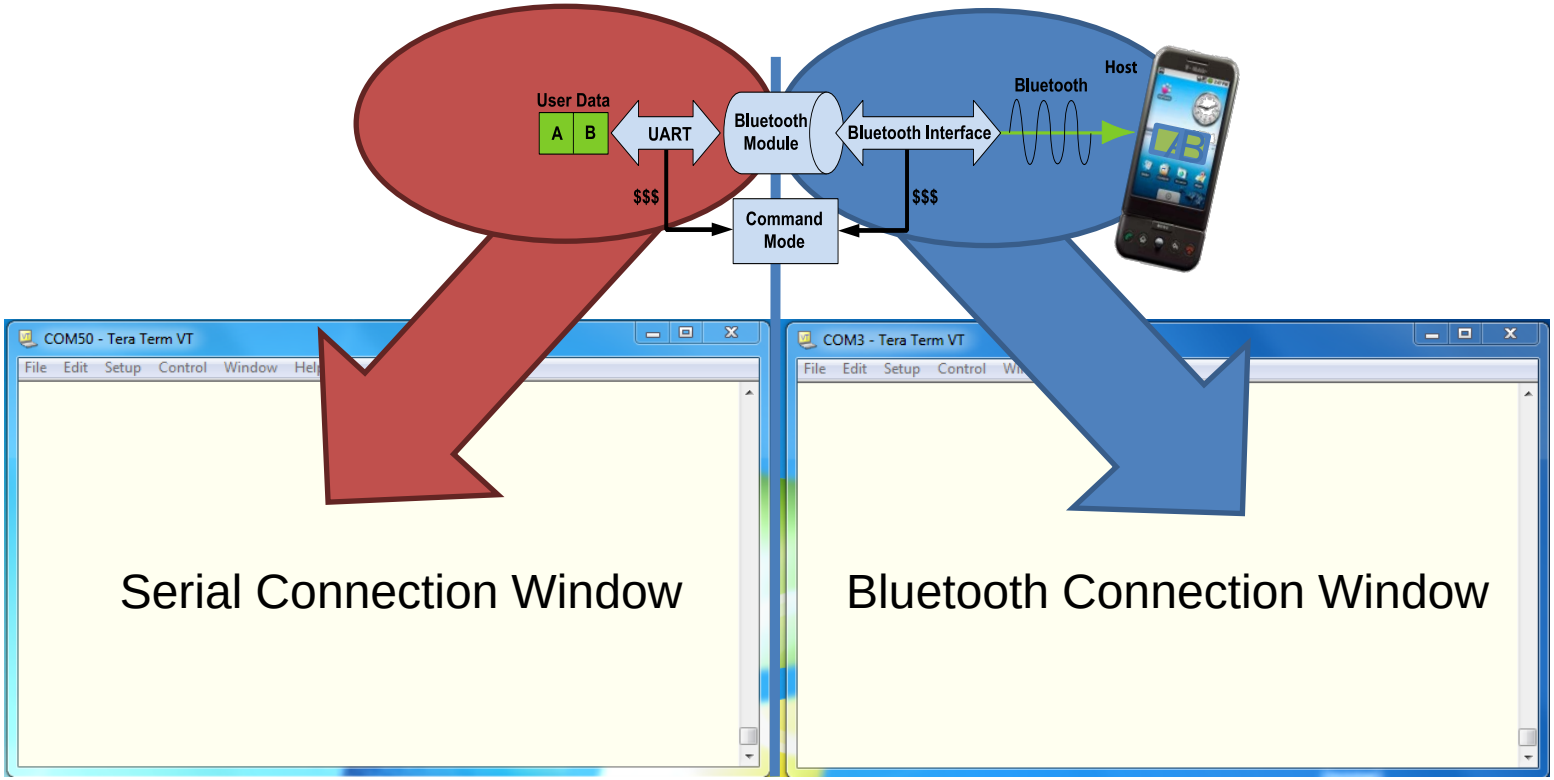
- **Connecting from PC to the module**
  - From TeraTerm, open up a new connection
  - Select the “Serial” button
  - Choose the Bluetooth COM port from previous step



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 2: Discovering and connecting from PC

- Open two TeraTerm Windows



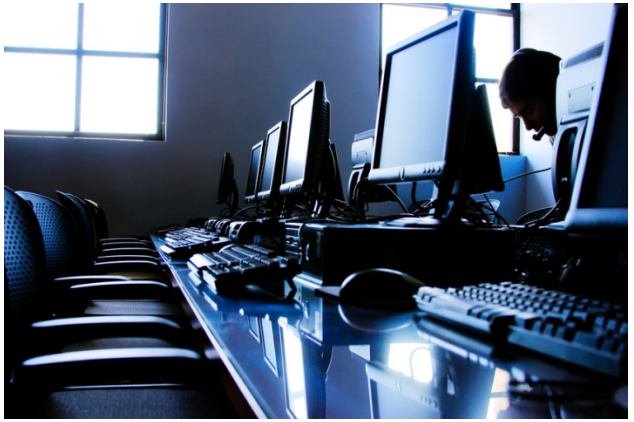
- Type data in serial window and it will appear in the Bluetooth window and vice versa

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 2: Summary

In this lab we learned:

- **The process of discovering the RN-42 module on the evaluation kit from PC**
- **We connected to the module from PC**
- **We sent data over the Bluetooth link between the PC and RN-42 module**



© 2012 Microchip Technology Incorporated. All Rights Reserved.

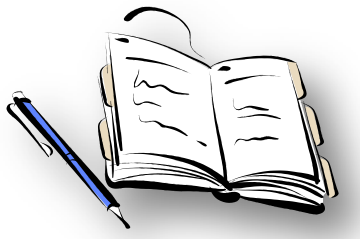
Lab 3: Connecting to a Bluetooth Device / Cable Replacement Mode

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 3: Learning Objectives

By the end of this lab you will be able to:

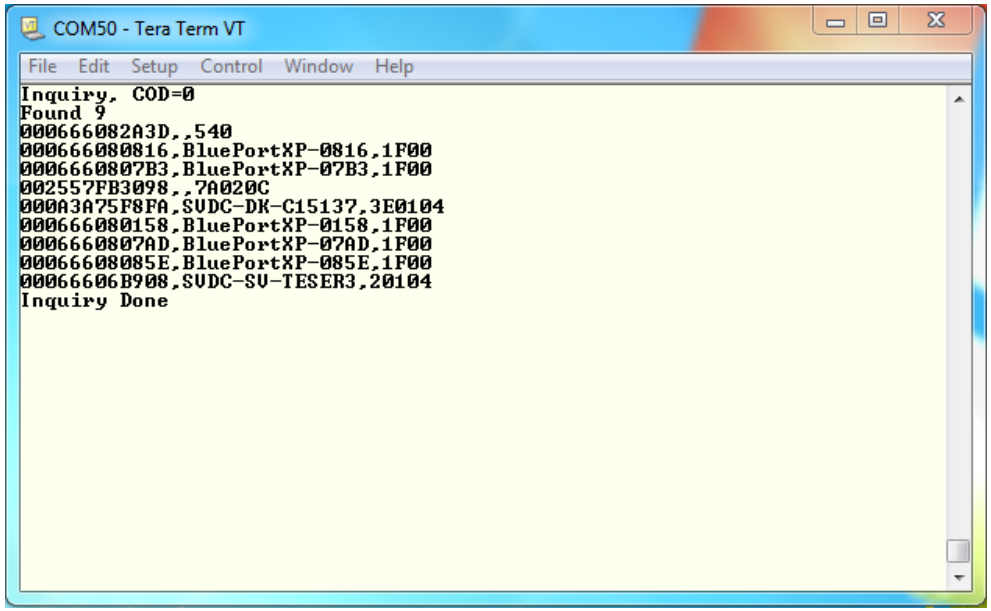
- **Perform a scan from the Roving module to discover other devices**
- **Establish a Bluetooth connection to another device**
- **Establish a connect to a Roving Bluetooth device and send data**
- **This also called cable replacement**
- **Using 2 Bluetooth devices to create a COM port cable without wire**
- **Use GPIOs to pair, connect and bond**



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 3: Connect to a Device

- **Discover Bluetooth devices from module**
  - **Issue the *I,10* command to start scan (inquiry)**
  - **The module returns a list of devices found with BT address, name and COD**
  - **A max of 9 devices are found at a scan**



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 3: Connect to a Device

- **Make connection using connect command**
  - For HID615 and HID611, do “sa,4” or “sa,0” to put in the right authentication mode
  - Get the BT address of you neighbors BT module from the label
  - **c,000666123456** // the second parameter is the BT address
  - Module returns status **TRYING**
  - When module connects successfully, green LED goes on solid

- **You’re now connected to your neighbor’s module**
  - Once connected, send data by typing in terminal window
  - Observe data that appears on your partner’s terminal window

© 2012 Microchip Technology Incorporated. All Rights Reserved.

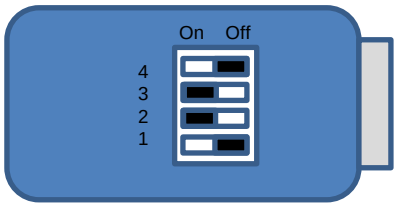
Lab 3: Disconnecting from a device

- **To disconnect from a connected device**
  - Go into command mode
  - Issue K,1 command
- **Enabling status stings for connect/disconnect**
  - Go into command mode
  - Issue the *SO,%* and *R,1* commands
  - Connect to your partner's module
  - Notice the %connect string when you connect
  - Notice the %disconnect string when you disconnect

© 2012 Microchip Technology Incorporated. All Rights Reserved.

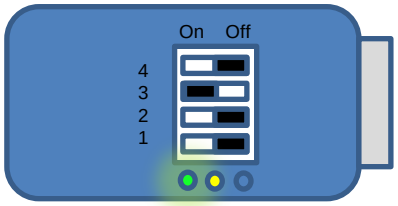
Lab3: Simple Cable Replacement (optional)

Adapter 1 (Master)



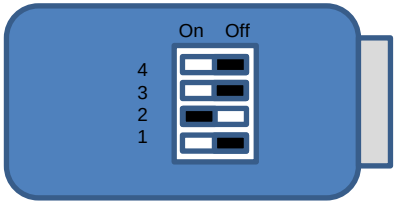
Step 1:
- While powered off, set switches as shown.
- Auto Discovery & Auto Master On.

Step 3:
- Power up master unit



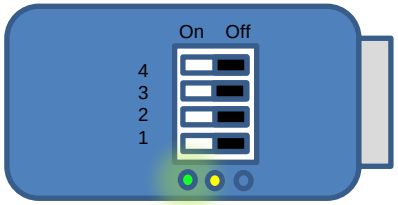
Step 5:
- Turn switch 2 off to stop further pairing.

Adapter 2 (Slave)



Step 2:
- While powered off set switches as shown.
- Auto Discovery & Auto Master Off

Step 4:
- Power up slave unit.
- Green LED goes solid on master & slave adapters once pairing completes.



Step 6:
- Turn switch 2 off to stop further pairing.

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab3: Creating an HID Device (optional)

- $$$
- SN, MCHIP_KEYS <CR>
- SH, 0200 <CR>
- S~,6 <CR>
- R,1 <CR>

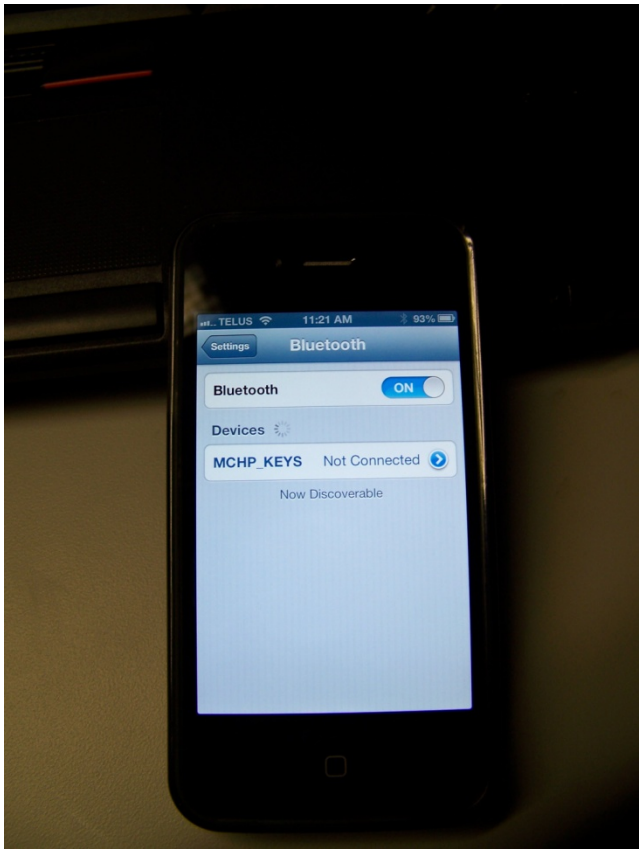
HID Flag Register Bits

9	8	7..4	3	2..0
Force HID mode if GPIO11 is high on power up	Toggle Virtual Keyboard on iOS	Type 0000 = keyboard 0001 = game pad 0010 = mouse 0011 = combo 0100 = joystick 1xxx = reserved	Send output reports over uart	# of paired devices to which module can reconnect

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab3: Discovering HID and connecting from PC (optional)

- On your PC, tablet, phone, go to Bluetooth® manager on and search for keyboard
- Connect to it
- And voila you now have a BT HID keyboard



© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 3: Summary

- **The module can scan for Bluetooth devices in its environment**
- **A max of 9 devices are found per inquiry**
  - By design, if you don't see yours, scan again
- **You can connect to the devices using the connect command**
- **The module only supports one active connection at a time**
- **Connection status strings print text over UART for every connect/disconnect**
- **You can also use GPIOs to pair and connect Roving Devices**

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 4: APP1632-7 Eval Board

© 2012 Microchip Technology Incorporated. All Rights Reserved.

APP1632-7 PIC32 RN42 Development Platform

- **APP1632-7 is a development platform based on PIC32MX250F128D**
- **USB powered. 3.3VDC operated**
- **RN42 on board**
  - 2 LEDs
  - 2 push buttons, 2 jumpers
- **Recommended Development Environment**
  - MPLAB-X IDE
  - MPLAB XC32

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 4a

- **Install MPLAB XC32**
- **Get APP1632-7 code from RTC 教育訓練光碟**
- **Open APP1632-7 project**
- **Connect to RN42 on APP1632-7 from PC Bluetooth adapter and open the COM port to see Time Tick data**
- **Modify the code to do the following**
  - Turn off Time Tick
  - Use ‘o’ to turn on Time Tick and ‘x’ to turn off Time Tick

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Configure RN42 on APP1632-7

- **There are 2 ways to configure RN42 on APP1632-7**
  - Load USB to UART serial port emulator to APP1632-7 to use APP1632-7 as RN-42-EK
  - Remote console
- **To use the remote console**
  - Pair your PC with the RN42 on APP1632-7
  - Power up the APP1632-7 board
  - Press BT4 (Bluetooth Reset) button on APP1632-7 to reset RN42
  - Connect to the RN42 on APP1632-7 from a PC Bluetooth
  - Open the Bluetooth COM port within 60 seconds and input “$$$” escape characters from PC COM port console (TeraTerm)
  - You should see the TereTerm terminal return CMD
  - You can send commands to the module to change settings
  - Reset the RN42 on APP1632-7

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Lab 4b

- **Modify the code to do the following**
  - Add code to detect BT2 push button
  - Add code to enter command mode and connect to your RN42-EK
  - Open TeraTerm to open COM port on RN42-EK
  - You will see data between RN42-EK and APP1632-7

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Real world issues and tricks to put RN Bluetooth modules in customer's design

© 2012 Microchip Technology Incorporated. All Rights Reserved.

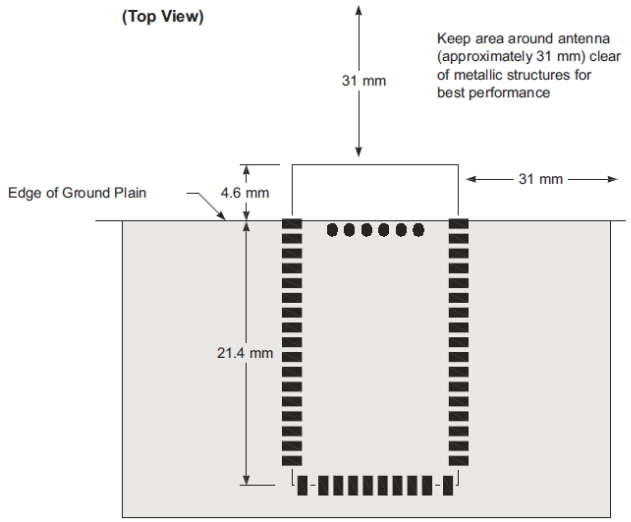
Poor Performance???

- Common problem encountered by customers: expertise in end product but lack experience in wireless
  - Disconnection or loss of data packet
  - Cannot cover normal distance between device and router
  - Unstable firmware
- RF module still need to follow all design rules that are applicable to RF design
- Microchip helps customers review the designs

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Integrate RN41/RN42 with your MCU

- **Good Antenna exposure**
  - Have it exposed
  - Keep Antenna away from other
  - Do not use Metal casing



- Power Supply
  - Reserve 150mA for RN41/42, 300mA for RN171 and 500mA for RN131
  - Condition your power with a 0.1uF and 47uF cap right before feeding into the module
  - Protect the power trace from other noise
- Put 3.3k ohm resister between MCU UART TX and module UART RX
- The module requires h/w flow control

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Configuration timer

- You can enter command mode locally over the serial port at any time when not connected. Once a connection is made, you can only enter command mode if the config timer has not expired.
- Use st,<value> command to set config timer

VALUE (decimal)	DESCRIPTION
0	No remote config, No local config when connected
1-252	Time in seconds from power up to allow config
253	Continuous config LOCAL only
254	Continuous config, REMOTE only
255	Continuous config, both LOCAL and REMOTE

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Hardware pins to connect

- It is recommended to reserve the 6 pin SPI interface
- Reset is recommended to be connected to MCU (active low)
- You can use GPIO pins to get status of RN42 or control RN42

GPIO	DESCRIPTION
GPIO2	Status, high when connected, low otherwise
GPIO3	Auto discovery = high
GPIO4	Set factory defaults
GPIO6	Set BT master (high = auto-master mode)
GPIO7	Set Baud rate (high = force 9,600, low = 115 K or firmware setting)

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Pairing / Connection Time Optimization

- The response time to Pairing inquiry is controlled by inquiry scan window.
- The response time to connection inquiry is controlled by page scan window.
- The wider the window is, the quicker the response is.
- The wider the window is, the more power the module takes
- To adjust inquiry scan window SI, <hex word> (min 0x12, max 0x800)
- To adjust page scan window SJ, <hex word> (min 0x12, max 0x800)

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Bluetooth Power Consumption Optimization

- Bluetooth radio typically uses 3-10mA when it is awake
- Putting into sleep mode will bring the power down to 300uA
- Use SI command to enable sleep mode when possible
- SI command will slow down response

© 2012 Microchip Technology Incorporated. All Rights Reserved.

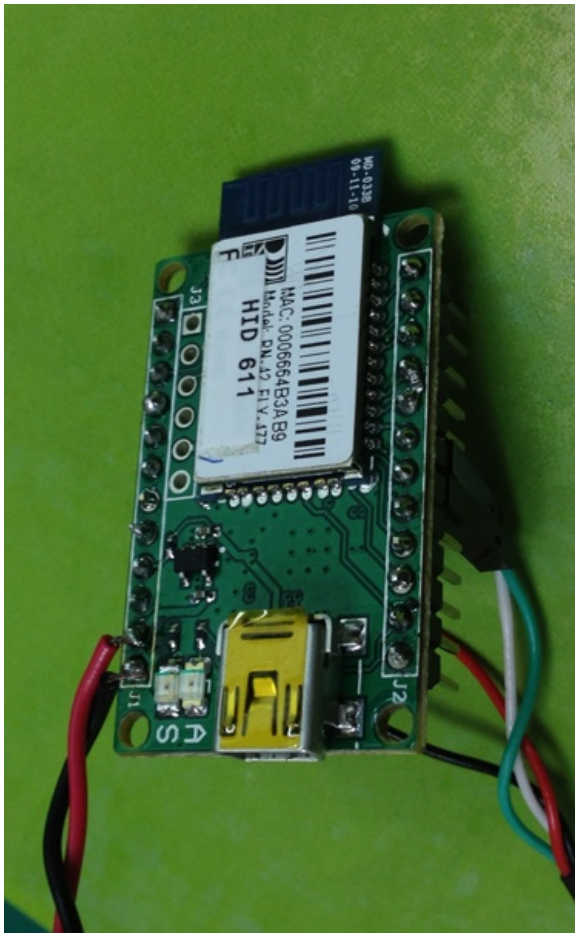
UART Performance limitation

- RN41/42 module is designed for medium to low data rate data only
- Use RN52 for audio application
- The UART baud rate can go up to 921600bps
- The realistic throughput is about 200kbps in combination of 2 directions (TX, RX) for none-Apple application
- The throughput is about 3-40kbps for iAP application

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Connecting RN42-EK board to your MCU

- Supply voltage is 3.3VDC (pin 11 and 12 on J1)
- The I/O voltage on RN42-EK is 3.3VDC
- Connect TX/RX (pin 6 and 7 on J2) to your MCU
- Must connect CTS/RTS to your MCU or simply short the 2 pins (pin 4 and 5 on J2)

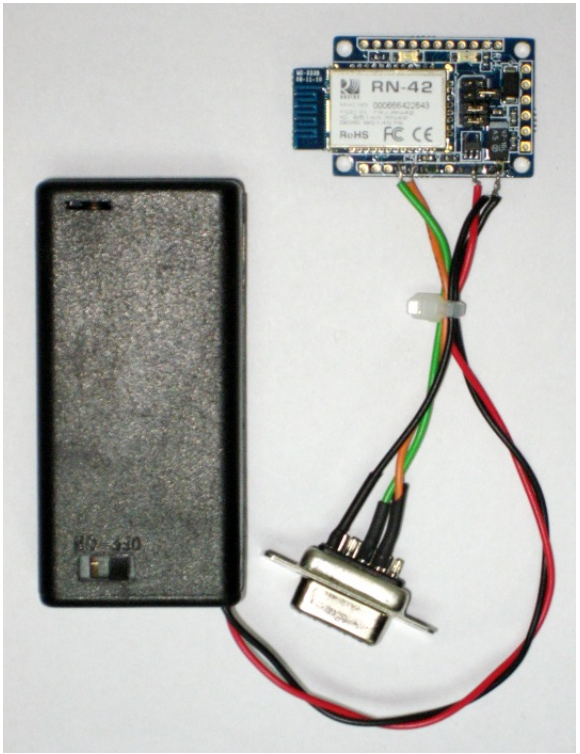


© 2012 Microchip Technology Incorporated. All Rights Reserved.

Power up/Connect RN-42-SM

- **The most practical way to power up / connect to a RN-42-SM from a PC is to use a 3V battery pack and a female DB9 connector**

- **Required components**
  - RN-42-SM module
  - Female DB9 connector and 3 wires
  - 3V Battery pack with 2 wires



- **Connect to RN-42-SM**
  - Short pin 10 and 11 of J1 to power up RS232 driver
  - Short pin 6 and 7 of J1 to short CTS/RTS
  - Connect 3VDC from battery pack to pin 11 (3V+) and pin 12 (GND) on J1. This set up bypass the LDO. The 3VDC goes into the module directly.
  - Connect pin 2 on DB9 to pin 5 on J1
  - Connect pin 3 on DB9 to pin 4 on J1
  - Connect pin 5 on DB9 to pin 12 (GND) on J1

© 2012 Microchip Technology Incorporated. All Rights Reserved.

New on Microchip RN product support

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Firmware release to use

- If you order the modules without specifying the part number, what you will get it the latest and greatest
- If your customer approved certain firmware release and do not want to use the latest release. You need to specify the custom f/w number at ordering time
- The part number convention is <default part number>+<f/w release>
- For example
  - RN42APL-I/RM536 for 5.36 release RN42 IAP
  - RN131G-I/RM238 for WiFly 2.38 RN131G
  - RN171-I/RM228 for WiFly 2.28 RN171

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Resources

- **Visit Roving's support site for all documentation**
  - http://www.microchip.com/wireless

- **User Manuals**
- **Data Sheets**
- **App Notes**
- **CAD Tools**
- **Schematics**
- **Certifications**
- **Utilities**
  - (e.g.. TeraTerm)

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Trademarks

The Microchip name and logo, the Microchip logo, dsPIC, KeeLoq, KeeLoq logo, MPLAB, PIC, PICmicro, PICSTART, PIC^{32} logo, rfPIC and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniscient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICtail, REAL ICE, rfLAB, Select Mode, Total Endurance, TSHARC, UniWinDriver, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2012, Microchip Technology Incorporated, All Rights Reserved.

Questions???

謝其煜
Martin.Shay@microchip.com
+886.939125122
+886.2.2508.8642

© 2012 Microchip Technology Incorporated. All Rights Reserved.

Thank You

© 2012 Microchip Technology Incorporated. All Rights Reserved.