17083 BAS

Bluetooth® Audio Solutions using the RN52 Module

Agenda

- Bluetooth® Basics
- Audio Overview
- Introducing RN52 Bluetooth Module
- Demonstrate Capabilities and Ease of Use

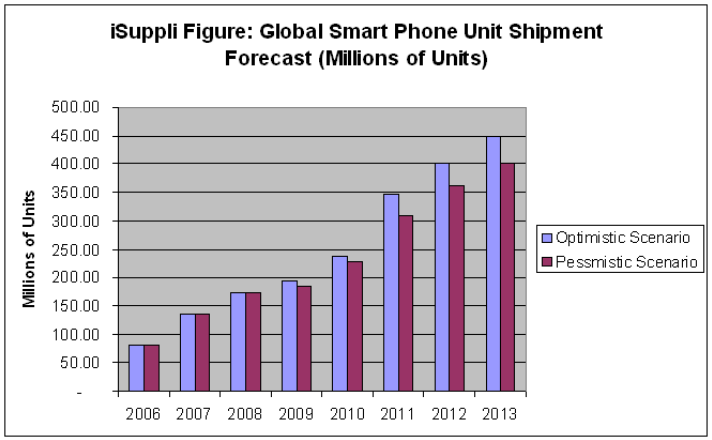
Objectives

- Understand Bluetooth® Protocol Architecture
- Learn Bluetooth Audio Fundamentals
- Learn RN52 capabilities
- Practical knowledge in with RN52EK dev tool
- Use MCHP technologies to create unique Audio applications
- RN52 Resources Available @ MCHP

BLUETOOTH® BASICS

Bluetooth® Applications

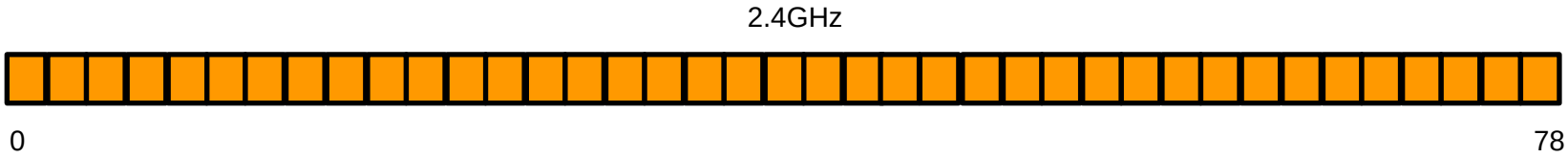
- **Data Communication**
  - Simple Cable Replacement
  - Easily make legacy wired devices – wireless
    - **Barcode scanners, Dongles**
    - **RS232 cable replacement**
- **Audio and Voice Communication**
  - Hands free headsets
  - Streaming audio and voice
  - Wireless Speakers & Docking Station
- **Smartphone is Driving the BT Market**
  - Smartphone is the preferred user interface
  - Apple has the ‘cool’ factor
  - Has become the lifestyle hub
    - **Health/fitness**
    - **Automotive**
    - **Industrial control**
    - **Home automation**

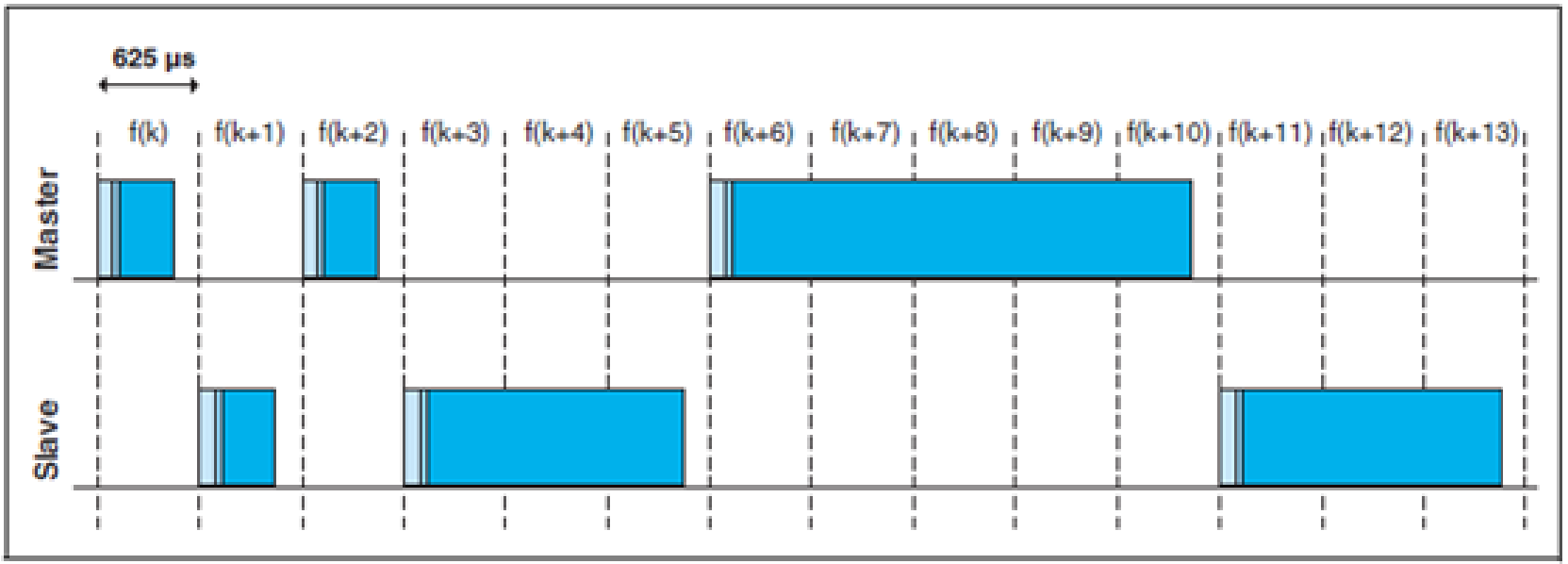


Bluetooth® RF Basics

- **ISM Unlicensed band 2.4 to 2.485GHz**
- **Divides the 83MHz into 79 1MHz channels**
- **Frequency Hopping Spread Spectrum (1600/s)**
- **Channel TDD time slot (625uS)**
- **Master/Slave architecture**
  - 1 master, 7 slaves form a PICONET
- **Class 1: 100m, Class 2: 10m**
- **Bluetooth SIG: www.bluetooth.org**

Bluetooth® Baseband





http://developer.bluetooth.org/TechnologyOverview/Pages/Technology-Overview.aspx

Bluetooth® Packet Types

Type	Payload Header (bytes)	Payload (bytes)	FEC	CRC	Symmetric Max. Rate (kb/s)	Asymmetric Max. Rate (kb/s)	
						Forward	Reverse
DM1	1	0-17	2/3	yes	108.8	108.8	108.8
DH1	1	0-27	no	yes	172.8	172.8	172.8
DM3	2	0-121	2/3	yes	258.1	387.2	54.4
DH3	2	0-183	no	yes	390.4	585.6	86.4
DM5	2	0-224	2/3	yes	286.7	477.8	36.3
DH5	2	0-339	no	yes	433.9	723.2	57.6
AUX1	1	0-29	no	no	185.6	185.6	185.6

Table 6.9: ACL packets

Type	Payload Header (bytes)	Payload (bytes)	FEC	CRC	Symmetric Max. Rate (kb/s)
HV1	na	10	1/3	no	64.0
HV2	na	20	2/3	no	64.0
HV3	na	30	no	no	64.0
DV[1]	1 D	10+(0-9) D	2/3 D	yes D	64.0+57.6 D
EV3	na	1-30	No	Yes	96
EV4	na	1-120	2/3	Yes	192
EV5	na	1-180	No	Yes	288

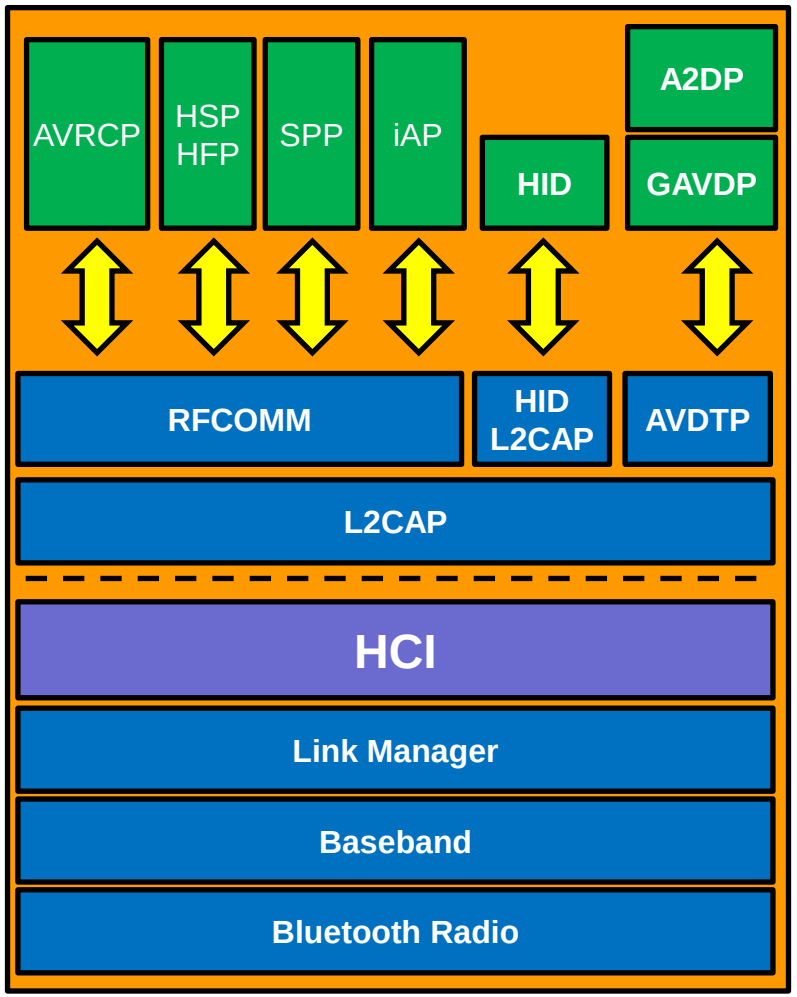
Table 6.10: Synchronous packets

Bluetooth® Stack

- Audio Profiles
  - ✓ **A2DP (Audio)**
    - Advanced Audio Distribution Profile. Allows for wireless distribution of stereo audio
  - ✓ **HFP/HSP (Voice)**
    - Hands Free & Headset Profiles allow for intercom type communication
  - ✓ **AVRCP (Media Stream Control)**
    - Audio Video Remote Control Profile, allows for basic play/pause, next/previous type media control

  Audio profiles do not require Apple MFI

- Data Profiles
  - ✓ ***SPP***
    - *Serial Port Profile, Bi-directional data communication*
  - ✓ ***iAP***
    - *iPhone Accessory Profile, for iAP connections and devices*



http://developer.bluetooth.org/TechnologyOverview/Pages/Technology-Overview.aspx

Bluetooth® Profiles

- Defined by Bluetooth Specifications
- Interoperability of Services
- List dependent protocols

The Bluetooth® AUDIO Profile

A2DP

A2DP: Bluetooth® Audio Profile

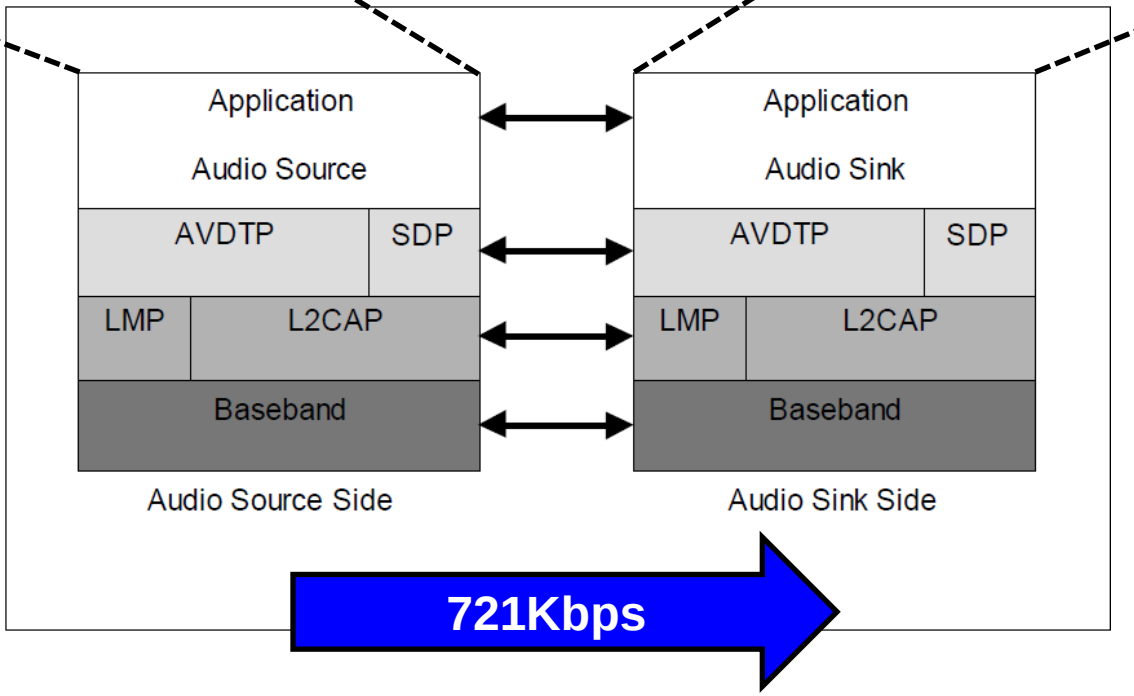
- **Advanced Audio Distribution Profile**
  - Defines protocols and functions needed to support stereo audio
  - Streaming Music
- **Architecture**
  - Source (SRC) encodes audio stream
  - Sink (SNK) decodes audio stream
- **Protocols Description**
  - AVCTP – control media player
  - AVDTP – transport protocol for media

- **https://www.bluetooth.org/en-us/specification/adopted-specifications**

A2DP: Architecture

- Media store
- CODEC Encoder
- Content Protection

- CODEC/Decoder
- Audio Rendering
- DAC, Audio Output



A2DP Spec 1.2

A2DP CODECs

- **The DEFAULT CODEC**
  - SBC: Bluetooth® SIG default
    - **Required for every device using A2DP profile**
    - **Supported by all A2DP Bluetooth Audio devices**
- **Proprietary CODEC**
  - aptX
    - **Licensed by CSR**
    - **Customer must sign and pay for license agreement**
    - **Per module royalty**
  - AAC
    - **Licensed by VIAlicensing.com**
    - **Per module royalty**
  - MP3
    - **Licensed by MP3Licensing.com**
  - Atrac
    - **Licensed by SONY**
- **Codec must be supported by both sides of the connection**
  - ADVTP protocol will negotiate the CODEC before establishing stream

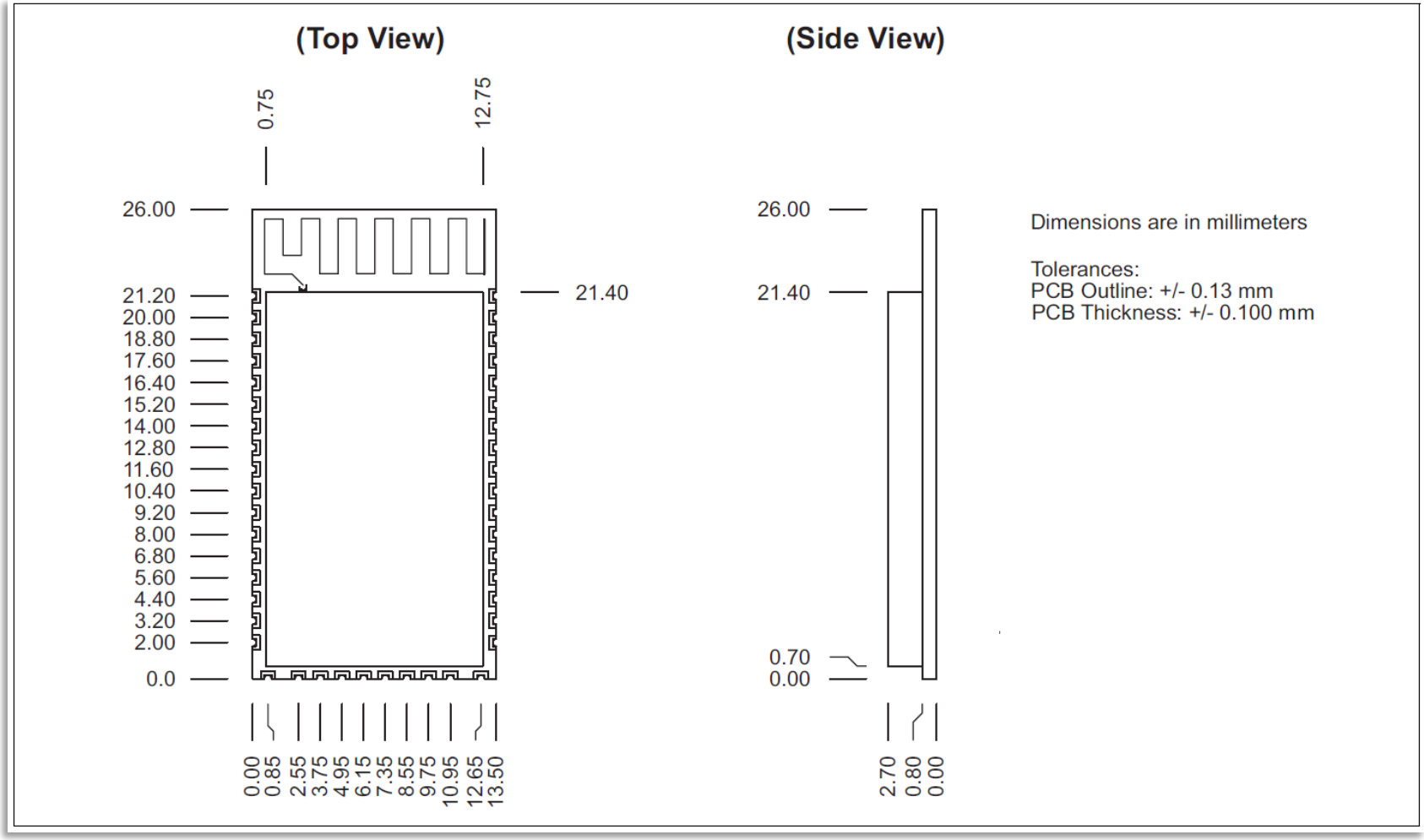
RN52
BLUETOOTH® AUDIO MODULE

RN-52 Bluetooth® Audio Module

- **On-board Bluetooth 3.0+EDR stack**
  - Key audio functions integrated on a single module
  - Compatible with ALL earlier version Bluetooth stacks
  - Profile support *(A2DP, AVRCP, HSP, HFP, SPP, iAP*)*
- **Audio interfaces**
  - Digital - I2S, S/PDIF
  - Analog – two channel audio, built-in amplifier for mic and speaker
- **GPIO for control**
- **UART data and command interface**
- **Compact Footprint**
  - 13.5x 26 x 2.7mm
  - Integrated antenna
- **Fully Certified**
  - FCC, IC, CE, Bluetooth QDID, RoHS

*Note: iAP support requires MFi membership

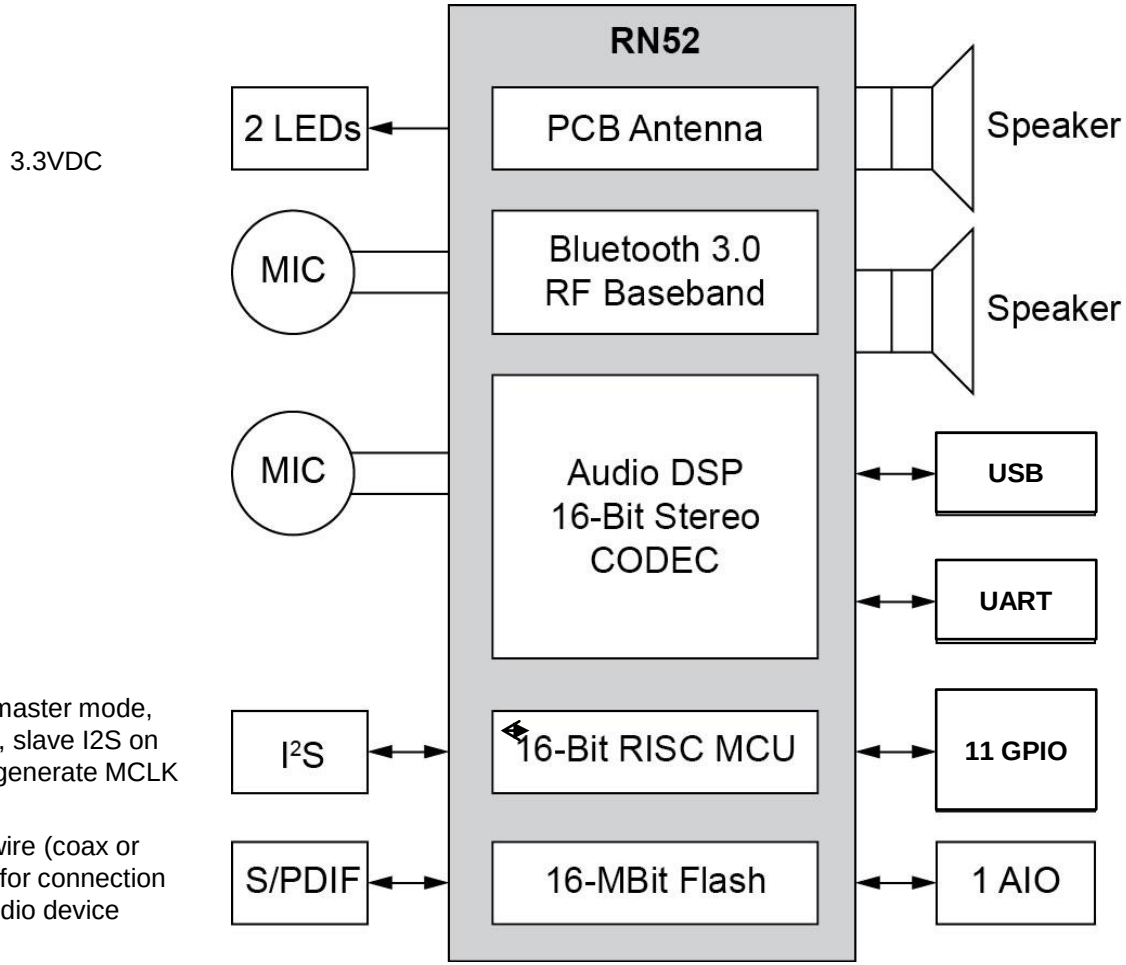
Module Dimensions



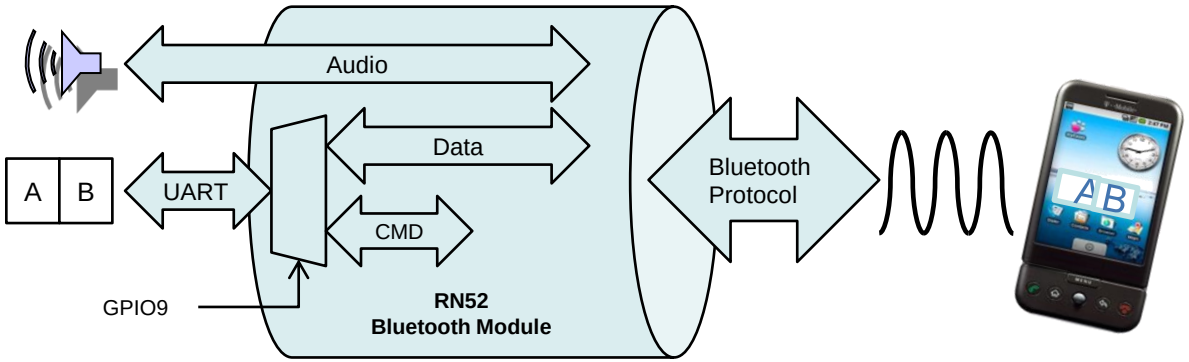
Audio and Data Interfaces

- **Audio Interfaces**
  - Analog Audio Output and Input
  - Built in amplifier to drive headphone
  - Digital Audio Output for External Codec
    - **I2S**
    - **S/PDIF**
- **Data**
  - UART
    - **SPP**
    - **Wireless iAP low level**

RN52 Interfaces

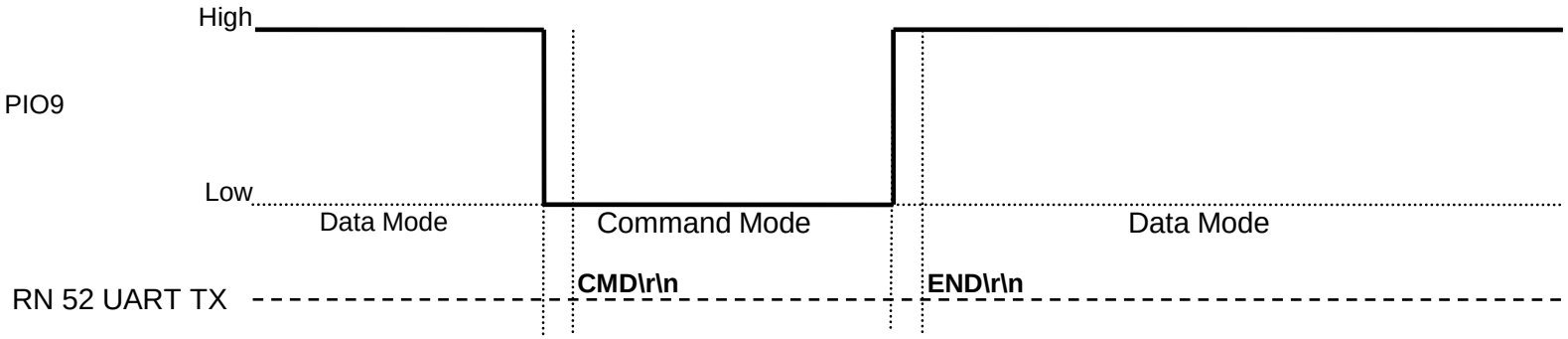


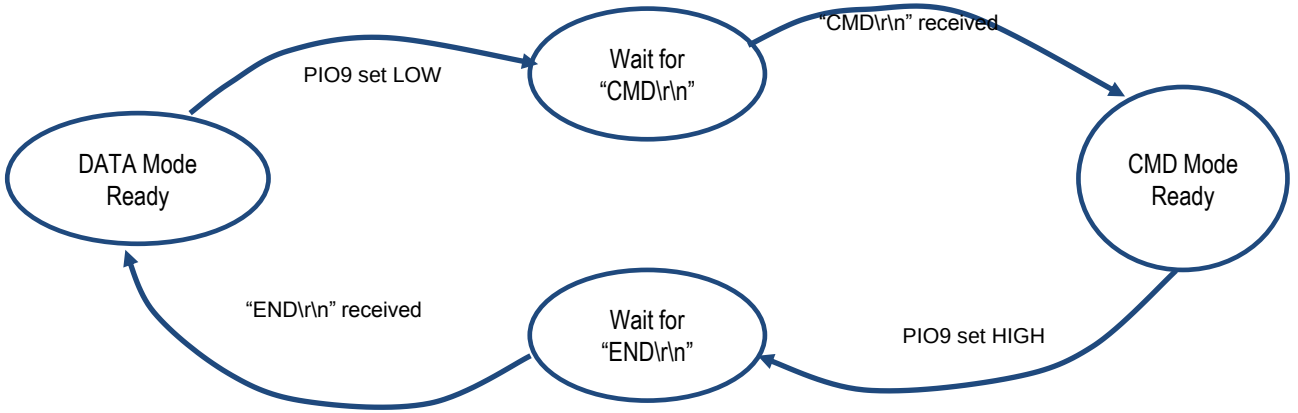
RN-52 Audio and Data Pipe



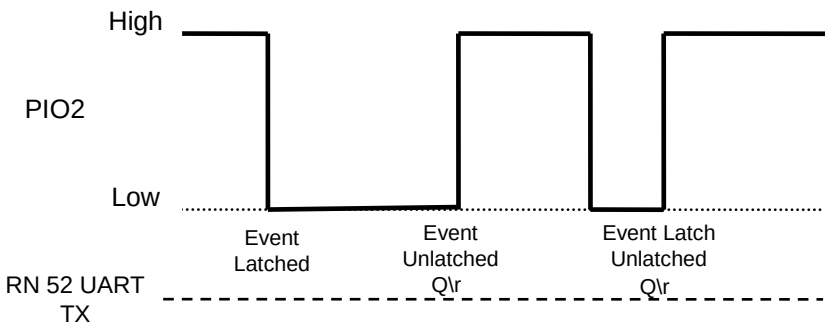
- **Audio and Data is transferred across the Bluetooth® link**
  - What you see is what you get
- **Commands and configuration over the Data UART**
  - GPIO9 LOW puts the module into Command Mode
    - **Does not support over-the-air configuration**
    - **Unlike RN-42 and RN-41 $$$ is NOT required**
    - **Must wait for CMD and END strings on UART before sending data again**
    - **Being in command mode does not effect Audio streams**
  - Examples of Configuration **Set** commands
    - **Switch audio interface**
    - **Control connections**
  - Example of **Action** commands for Audio (A2DP) and Voice (HFP/HSP)
    - **Play, Pause, FFWD**
    - **Accept and drop calls**

Command/Data Mode (GPIO9)





Event Notification (GPIO2)



- Monitor GPIO2 low level
- Drive GPIO9 low
- Wait for “CMD\r\n”
- Issue “Q\r” command
  - Return status
  - Unlatch GPIO2

Value	State	Description
0	Limbo	logically off but physically on
1	Connectable	connectable - page scanning
2	Connectable and Discoverable	connectable and discoverable - page and inquiry scanning
3	Connected	connected to an AG
4	Outgoing Call Establish	connected AG has an outgoing call in progress
5	Incoming Call Establish	connected AG has an active call in progress and the audio is in the headset
6	Active Call On Handsfree	connected AG has an active call in progress and the audio is in the headset
7	Test Mode	headset is in test mode
8	Three Way Call Waiting	connected AG has an active call and a second call on hold
9	Three Way Call On Hold	connected AG has an active call and a second call on hold
10	Three Way Call Multi Call	connected AG has an active call and a second call on hold
11	Incoming Call On Hold	connected AG has an incoming call on hold
12	Active Call On Handset	connected AG has an active call and the audio is in the handset
13	Audio Streaming	headset is streaming A2DP audio
14	Low Battery	low battery state

RN52 Command Groups

- **Bluetooth® Profile Management**
  - Select which profiles to connect
- **Connection Management**
  - Initiate, Accept, Reject, Drop voice calls
  - Reconnect to last host
  - Get Status “Q”: connected profiles
- **GPIO Control and Configuration**
  - Set direction and Get state
- **AVRCP Functions**
  - A2DP: Start/Stop, Next/Prev, Volume up/down
- **Extended Features**

Command Set

- **RN52 User Manual available www.microchip.com/RN52**

Set/Get Configuration	
S-,<text>	Serialized Name
S|,<hex8>	Audio Route
S^,<dec>	Auto Power Off timer
S%,<hex8>	Extended features
SA,<dec>	Authentication mode
SC,<hex24>	Class of Device
SD,<hex8>	Discovery Mask
SF,1	Factory Default
SK,<hex8>	Connection Mask
SN,<text>	BT Name
SP,<text>	Pin Code

Connection	
A,<text>	Initiate Voice Call
B	Reconnect to last device
C	Accept incoming voice call
E	Drop/Reject active or incoming call
K,<hex8>	Disconnect Profiles

AVRCP Media Control	
AP	Play/Pause toggle
AV+	Volume Up step
AV-	Volume Down step
AT+	Next Track
AT-	Previous Track

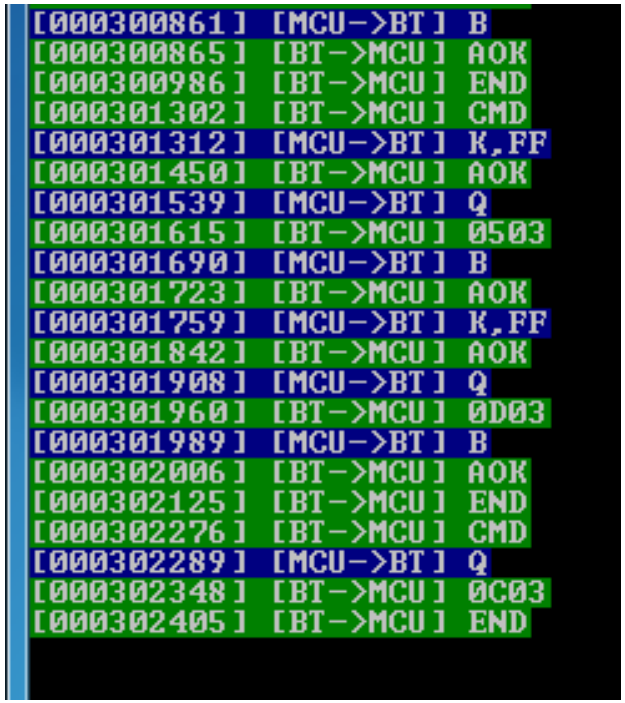
GPIO Configuration/Control	
I@	Show GPIO input/output mask
I@,<hex16>	Set GPIO input/output mask
I&	Show GPIO input/output state
I&,<hex16>	Set GPIO output state

Action	
+	Toggle local echo
@,<0,1>	Disable/Enable Discovery
D	Display configuration
Q	Connection Status
R,1	Reboot Module
V	Show firmware version
Y,<0,1>	Return gain level

RN52 GPIOs

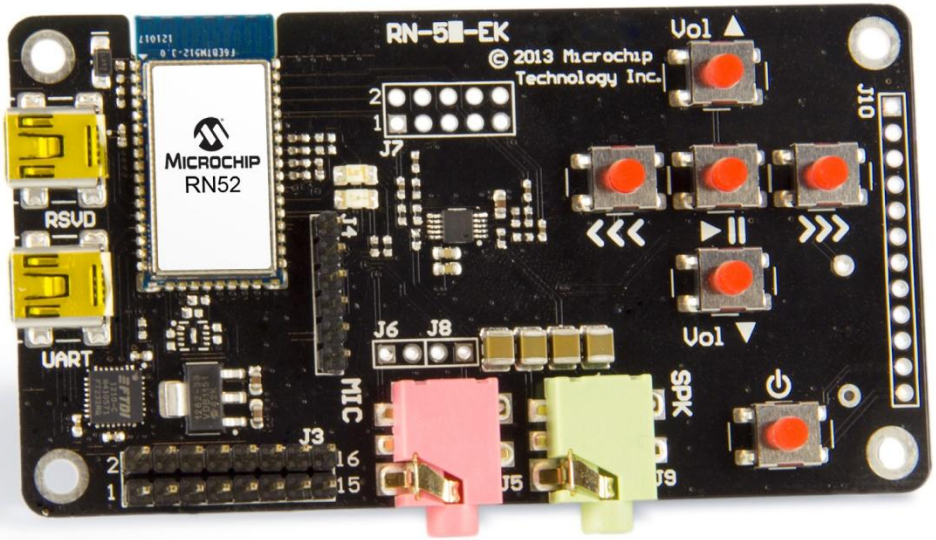
PIO	Mask	Description	
0	0001	N/A	
1	0002	N/A	
2	0004	RESERVED, output only used to drive state change notifications. The mask value “I@” will always return “0004”	
3	0008		DFU
4	0010		Factory
5	0020	Volume up in AVRCP mode	
6	0040		9600
7	0080		
8	0100	N/A	
9	0200	RESERVED, input only used to detect CMD mode entry.	
10	0400	Volume down in AVRCP mode	
11	0800	Previous track in AVRCP mode	
12	1000	Next Track in AVRCP mode	
13	2000	Pause/Play in AVRCP mode	
14	4000	N/A	
15	8000	N/A	

RN52 “Q” Command



BYTE0	
Bit	Description
0	iAP Wireless active connection to remote device
1	SPP active connection to remote device
2	A2DP active connection to remote device
3	HFP/HSP active connection to remote device
4-7	RESERVED
BYTE1	
Bit	Description
0-3	Connection States: 0-15, see table 2 below
4	HFP audio volume level change from audio gateway (phone), use “Y,0” to retrieve volume level
5	HFP audio microphone level change from audio gateway (phone), use “Y,1” to retrieve microphone level
6	HFP Voice mute/hold event triggered by Phone
7	Connection timeout flag: used to indicate if “B” re-connect command time out. This flag is cleared after “Q” status is returned.

The RN52EK Dev Tool



Bluetooth® Audio Evaluation Kit
(Part # RN-52-EK)

RN52EK Evaluation Kit

Out of the Box Streaming Audio Demo

1. Plug in the cables
2. Pair with a Smartphone
3. Play your favorite music remotely

Features

- Track and volume control buttons
- Pause button
- Status LEDs
- Stereo Microphone & Speaker ports

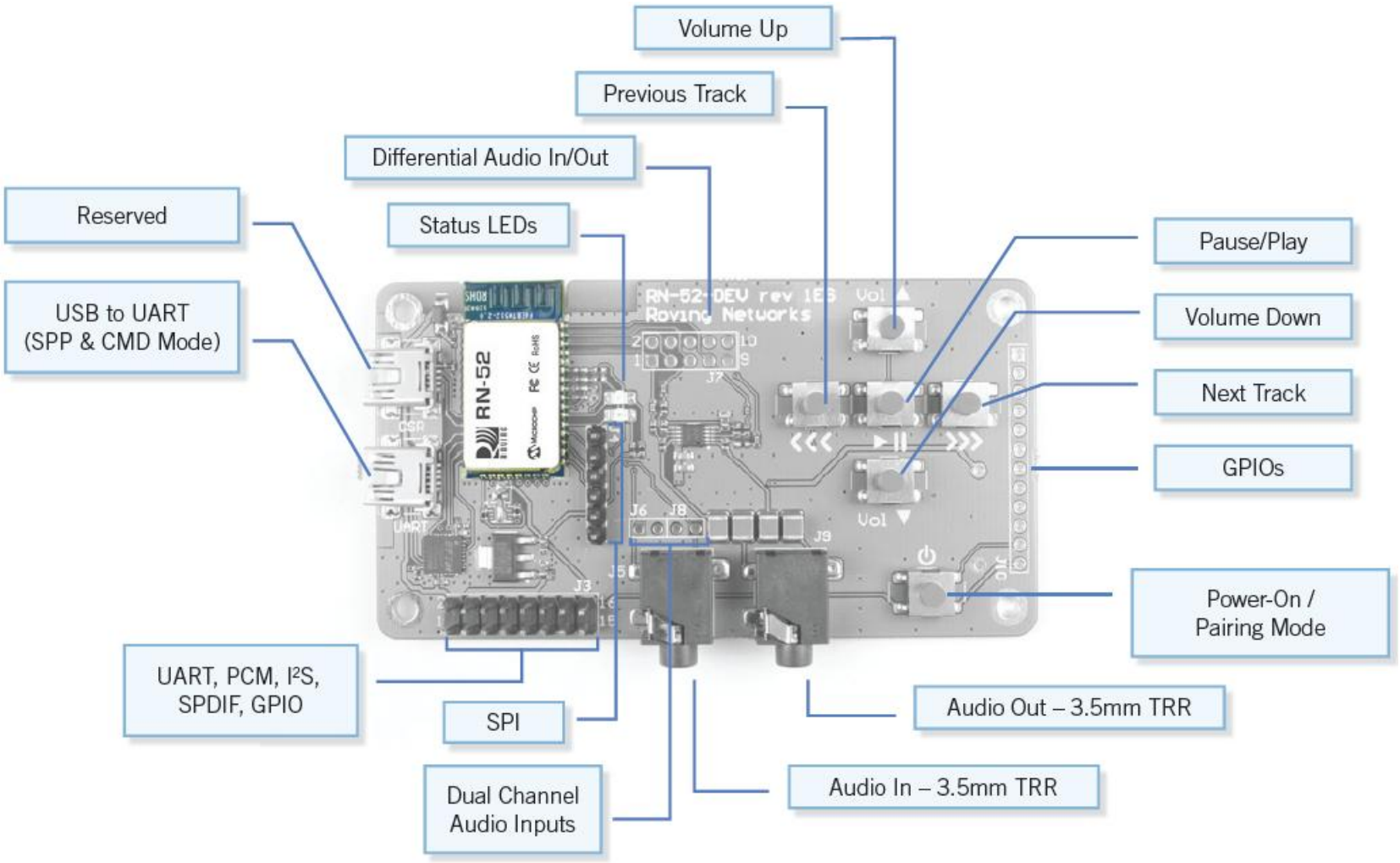
RN-52-EK Interfaces

- Stereo speaker and microphone
- Digital Audio i2s, SPDIF
- PCM port – use with external codec's
- External PA
- GPIO for control
- USB DFU
- USB console
- TTL UART
- iAP auth. chip footprint

Overview

- Dev tool to rapid prototype BT Audio Application
- Everything you need to get started
- Runs hosted (MCU) or hostless

RN52EK Interfaces



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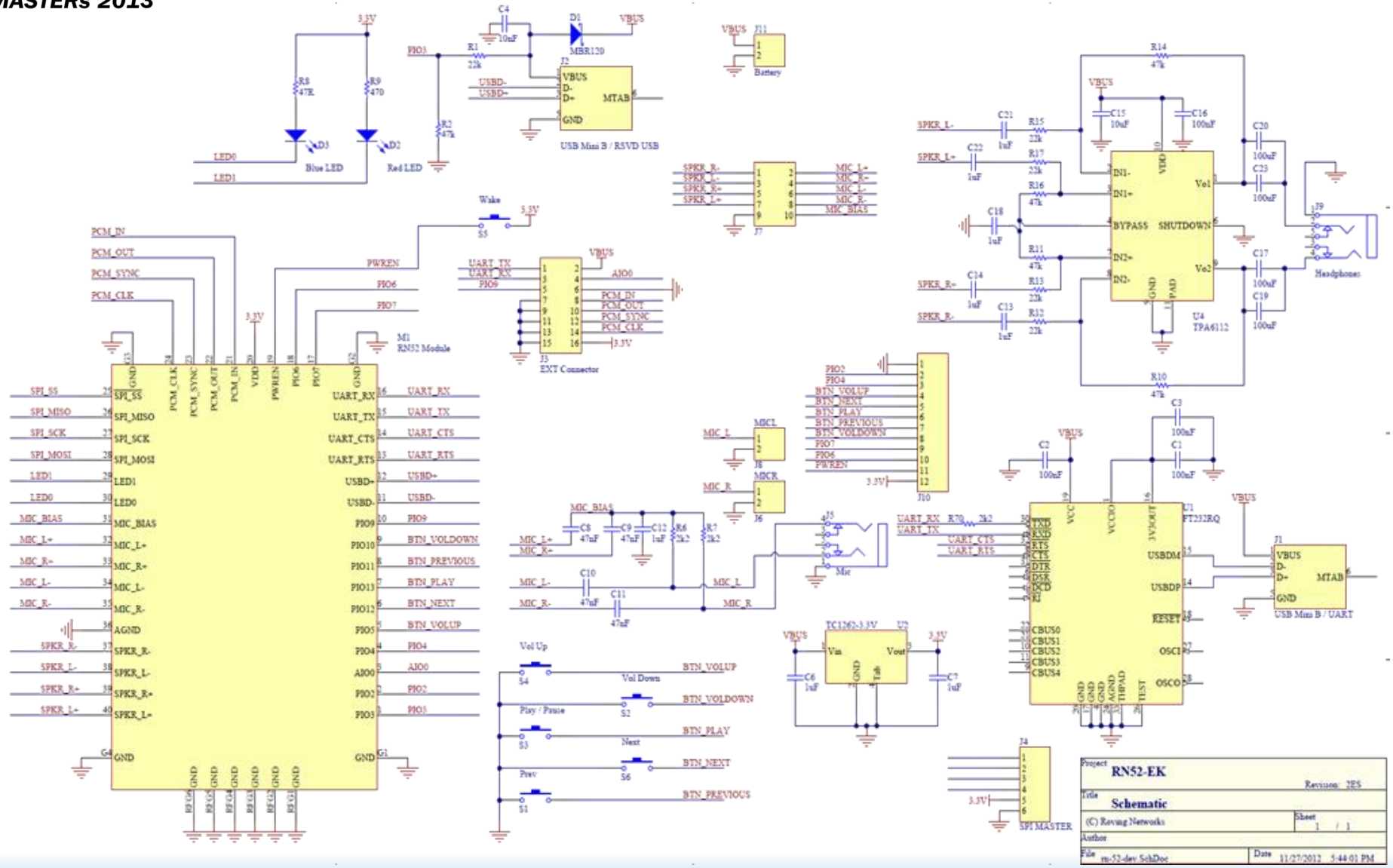
RN52EK Schematic



Hostless Applications

- **Wireless Speakers**
  - Ready to run
  - Select your audio chain
- **Basic Docking Station**
  - Use the built in AVRCP functions
  - Built in audio amplifiers

Hosted Applications

- **Digital Audio to External CODEC**
- **iAP/SPP adds value to Audio Applications**
- **Control the Audio using MCU**
  - SMART DOCKING STATION
  - JUKE BOX EXAMPLE
- **Leverage Microchip Solutions**
  - GestIC® Technology, mTouch™ sensing solution,PIC32 Audio Lib

Using RN52EK

- **Connect USB to UART**
  - To access CMD mode, use terminal emulator
- **Connect speaker mic**
- **Hold Power On**
- **Pair to Smartphone**
- **Start streaming and making calls**

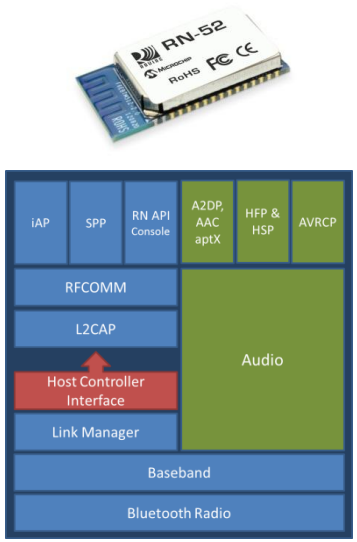
RN52 Example

Recommendations

- **Buy the RN52EK**
- **Engage with MCHP early and often during requirements definition**
- **Follow the Reference design in the data sheet**
  - Data sheet is www.microchip.com/RN52
- **Include header and control signals for DFU**
- **Provide good grounding for good antenna performance**
  - Ground fill under the module and stitch with vias to gnd plane
  - No metal or components in antenna keep out areas
- **Resources**
  - Contact MCHP FAE or sales representative
  - www.microchip.com/RN52
  - www.microchip.com/support

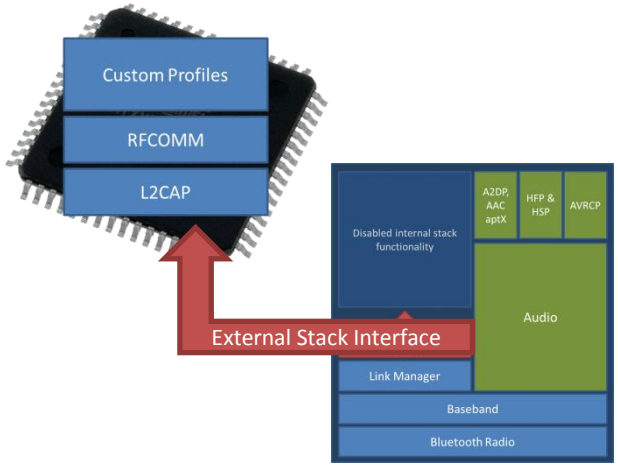
Module vs CHIP Down

Stack/Profiles **on** Board



- Simple to integrate
- 90% of use cases
- Any microprocessor or No microprocessor
- Focus on the Application,
  not the Bluetooth® profiles
- Certifications Done

Stack/Profiles **off** Board



- Flexible design, allows for additional profiles
- Lower cost module, simple HCI Bluetooth
- Longer time to market
- Increased engineering development cost

Certifications

- FCC grant (T9J-RN52)
- CE Mark
- IC grant (6514A-RN52)
- Bluetooth® QDID

Bluetooth® Family of Modules

	RN-41 / RN-41-N	RN-42 / RN-42-N	RN-52
Application	Data	Data	**Audio *(and data)***
Bluetooth	BT 2.1 device	BT 2.1 device	BT 3.0 device
Type / Range	Class 1 – 100m range	Class 2 - 30m range	Class 2 - 30m range
Interfaces	UART / USB	UART / USB	Analog speaker and mic, I2S, S/PDIF, PCM, UART
Profiles	SPP / HID / iAP / HCI	SPP / HID / iAP / HCI	A2DP / AVRCP / 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	13.5mm x 26mm x 2.7mm
Certification	FCC / CE / ICS	FCC / CE / ICS	FCC / CE / ICS
Chipset	CSR BC04	CSR BC04	CSR BC05

Thank You

- RN52EK discounted MASTERs Dev tool Store
- See more RN52 demos @ Ask the Experts booth
- www.microchip.com/RN52
- Q&A

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