Application Note

WICED™ APOLLO

WICED™ APOLLO Wireless Audio

5300 California Avenue • Irvine, California, 92677 • Phone: 949-926-5000 • Fax: 949-926-5203

WICED-FLAC-R
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Revision History

Revision	*Date*	*Change Description*
WICED-APOLLO-1.0	December 18, 2015	Initial revision

Broadcom Corporation
5300 California Avenue
Irvine, CA 92617

Table of Contents

1 About this Document

1.1 Purpose and Scope

This document provides instructions to use the WICED Apollo wireless audio distribution system.

Note: This document applies to **WICED SDK 3.5.2** or higher.

1.2 Audience

This document is for software developers who are using the WICED Development System to create Wireless audio distribution systems using BCM4390x product family (e.g. BCM943909WCD1_3, BCM943907WAE_1, etc).

2 Apollo Wireless Audio Distribution System

Apollo is the software stack for implementing a whole-home multichannel Wireless Audio distribution system. Central to the design of Apollo is the concept of a sender (transmitter) or "source" device and one or more receiver or "sink devices". The system allows a source device or "source" to transmit music via Wi-Fi (over an 802.11 network) to one or more receivers (Wireless speakers) allowing for scalable speaker configurations from 2 speakers (stereo) up to 5.1 (6 speakers) and later 22.2 (UHD) surround sound. Core features in the Apollo wireless audio streaming system:

- 802.1AS Precision Time Protocol and Grand Master Clock (GMC) supporting 802.11v
- Reliable Multicast Streaming protocol for one or more speaker devices
- Audio Packet Loss Concealment
- End to end delay from 10ms to 50ms

The following configurations below are supported:

Input Source	Source Device	Sink Device(s)	Configuration	Availability
File (WAV)	Gigabyte BRIX + BCM4356	2 x BCM943907WAE_1	Stereo	Contact sales
File (WAV)	Gigabyte BRIX + BCM4356	6 x BCM943907WAE_1	5.1 Surround	Contact sales
Bluetooth A2DP	BCM943907WAE_1	BCM943907WAE_1	Stereo	WICED 3.5.2
Bluetooth A2DP	BCM943907WAE_1	2 x BCM943907WAE_1	Multi-zone (Stereo)	WICED 3.5.2
Analog Stereo	BCM943907WAE_1/BCM943909WCD1_3	BCM943907WAE_1	Stereo	WICED 3.5.2
Analog Stereo	BCM943907WAE_1/BCM943909WCD1_3	2 x BCM943907WAE_1	Multi-zone (Stereo)	WICED 3.5.2
SPDIF (Optical)	BCM943907WAE_2	6 x BCM943907WAE_1	5.1 Surround	Q2 2016

2.1 Audio Speaker Configurations

Apollo also scales and addresses the growth needs of the user as more speakers are added to the system - Stereo (2), 2.1 (3) (L/R/Bass), 6 (5.1), and larger systems may be built. Apollo supports up to 16 different speaker/channel configurations all of which may be adapted to the user's entertainment requirements.

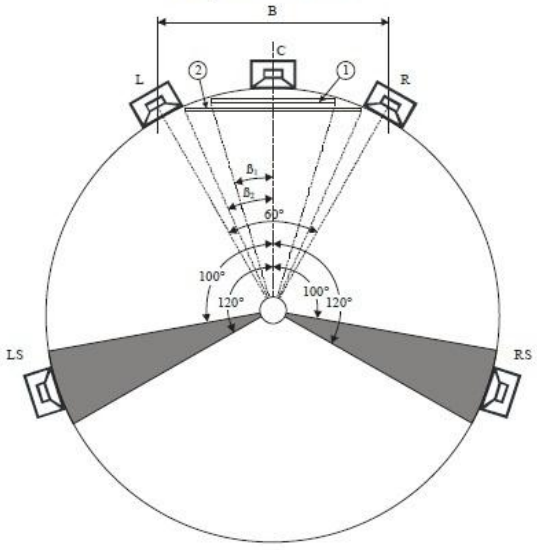
2.2 Stereo/2.1

The most common use case which Apollo addresses are two independent speakers (stereo) where (rather than having one receiver driving 2 speakers) each receiver renders one of the speaker pairs - a Left (L) or Right (R) channel independently. This system may be further enhanced to support a Center (C) configuration.

2.3 5.1/7.1 Surround Sound

The true benefit of Apollo comes from support for more than 2 speakers; the most relevant use case is "Surround sound" or a 5.1 system and larger. The 5.1 channel sound system has been specified in Recommendation ITU-R BS.775. The system is widely used as a part of digital broadcasting services. It enhances the directional stability of the frontal sound image and the sensation of spatial reality (ambience). The reference loudspeaker arrangement is shown below in which each loudspeaker is set at the same height as a listener's ears.

Reference loudspeaker arrangement with loudspeakers L/C/R an LS/RS



Screen 1 HDTV - Reference distance = 3 H ($2\beta_1 = 33°$)
Screen 2 = 2 H ($2\beta_2 = 48°$)
H: height of screen
B: loudspeaker base width

Loudspeaker	Horizontal angle from centre (degrees)	Height (meters)	Inclination (degrees)
C	0	1.2	0
L, R	30	1.2	0
LS, RS	100 ... 120	≥ 1.2	0 ... 15 down

2.4 Equipment Needed

- 2 Broadcom WICED platforms of the above configurations (minimum for multi-zone Stereo)
- iPhone or Android phone supporting Bluetooth
- 2 Speakers (Amplified) or Headphones supporting standard 3.5mm Audio plug
- Power connectors
- WICED Debug board

2.5 Building the Firmware

Follow the steps below to build the firmware image for the platforms.

2.5.1 Build Prerequisites

Install Apollo RMC/AVB WLAN firmware (for all 4390x platforms)

```
cd WICED-SDK-xxx/WICED-SDK/resources/firmware/43909
cp 43909B0-apollo.bin 43909B0.bin
```

Edit `WICED-SDK/apps/demo/apollo/wifi_config_dct.h` to specify SSID and channel; the defaults below are recommended for first time use:

```
/* This is the soft AP available for normal operation */
#define SOFT_AP_SSID "apollo"
#define SOFT_AP_CHANNEL 132
/* This is the default AP the device will connect to (as a client)*/
#define CLIENT_AP_SSID "apollo"
#define CLIENT_AP_BSS_TYPE WICED_BSS_TYPE_ADHOC
#define CLIENT_AP_SECURITY WICED_SECURITY_OPEN
#define CLIENT_AP_CHANNEL 132
#define CLIENT_AP_BAND WICED_802_11_BAND_5GHZ
```

```
Note: supported 5Ghz DFS channels are: 132, 116, 108
```

2.5.2 Platform Build strings

In the WICED IDE, create the following two build targets. Build and install on two systems (not necessarily the same HW)

Wireless Audio Edition 1 (WAE_1)

```
demo.apollo-BCM943907WAE_1.B0 download run
```

Wireless Connectivity Device 1 (WCD1_3)

```
demo.apollo-BCM943909WCD1_3.B0 download run
```

NOTE: WCD1_3 platforms use AKM audio output by default. You can change this with the "`config ad_tx`" option (to use for example the Wolfson codec)

2.6 Configuration

Start by designating one system as the source device and the other as the sink device. Connect the speakers and power. Now (with the USB serial port attached), issue the below commands on each device:

2.6.1 Multi-Zone - Bluetooth Re-broadcaster (> 2 devices)

Source configuration

```
> config apollo_role source
> config src_t bt
> config network_name <name>
> config network_channel <channel>
> config mac <mac>
> config bt_name <name>
> config pll 1
> config save
```

Stereo Sink Configuration(s)

```
> config apollo_role sink
> config network_name <name>
> config network_channel <channel>
> config speaker_channel FL FR
> config mac <mac>
> config clock 1
> config pll 1
> config save
```

NOTE: name, channel must be the same on source/sink

NOTE: the mac address should be unique on each board

Finally reboot each board after “config save”. Use your iPhone/Android phone and discover the device under your Bluetooth settings menu. Connect and play music. You will hear the music on both the source and sink devices.

2.6.2 Multi-Zone - Analog Re-broadcaster

Source configuration

```
> config apollo_role source
> config src_t capture
> config network_name <name>
> config network_channel <channel>
> config mac <mac>
> config save
```

Stereo Sink Configuration

```
> config apollo_role sink
```

```
> config network_name <name>
> config network_channel <channel>
> config speaker_channel FL FR
> config mac <mac>
> config clock 1
> config pll 1
> config save
```

Connect the audio input to the source device. As before, reboot the system and start playback.

2.6.3 Multi-Speaker

To support multiple speakers, each sink device is designated a channel which it would play. For a stereo system you would need 1 set of speakers on the source (playing stereo (FL/FR)) and a speaker attached to 2 more sink devices (one playing left – FL, the other playing right – FR).

Sink Configuration

```
> config speaker_channel FL FR
> config save
```

2.6.4 5.1 Surround sound

With BRIX platforms, the following channel mappings must be established on each sink device.

```
> config speaker_channel FL
> config save
```

```
> config speaker_channel FR
> config save
```

```
> config speaker_channel FC
> config save
```

```
> config speaker_channel LFE
> config save
```

```
> config speaker_channel BL
> config save
```

```
> config speaker_channel BR
> config save
```

2.7 Available Commands

Use the “config help” command for details on console commands.

```
> config help
```

```
Config commands:

    config                                : output current config

    config <?|help>                       : show this list

    config auto_start <0|off|1|on>      : 0 = auto start off, 1 = auto start
on

           auto       <0|off|1|on>

    config buffering_ms <xxx>           : xxx = milliseconds

           buff_ms <xxx>                :       (range:0 <= xx <= 1000)

    config clock <0|disable|1|enable>   : 0 = disable AS clock, 1 = enable

    config pll    <0|disable|1|enable>    : 0 = disable audio PLL tuning, 1 =
enable

    config pll_tuning <0|disable|1|enable>

    config mac_addr <xx:xx:xx:xx:xx:xx> : xx:xx:xx:xx:xx:xx = new MAC address

    config mac <xx:xx:xx:xx:xx:xx>      : Shortcut:

    config mac <xx>                          :    enter 1 octet to change last
octet

    config network_channel <xxx>        : xxx = channel

           net_chan <xxx>               :  (1-11,36,40,44,48,52,56,60,64,

                                        :   100,104,108,112,116,120,124,128,

                                        :   132,136,140,149,153,157,161,165)

    config network_name <ssid_name>     : name of AP (max 32 characters)

           net_name <ssid_name>

           ssid <ssid_name>

    config  network_passphrase  <pass>         :  passkey/password  (max  64
characters)

           net_pass <pass>

           pass <pass>

    config network_security <type>      : security type is one of:

           net_sec   <type>                                                  :
open,none,ibss,wep,wepshared,wpatkip,wpaaes,
```

```
                                        :
wpa2tkip,wpa2aes,wpa2mix,wpsopen,wpsaes

    config speaker_name <name>          : speaker name (max 36 characters)

           spkr_name <name>

    config speaker_channel <ch> [ch]... : channel mix - all will be OR'ed
together

           spkr_chan     <ch>     [ch]...                                  :
FL,FR,FC,LFE1,BL,BR,FLC,FRC,BC,LFE2,

                                        :
SIL,SIR,TPFL,TPFR,TPFC,TPC,TPBL,TPBR,

                                        :    TPSIL,TPSIR,TPBC,BTFC,BTFL,BTFR

    config threshold_ms <xx>            : xx = milliseconds

           thresh_ms <xx>               :      (range:0 <= xx <= 1000)

    config volume <xx>                  : xx = volume level

           vol <xx>                     :      (range:0 <= xx <= 100)

    config payload_size <size_in_bytes> : from 64 to 1432 bytes

    config fec_order     <string>          : "pre" = before audio, "post" =
after audio

    config fec_length   <packet_count>  : from 0 to 16

    config fec          <packet_count>

    config source_type  <string>         : "bt" = BT A2DP audio, "capture" =
using local ADC

    config src_t        <string>

    config audio_device_rx <device_X>    : enter X as in WICED_AUDIO_X, X
starts at 0 for all WICED platforms

    config ad_rx           <device_X>

    config audio_device_tx <device_X>    : enter X as in WICED_AUDIO_X, X
starts at 0 for all WICED platforms

    config ad_tx           <device_X>

    config apollo_role <source | sink>  : Configure as a source or a sink

    config role <source | sink>

    config clientaddr <IP address>      : Client IP address for sender to use
```

```
    config addr <IP address>

    config rtp_port <port number>       : RTP port number

    config port <port number>

    config log_level <level>            : Set the default application logging
level

    config log <level>

    config is_configured <0|no|1|yes>     : Set to 0 to force BT GATT
configuration

    config is_conf       <0|no|1|yes>

    config bt_name <name>               : Set the bluetooth device name

    config bt_dev <name>

    config bt_mac <xx:xx:xx:xx:xx:xx>    : xx:xx:xx:xx:xx:xx = new Bluetooth
MAC address

    config bt_mac <xx>                     :    enter 1 octet to change last
octet

    config bt_class <xx:xx:xx>            : xx:xx:xx = new Bluetooth device
class

    config save                           : save data to flash NOTE: Changes
not

                                          :   automatically saved to flash!

>
```

2.8 Extra Debugging

Use the log command to get additional information on the source or sink. To make the setting persistent across reboot, use the "config loglevel" command. Valid values are 0 (no messages) to 10 (full debug messages). NOTE: when increasing the log-level for debug, audio artifacts may be heard due to too many UART interrupts during playback. This will be addressed in future releases.

```
> log 10
Setting new log level to 10 (0 - off, 9 - max debug)
>
```

Sink Configuration

```
> config log_level 3
> config save
```

3 iOS Apollo Audio Configuration Application

The iOS Apollo Configuration App demonstrates how to configure Wi-Fi and speaker settings of WICED Audio based speakers running the Apollo Wireless Audio stack vthrough Bluetooth Low Energy (BLE) on an iOS device.

3.1 Setup

- BCM43907WAE_1 or BCM43907WAE_2 WICED Audio boards. Up to 6 can be configured at a time. Follow the build instructions above.
- Install WICED-SDK-3.5.2 or later on your computer. NOTE: The Apollo iOS application is distributed as a patch available upon request from Broadcom.
- Apple Mac
    - Clone and build the "Apollo Audio Config" source in Xcode from the SDK release 3.5.2 or later plus patch located in apps\demo\apollo\peerapps
- iPhone or iPad
    - Connect the iPad/iPhone to the Mac PC and install the iOS application
- WiFi Access point with internet connection.

Once the system starts, the application will come up as a remote speaker in its default configuration and you should see console output below

```
Config Info: * = dirty

  Apollo app DCT:

     is configured: yes

       apollo role: sink

      speaker name: Apollo

           channel: (0x00000003) FL FR

         buffering: 50 ms

         threshold: 40 ms

        auto_start: on
```

```
      clock enable: enable
PLL tuning enable: enable
            volume: 50
       source type: bt
      payload size: 1432
```

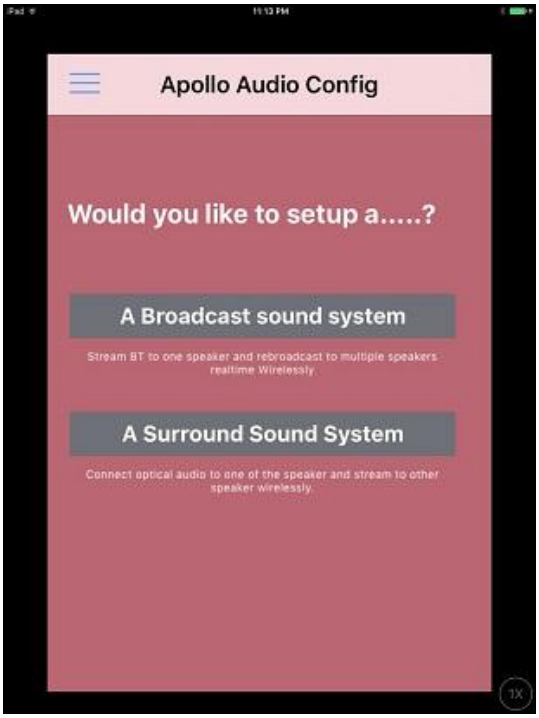
3.2 System configuration via the iOS Apollo application

- Step 1: Press the "BACK" button on the BCM43907WAE_1 or BCM43907WAE_2 WICED Audio boards. The Apollo audio application starts up, resets the device configuration and then launches a BLE GATT server advertising the Apollo service. You should see the console output below:

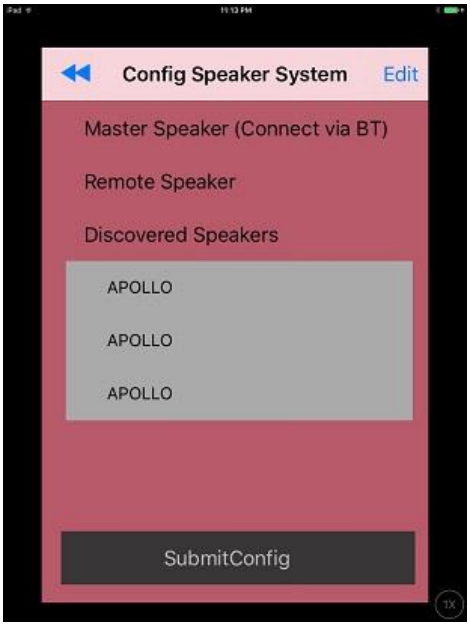
```
0000 00:00:02.217 *** Waiting for GATT configuration... ***

wiced_bt_ble_set_advertisement_data 0
```

- Step 2: On the iPhone or iPad, turn BT ON. Open the installed Apollo application whose icon appears as below:

- Step 3: The application's initial home screen will come up. Note: If the screen does not comes up there are no Speaker devices present running in GATT configuration mode. Separately, if no devices are found, confirm that BT is enabled on your iPhone/iPad.

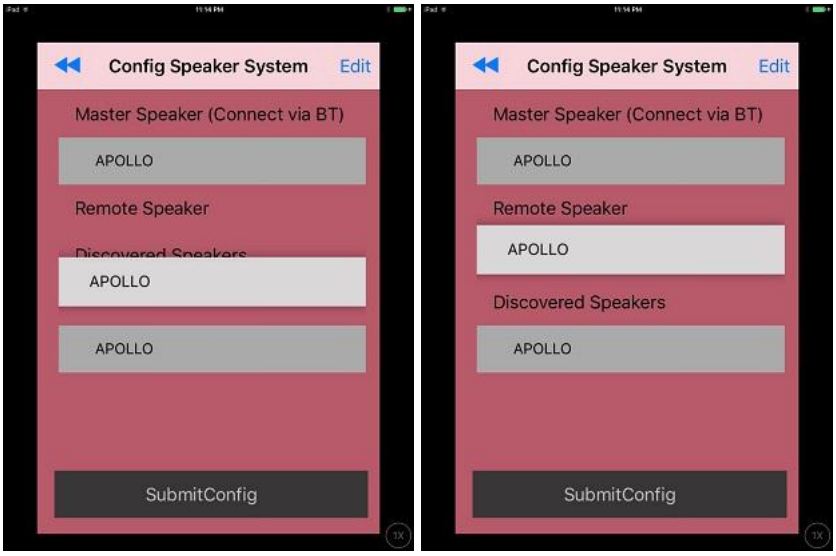


- Step 4: The iOS app only configures the Broadcast sound system in the first release. Press the button titled "Configure A Broadcast sound system". This brings up the screen as below. Note: Pressing "Configure A Surround Sound System" will not do anything.



- Step 5: In the above screen, the app lists all the discovered WICED devices which are running Apollo firmware in configuration mode. If you do not see a device or only one device being listed in the "Discovered Speakers" Section please go back to Step 1 to insure all devices are in the configuration state.

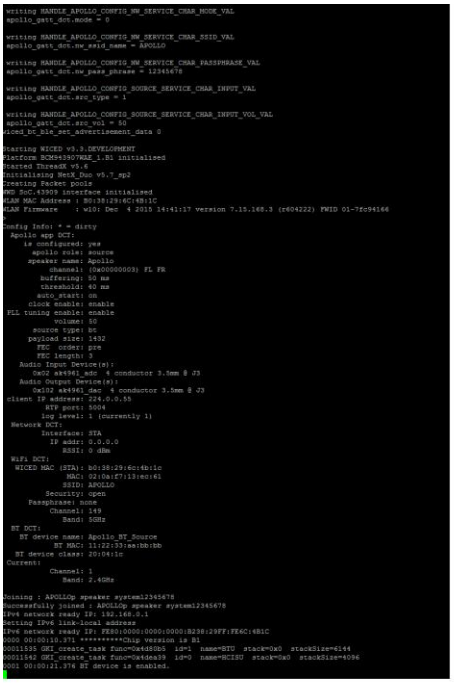
- Step 6: With at least two devices listed under the Discovered Speakers section, drag and drop each of these devices to the master and remote speaker section respectively. Tap and hold on the device in the Discovered speakers area and then start dragging to a destination source device. Make sure the Master Speakersection and the Remote speaker section have at least one device. The following screens below show the drag and drop association in action:

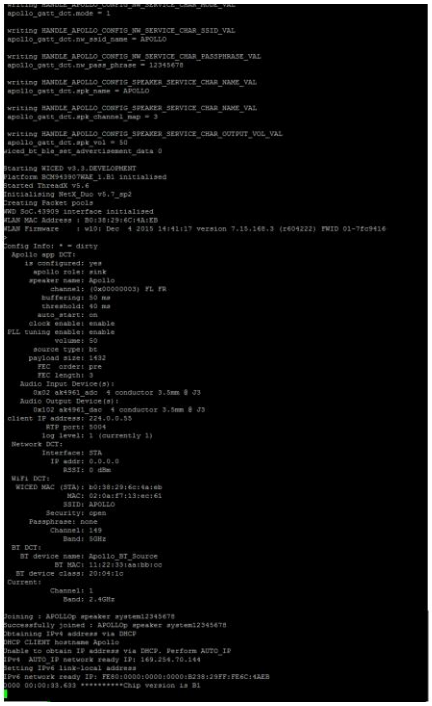


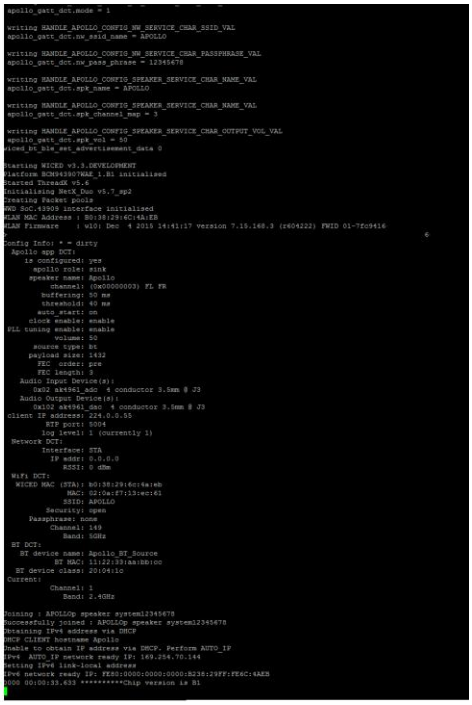
- Step 7: Tap on the Edit button in the top right corner, this brings up the soft keyboard to enter the Network Name in the Master Speaker Section. Once entered tap the enter key in the soft keyboard of iPad to close the keyboard. Now similarly enter speaker names for the speakers in Remote Section by tapping on each of them (and which pops up the soft keyboard). The following screens shows all of this in action:

- Step 8: Once done tap the "Done" button in the top right corner to signal the application that you are Done with the Editing of the devices.

- Step 9 : Tap the "SubmitConfig" button and you should see the WICED devices console print following where one of the device is being configured as a source device (Designated as “Master” in the app) and the all other devices are being configured as sink devices (remote speakers). Please verify that the master device starts a SoftAP with the network name you provided in the above screen and also verify the sink devices do the same. You should also verify that the sink devices connect to the source and properly obtain their IP addresses.







4 Roadmap

Future support for SPDIF and surround sound with BCM943907_WAE1

BROADCOM CORPORATION
5300 California Avenue
Irvine, California, 92677

Phone : +1-949-926-5000
Fax: +1-949-926-5203
E-mail: info@broadcom.com
Web: www.broadcom.com

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