AN992: HANDS-FREE AND HEADSET PROFILES

iWRAP APPLICATION NOTE

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Version 1.13

VERSION HISTORY

Version	Comment
1.0	First version
1.1	HFP usage added
1.2	HSP usage added
1.3	iWRAP overview added
1.4	Added useful AT commands to manipulate phonebook and SMS messages
1.5	Added 1.6 feature updates and iWRAP5 features
1.6	iWRAP5 release version
1.7	Added Apple specific AT commands
1.8	Added extra parameter to ANSWER command
1.9	Added HFP volume event
1.10	Added note about HFP configuration
1.11	Added MEMORY command description
1.12	Added note about SET CONTROL HFPINIT command
1.13	Updated references

TABLE OF CONTENTS

1 Introduction

This application note discusses Bluetooth Hands-Free Profile (HFP) and Bluetooth Headset Profile (HSP) their advantages and how these profiles can be utilized. Also practical examples are given how the HFP and HSP are used with the iWRAP firmware.

1.1 Hands-Free profile

Hands-Free Profile describes how an audio gateway device can be used to place and receive calls for a hand-free device.

A common scenario would be a mobile phone used together with a wireless headset. The headset will connect to the mobile phone and can be used to place and receive phone calls. The HFP defines two roles, that of an Audio Gateway (HFP-AG) and a Hands-Free unit (HF):

- HFP Audio Gateway (HFP-AG) is the device that is the gateway of the audio, both for input and output, typically a mobile phone.

- Hands-Free Unit (HF) is the device acting as the Audio Gateway's remote audio input and output mechanism. It also provides some remote control means. Typically a wireless headset or a car kit.

Hands-Free control is the entity responsible for Hands-Free unit specific control signalling; this signalling is AT command based. Control channel works on top of RFCOMM connection and the audio channel on top of SCO or eSCO channel.

Hands-Free profile v.1.5 and older support 8kHz, 8-bit audio and Hands-Free profile v.1.6 support 16kHz and 8-bit audio also known as Wide Band Speech or HD Voice.

Figure 1: Typical HFP use case

Source: [1]

1.2 Headset profile

The HSP describes how a Bluetooth enabled headset should communicate with a computer or other Bluetooth enabled device such as a mobile phone.

The typical usage scenario is, of course, using a wireless headset to connect with your mobile phone.

The HSP defines two roles, that of an Headset Audio Gateway (HSP-AG) and a Headset (HS):

- Headset Audio Gateway (HSP-AG) is a device that is the gateway of the audio, both for input and output, typically a mobile phone or PC.
- Headset (HS) is a device acting as the Audio Gateway's remote audio input and output mechanism.

Headset control is the entity responsible for Headset unit specific control signalling. Control channel works on top of RFCOMM connection and the audio channel on top of SCO or eSCO channel.

One should know that HSP offers significantly less control possibilities then HFP. Therefore modern implementations prefer Hands-Free Profile over the Headset Profile.

Headset profile supports 8kHz, 8-bit audio.

Figure 2: Typical HSP use case

Source: [2]

2 iWRAP firmware overview

iWRAP6 is an embedded firmware running entirely on the RISC processor of WT11i, WT12, WT32i and WT41 modules. It implements the full Bluetooth protocol stack and many Bluetooth profiles as well. All software layers, including application software, run on the internal RISC processor in a protected user software execution environment known as a Virtual Machine (VM).

The host system can interface to iWRAP firmware through one or more physical interfaces, which are also shown in the figure below. The most common interfacing is done through the UART interface by using the ASCII commands that iWRAP firmware supports. With these ASCII commands, the host can access Bluetooth functionality without paying any attention to the complexity, which lies in the Bluetooth protocol stack. GPIO interface can be used for event monitoring and command execution. PCM, SPDIF, I2S or analog interfaces are available for audio. The available interfaces depend on the used hardware.

The user can write application code to the host processor to control iWRAP firmware using ASCII commands or GPIO events. In this way, it is easy to develop Bluetooth enabled applications.

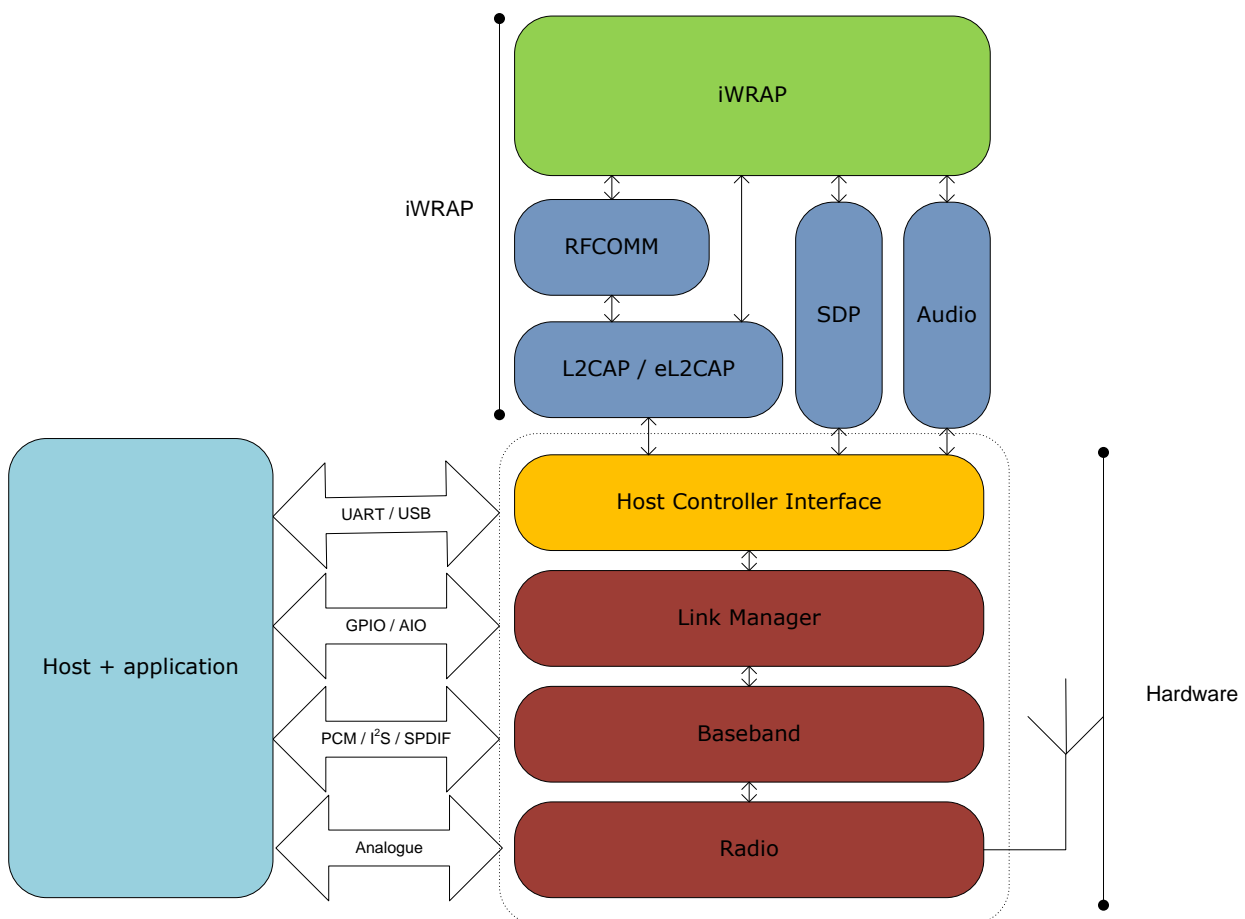On WT32i, there is an extra DSP processor available for data/audio processing.

Figure 3: iWRAP Bluetooth stack

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In the figure above, a Bluetooth module with iWRAP firmware could be connected to a host system for example through the UART interface. The options are:

- If the host system has a processor, software can be used to control iWRAP by using ASCII based commands or GPIO events.

- If there is no need to control iWRAP, or the host system does not need a processor, iWRAP can be configured to be totally transparent and autonomous, in which case it only accepts connections or automatically opens them.

- GPIO lines that Bluegiga's Bluetooth modules offer can also be used together with iWRAP to achieve additional functionality, such as Carrier Detect or DTR signaling.

- Audio interfaces can be used to transmit audio over a Bluetooth link.

2.1 Multi profile operation

iWRAP supports multi profile operation with HDP. This means on addition to HDP also other types of *Bluetooth* connections can be established as well. This can include for example *Bluetooth* Serial Port Profile (SPP), Hands-Free Profile (HFP) or Dial-Up Networking (DUN). At the moment iWRAP supports the following *Bluetooth* profiles:

- Serial Port Profile (SPP) / DevA and DevB

- Hands-Free Profile (HFP) v.1.5 / HFP and HFP-AG modes

- Headset Profile (HSP) v.1.2 / HSP and HSP-AG modes

- Dial-up Networking Profile (DUN) / Terminal emulation

- OBEX Object Push Profile (OPP) / OPP Server and Client

- OBEX File Transfer Profile (FTP) / FTP Client

- Phone Book Access Profile (PBAP) / PCE mode

- Human Interface Device (HID) / HID device

- Advanced Audio Distribution Profile (A2DP) / Sink and Source modes

- A/V Remote Control Profile (AVRCP) / AVRCP Controller and Target

- Device Identification Profile (DI)

- Health Device Profile (HDP) v1.0 / Source and Sink modes

3 Using HFP with iWRAP

This chapter instructs the HFP usage and configuration with the iWRAP firmware.

3.1 Configuration

3.1.1 Hands-Free unit (HF)

HF mode is enabled with command "**SET PROFILE HFP {*service_name*}**"

>*service_name*   This parameter configures an user friendly description of the service. Neither special characters nor white spaces are allowed. Service name **ON** enables the profile with the default name.

The Bluetooth Class-of-Device (CoD) needs to be also configured properly. Some device may not be able to discover and connect iWRAP unless it's properly set. For HFP devices the CoD should be set to 200404.

Finally a reset is needed to for the HFP profile to become active.

Below is an example how to enable HFP mode.

SET PROFILE HFP ON

SET BT CLASS 200404

RESET

Note: Connecting iWRAP configured as Hands-Free unit to BT Hands-Free device is against Bluetooth specification. Such configuration is forbidden - module's behaviour will be unpredictable in such case.

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3.1.2 Hands-Free Audio Gateway (HFP-AG)

HFP-AG is enabled with command "**SET PROFILE HFP-AG {*service_name*}**"

service_name	This parameter configures an user friendly description of the service. Neither special characters nor white spaces are allowed. Service name **ON** enables the profile with the default name.

The Bluetooth Class-of-Device (CoD) needs to be also configured properly. Some device may not be able to discover and connect iWRAP unless it's properly set. For HFP devices the CoD should be set to 400204.

Finally a reset is needed to for the HFP-AG profile to become active.

Below is an example how to enable HFP-AG mode.

```
SET PROFILE HFP-AG ON
SET BT CLASS 400204
RESET
```

3.1.3 Security configuration

To be able to pair with other *Bluetooth* enabled devices the *Bluetooth* security needs to be properly configured. iWRAP support Secure Simple Pairing (SSP) defined in *Bluetooth* 2.1 + EDR specification, and the use of it is mandatory, but PIN code pairing is also supported to enable pairing with legacy devices.

In order to enable SSP and PIN code pairing, the following configuration commands are needed:

"SET BT SSP 3 0"   This enables SSP "just works" mode, where no PIN code entry or passkey verification is needed. To enable the optional man-in-the-middle protection, please refer to iWRAP user guide.

"SET BT AUTH * <pin>"   This command enables PIN code pairing, to support pairing with legacy defines. **<pin>** is the desired PIN code, which can be 1-16 alphanumeric characters.

Finally a reset is needed to for the security settings profile to become active.

Below is an example how to enable SSP just works and PIN code pairing in iWRAP.

SET BT SSP 3 0

SET BT AUTH * 0000

RESET

3.1.4 Service discovery

Bluetooth technology enables wireless service discovery, so you can find out the capabilities the remote device supports. Wireless service discovery uses the Bluetooth Service Discovery Profile (SDP).

With iWRAP the service discovery is performed with command: "**SDP {*bd_addr*} {*uuid*}**".

bd_addr	Bluetooth device address of the remote device.
uuid	Universally unique identifier. Refers to the Bluetooth profile to be discovered. For HFP-AG the ***uuid*** is 111F and for HF 111E.

Below is an example how to perform a service discovery for HFP-AG device.

SDP 00:07:80:93:0c:aa 111F

SDP 00:07:80:93:0c:aa < I SERVICENAME S "**HF Voice Gateway**" > < I PROTOCOLDESCRIPTORLIST < < U L2CAP > < U RFCOMM I **03** > > >

SDP

HF Voice Gateway	= Service name
03	= RFCOMM channel for HFP control channel

Below is an example how to perform a service discovery for HF device.

SDP 00:07:80:81:66:6f 111E

SDP 00:07:80:81:66:6f < I SERVICENAME S "**Hands-Free**" > < I PROTOCOLDESCRIPTORLIST < < U L2CAP > < U RFCOMM I **03** > > >

SDP

Hands-Free	= Service name
03	= RFCOMM channel for HFP control channel

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3.2 Connection establishment

3.2.1 HFP control channel

With Hands-Free Profile, first a control channel needs to be first established. The control channel is used for AT command signalling between the HF and HFP-AG devices.

The HFP control channel is opened, typical to iWRAP, with a **CALL** command:

"**CALL {*bd_addr*} 111F HFP**"   - When opening connection from HF device to HFP-AG device

"**CALL {*bd_addr*} 111E HFP-AG**"   - When opening connection from HFP-AG device to HF device

        bd_addr   Bluetooth device address of the remote device.

Below is an example how to set up a HFP connection from HF to HFP-AG.

```
CALL 00:07:80:93:0c:aa 111F HFP
CALL 0
CONNECT 0 HFP 3
HFP 0 STATUS "service" 0
HFP 0 STATUS "call" 0
HFP 0 STATUS "callsetup" 0
HFP 0 STATUS "callheld" 0
HFP 0 STATUS "signal" 0
HFP 0 STATUS "roam" 0
HFP 0 STATUS "battchg" 5
HFP 0 READY
```

A typical indications of outgoing call and successful connection are received (CALL and CONNECT). After a successful connection the HFP-AG device sends various status reports to the HF device. These reports are output to the user as HFP status messages, which have a general format:

"HPF {*link_id*} STATUS {*status*} {*value*}"

        link_id   Numeric connection identifier

        feature   HFP status indicator

        status   Value of status indictor

Sometimes the HPF-AG devices may send manufacturer proprietary AT commands, which are not recognized by iWRAP. A different report is then output:

"HPF {*link_id*} UNKNOWN {*string*}"

        link_id   Numeric connection identifier

        string   String sent by HFP-AG device

Finally when the connection initialization is complete a message is displayed: **"HPF {*link_id*} READY"**. AT commands must not be sent before this event is received.

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Below is an example how to set up a HFP connection from HFP-AG to HF.

```
CALL 00:07:80:81:66:6f 111E HFP-AG
CALL 0
CONNECT 0 HFP-AG 3
HFP-AG 0 READY
HFP-AG 0 VOLUME 4
```

In the example above HFP device reports its volume level to the HFP-AG. The volume level is indicated by message:

"HPF {*link_id*} VOLUME {*level*}"

link_id	Numeric connection identifier
level	HFP device's volume level. Range: 0 -15

3.2.1.1 HFP-AG implementation

For HFP-AG implementers it's worth mentioning that the network service status should be indicated to the HF device right after connection setup. By default iWRAP sets the network status to 0 telling the HFP-AG does not have network (GSM, PSTN etc.) connectivity. If there is no network connectivity many of the HF features such and making outgoing connections is not available. The network service status is indicated with command:

"**STATUS service {*status*}**"

status	Network service status
	0 = Network is inactive
	1 = Network is active

From iWRAP 6.2 command **SET CONTROL HFPINIT** was introduced. Using this command initial parameters for HFP-AG status may be changed. Indicators values set by this command are used during connection setup and should represent actual state of device.

3.2.2 HFP audio channel

Once the HFP control channel has been set up an audio channel can be created. There are several ways how the audio channel can be established depending on the use case.

3.2.2.1   HFP-AG receives an incoming phone call

A typical scenario is that the HFP-AG device (f.ex. a mobile phone) receives an incoming phone call and indicates this to the HF device. HF device then accepts or rejects the incoming call. The example below shows how this is accomplished.

Below is a trace of the same situation as seen on the HF device.

HFP 0 STATUS "callsetup" 1	(Indicates a callsetup change to active)
HFP 0 RING	(Indicates that HFP link 0 is ringing)
RING 1 00:07:80:93:0c:aa SCO	(Indicates an incoming SCO connection with link_id 1)
ANSWER	
HFP 0 STATUS "call" 1	(Indicates a call change to active)
HFP 0 STATUS "callsetup" 0	(Indicates a callsetup change to inactive)

ANSWER command can be used to answer the incoming call on the HF device. For keeping SCO connection we have to use command with additional parameter: **ANSWER 1.**

3.2.2.2   HF device makes an outgoing call request

A 2nd typical scenario is that the HF device makes an outgoing phone call. The examples below show how this is accomplished.

On the HF device outgoing connection can be established with two different commands:

> "**ATD{*number*};**"   - Asks HFP-AG to dial to *number.*
>
> "**AT+BLDN**"   - Asks HFP-AG to dial to last dialled number.

Here's an example trace from HF device.

ATD777;	(Dial to 777)
HFP 0 OK	(OK indication from HFP-AG)
HFP 0 STATUS "callsetup" 2	(Indicates a callsetup change happened at the gateway side)
RING 1 00:07:80:93:0c:aa SCO	(Indicates an incoming SCO connection with link_id 1)
HFP 0 STATUS "callsetup" 3	(Indicates a callsetup change)
HFP 0 STATUS "call" 1	(Indicates a call status change to active)
HFP 0 STATUS "callsetup" 0	(Indicates a callsetup change to inactive)

3.2.2.3 HFP-AG makes an outgoing call

A 3nd typical scenario is that the HFP-AG device makes an outgoing phone call and this is indicated to the HF device. The examples below show how this is accomplished.

Here's an example trace from HFP-AG device.

DIALING	(Indicates to HF that outgoing call is made)
CONNECT 1 SCO	(SCO connection indication)
HFP-AG 0 CALLING	(HFP-AG status change to calling state)
CONNECT	(**CONNECT** command to indicate that network call was successful)
HFP-AG 0 CONNECT	(HFP-AG status change to connected)

The same situation as seen on the HF device.

HFP 0 STATUS "callsetup" 2	(Indicates a callsetup change)
RING 1 00:07:80:93:0c:aa SCO	(Indicates an incoming SCO connection with link_id 1)
HFP 0 STATUS "callsetup" 3	(Indicates a callsetup change)
HFP 0 STATUS "call" 1	(Indicates a call status change to active)
HFP 0 STATUS "callsetup" 0	(Indicates a callsetup change to inactive)

3.2.2.4 HFP-AG indicates an incoming phone call to a HFP device.

On the HFP-AG device **RING** command is used to indicate an incoming phone call to the HF device.

RING	
CONNECT 1 SCO	(Indicates that SCO connection was established)
HFP-AG 0 RINGING	(Indicates that the HF device is ringing)
HFP-AG 0 CONNECT	(Indicates that the HF device answered the phone call)

3.2.2.5 HFP-AG receives an outgoing phone call request from HFP

Below is a trace of the when HFP-AG receives a request to make an outgoing phone call from HFP device.

HFP-AG 0 DIAL NUM 777	(Dial request to 777 from HF device)
CONNECT 1 SCO	(SCO connection indication, established by gateway)
HFP-AG 0 CALLING	(HFP-AG status change to calling state)
CONNECT	(**CONNECT** command to indicate that network call was successful)
HFP-AG 0 CONNECT	(HFP-AG status change to connected)

3.2.2.6   Forcing SCO connection open

With HFP 1.6 version codec negotiation prevents the possibility of forcing the connection open like it was possible in the iWRAP4 and HFP 1.5. In HFP

It's also possible simply to open the SCO connection without any status updates. This can be done with command:

"SCO OPEN {*link_id*}"

> ***link_id***   Numeric connection identifier of the RFCOMM control channel associated to the current Hands Free Profile connection.

In case both ends support codec negotiation in HFP 1.6 the SCO connection must be opened by the HFP-AG. In this case if the HFP side issues the **SCO OPEN {*link_id*}** command, it will cause a HFP command to be sent to the HFP-AG. After receiving this command the HFP-AG will open the SCO connection. If this happens HFP will receive **RING** event instead of **CONNECT** event.

Example trace from HFP-AG

SCO OPEN 0

CONNECT 1 SCO

3.3 Connection termination

3.3.1 HFP audio channel

The simplest way to terminate the audio (SCO) connection and the phone call is to use "**HANGUP**" command. It can be issued on both HF and HFP-AG device to indicate that the call was terminated.

Termination of the call from HF device:

HANGUP

NO CARRIER 1 ERROR 113 HCI_ERROR_OETC_USER (Indication that HFP-AG terminated SCO)

HFP 0 STATUS "call" 0   (Call status change to inactive)

(Despite the "error" string, the above message is not related to an error: OETC=OtherEquipmentTerminatedConnection)

Termination of the call from HFP-AG device:

HANGUP

HFP-AG 0 NO CARRIER   (NO CARRIER indication)

NO CARRIER 1 ERROR 0   (SCO connection termination)

It also possible to forcibly close the SCO connection with the iWRAP's normal "**CLOSE {sco_link_id}**" command.

Closing the SCO connection from HF device (note that HFP-AG keeps the network call active in this case):

CLOSE 1

NO CARRIER 1 ERROR 0

3.3.2 HFP control channel

The HFP control channel is simply be closed with iWRAP command "**CLOSE {*link_id*}**"

> ***link_id***   Numeric connection identifier of the HFP associated RFCOMM link

HFP control channel termination.

CLOSE 0

NO CARRIER 0 ERROR 0

3.4 Three way calling (HF only)

iWRAP5 and some iWRAP4.1.0 beta builds support three way calling on the HF side. Three way calling enables the HF user to put calls on hold and join calls into multiparty "conference" calls, if the AG supports these features. If the AG supports three way calling, only the "hold" state is mandatory to support.

3.4.1 Enabling three-way calling

Whether the AG supports three way calling or not can be deduced from the presence of the CHLD iWRAP event. If the AG doesn't support three way calling, the event will not be displayed in the connection setup. The CHLD event lists the supported values of <n> for AT+CHLD=<n>. Only 1 and 2 are mandatory to support.

If the user wishes to use three way calling features, the call waiting notifications must be enabled by issuing **AT+CCWA=1** to the AG. The notifications are enabled until the connection is broken or **AT+CCWA=0** is issued.

```
RING 0 00:21:e9:7f:76:2f 3 HFP

HFP 0 BRSF 491

HFP 0 STATUS "service" 1

[More indicator status messages…]

HFP 0 STATUS "callheld" 0

HFP 0 CHLD (0,1,1x,2,2x,3)

HFP 0 READY

HFP 0 NETWORK "FI SONERA"

AT+CCWA=1

HFP 0 OK
```

3.4.2 Using AT+CHLD

Once three-way calling is set up, the HF will receive notifications of incoming calls when a call is already active. Upon receiving a CCWA notification, the user can use **AT+CHLD=**<n> to control the calls:

Command	Function
AT+CHLD=0	Release all held calls, reject waiting calls with "User busy"
AT+CHLD=1	Release all active calls, accept held or waiting call
AT+CHLD=1x	As above, but release only the call whose idx is x
AT+CHLD=2	Put all active calls on hold, accept held or waiting call
AT+CHLD=2x	Put all calls on hold, except for the one whose idx is x ("private consultation mode")
AT+CHLD=3	Add a held call to the current conversation ("multiparty" / "conference" call)
AT+CHLD=4	Connect active and held call, disconnect user from the call ("explicit call transfer")

Table 11: Supported AT+CHLD commands

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Example: answer another incoming by putting the current call on hold, then release the 2nd call and resume the 1st call.

HFP 0 STATUS "callsetup" 1	(Incoming call)
HFP 0 RING	
RING 1 00:07:80:93:0c:aa SCO	
ANSWER	
HFP 0 STATUS "call" 1	
HFP 0 STATUS "callsetup" 0	
[Call is active]	
HFP 0 CCWA "+358501234567",145	(Another incoming call)
HFP 0 STATUS "callsetup" 1	(Incoming call status is updated)
AT+CHLD=2	(Put current active call on hold, answer waiting or held call)
HFP 0 STATUS "callsetup" 0	(No calls are being set up)
HFP 0 STATUS "call" 1	(A call is active)
HFP 0 STATUS "callheld" 1	(A call is held and a call is active)
AT+CHLD=1	(Release active call, answer waiting or held call)
HFP 0 STATUS "callheld" 0	(No call is held any longer)

3.5 General HFP information

This chapter contains general information and tips about the iWRAP and HFP profile for the implementers.

3.5.1 HFP commands

HF and HFP-AG support various commands to perform certain actions such as answer and terminate calls. These commands are described in the tables of this chapter.

Command	Function	Explanation
ANSWER	Answer to call	callsetup 0, call 1
DISCONNECT	Hang-up call	callsetup 0, call 0
HANGUP	Hang-up call	callsetup 0, call 0
REJECT	Reject call	callsetup 0, call 0
DTMF {*code*}	Instructs the gateway to generate DTMF tones	
{raw AT command}	Sends the raw AT command to the headset	Any standard AT command can be sent from iWRAP to the HFP-AG (f.ex. phone)

Table 2: Supported HF device commands

Command	Function	Explanation
ANSWER [audio_routing]	Answer to call. Optional parameter [*audio_routing*] has two possible value: *0*: route audio locally and disconnect SCO *1*: route audio remotely and keep SCO alive	callsetup 0, call 1
DISCONNECT	Hang-up call	callsetup 0, call 0
ERROR	Send ERROR result to HF device	error
HANGUP	Hang-up call	callsetup 0, call 0
REJECT	Reject call	callsetup 0, call 0
OK	Send OK result to HF device	OK
DIALING	Notifies the HF that the AG is dialing an outgoing call, for example if the user dials a number on the phone. Issuing this command establishes SCO connection.	callsetup 2 followed by callsetup 3
CONNECT	Notifies the HF that the aforementioned call was accepted by the remote party.	call 1 followed by callsetup 0
RING [*count*] [*number*] [*name*]	Notify HF device for incoming call. Optional parameter [*count*] indicates the amount of ring indications. Optional parameter [*number*] displays the number from where the call is coming from. [*name*] is an optional parameter describing the caller name.	callsetup 1, ring is sent [*count*] times, then callsetup 0. If [*number*] or [*name*] is given, AT+CLIP is sent with the ring.
STATUS {*indicator*} {*status*}	Set indicator status and send it to Hands Free. For example, "status service 0" would mean indicate no GSM connectivity and "status service 0" would mean active GSM connection.	Related to AT+CIEV and AT+CIND
MEMORY {result}	Send answer for memory dialing or redial. Parameter {result} should be ERROR, if there is no number stored for the memory location given by the HF. Otherwise parameter {result} should be OK to continue dialing procedure.	Answer to DIAL POS and DIAL LAST events. To preserve backward compatibility, after 5 seconds answer OK is sent automatically. If ERROR have to be sent, it must be done before 5 seconds timeout. If provided {result} is OK, iWRAP continues memory dialing or redial procedure.
{raw AT command}	Sends the raw AT command to the HF device	

Table 3: Supported HFP-AG device commands

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3.5.2 HFP events

HF and HFP-AG output various events to indicate the user of status changes. These events are described in this chapter.

Event	Explanation

HFP *{link_id}* **STATUS "***{indicator}***" {***status***}**	Status of *indicator*
	
	 indicator
	
	         HFP-AG feature:
	
	         service = Network status
	
	         call = call status
	
	         call_setup = call setup
	
	         call_held = call hold status
	
	         signal = signal status
	
	         roam = roaming status
	
	         batt_chg = battery status
	
	 status
	
	         Status identifier

HFP *{link_id}* **READY**	Service Level Connection open, HFP ready *link_id* Numeric connection identifier

HFP *{link_id}* **NETWORK** *"{name}"*	Network operator name
	
	 link_id
	
	         Numeric connection identifier
	
	 name
	
	         Network operator name string

HFP {*link_id***} OK**	OK response from HFP-AG *link_id* Numeric connection identifier
HFP {*link_id***} RING**	Incoming call *link_id* Numeric connection identifier

HFP {*link_id***} CALLERID "{***number***}" "{alpha}" {***type***}**	Caller ID
	
	 link_id
	
	         Numeric connection identifier
	
	 number
	
	         Phone number
	
	 alpha
	
	         Optional string type alphanumeric representation of *number*
	
	 type
	
	         The phone number format in hex

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HFP {*link_id*} UNKNOWN {*string*}	Unrecognized AT command
	link_id
	Numeric connection identifier
	string
	Raw incoming data related to unrecognized command
HFP {*link_id*} CCWA "{*number*}",{format}	Call waiting notification.
	link_id
	Numeric connection identifier
	number
	Phone number of incoming call
	format
	Phone number representation format
HFP {*link_id*} CODEC {*codec*}	Selected audio codec indication
	link_id
	Numeric connection identifier
	codec
	Negotiated SCO codec. CVSD for standard SCO connections, MSBC for wideband speech connections. CVSD sampling rate is 8 kHz while MSBC is 16 kHz.
HFP *{link_id}* VOLUME *{level}*	Volume level information which should be used to update volume level. According to Bluetooth documentation after receiving this event, HFP device should change its volume. It can be done in iWRAP by calling "**VOLUME {*level*}**" command or by host MCU in another way.
	link_id
	Numeric connection identifier
	level
	Volume level information

Table 4: HF device's events

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The possible HFP-AG status reports mentioned in the example are described below:

Event	Explanation
HFP-AG *{link_id}* **READY**	Service Level Connection open, HFP ready ***link_id*** Numeric connection identifier

HFP-AG *{link_id}* **VOLUME** *{level}*	Volume level information
	
	link_id
	
	      Numeric connection identifier
	
	level
	
	      Volume level information

HFP-AG *{link_id}* **MIC** *{level}*	Headset microphone gain information
	
	link_id
	
	      Numeric connection identifier
	
	level
	
	      Volume level information

HFP-AG {*link_id*} **RINGING**	Incoming call / headset ringing ***link_id*** Numeric connection identifier
HFP-AG {*link_id*} **CONNECT**	HFP connection / call active ***link_id*** Numeric connection identifier
HFP-AG {*link_id*} **NO CARRIER**	Call ended ***link_id*** Numeric connection identifier

HFP-AG {*link_id*} **DIAL POS** {*pos*}	Dial a number from memory position. Command **MEMORY** should be used to answer to this event.
	
	link_id
	
	      Numeric connection identifier
	
	pos
	
	      Memory position number

HFP-AG {*link_id*} **DIAL LAST**	Dial to last dialled number. Command **MEMORY** should be used to answer to this event. ***link_id*** Numeric connection identifier

HFP-AG {*link_id*} **DIAL NUM** {*num*}	Dial a number
	
	link_id
	
	      Numeric connection identifier
	
	num
	
	      Number to dial

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HFP-AG {*link_id*} UNKNOWN {*data*}	Unrecognized AT command
	
	link_id
	
	    Numeric connection identifier
	
	Data
	
	    Raw input data

HFP-AG {*link_id*} CODEC {*codec*}	Selected audio codec indication
	
	link_id
	
	    Numeric connection identifier
	
	codec
	
	    Negotiated SCO codec. CVSD for standard SCO connections, MSBC for wideband speech connections. CVSD sampling rate is 8 kHz while MSBC is 16 kHz.

Table 4: HFP-AG device's events

- ***"%s %d CALLING\r\n"***

  Outgoing call

- ***"%s %d BUSY\r\n"***

4 Using HSP with iWRAP

This chapter instructs the Headset profile usage and configuration with the iWRAP firmware.

4.1 Configuration

4.1.1 Headset unit (HS)

HF mode is enabled with command "**SET PROFILE HSP ON**"

The Bluetooth Class-of-Device (CoD) needs to be also configured properly. Some device may not be able to discover and connect iWRAP unless it's properly set. For HSP devices the CoD should be set to 200404.

Finally a reset is needed to for the HSP profile to become active.

Below is an example how to enable HSP mode.

SET PROFILE HSP ON

SET BT CLASS 200404

RESET

4.1.2 Headset Audio Gateway (HSP-AG)

HFP-AG is enabled with command "**SET PROFILE HSP-AG ON**".

The Bluetooth Class-of-Device (CoD) needs to be also configured properly. Some device may not be able to discover and connect iWRAP unless it's properly set. For HSP devices the CoD should be set to 400204.

Finally a reset is needed to for the HSP-AG profile to become active.

Below is an example how to enable HSP-AG mode.

```
SET PROFILE HSP-AG ON
SET BT CLASS 200204
RESET
```

4.1.3 Security configuration

To be able to pair with other *Bluetooth* enabled devices the *Bluetooth* security needs to be properly configured. iWRAP support Secure Simple Pairing (SSP) defined in *Bluetooth* 2.1 + EDR specification, and the use of it is mandatory, but PIN code pairing is also supported to enable pairing with legacy devices.

In order to enable SSP and PIN code pairing, the following configuration commands are needed:

"SET BT SSP 3 0"   This enables SSP "just works" mode, where no PIN code entry or passkey verification is needed. To enable the optional man-in-the-middle protection, please refer to iWRAP user guide.

"SET BT AUTH * <pin>"   This command enables PIN code pairing, to support pairing with legacy defines. **<pin>** is the desired PIN code**,** which can be 1-16 alphanumeric characters.

Finally a reset is needed to for the security settings profile to become active.

Below is an example how to enable SSP just works and PIN code pairing in iWRAP.

```
SET BT SSP 3 0
SET BT AUTH * 0000
RESET
```

Service discovery

Bluetooth technology enables wireless service discovery, so you can find out the capabilities the remote device supports. Wireless service discovery uses the Bluetooth Service Discovery Profile (SDP).

With iWRAP the service discovery is performed with command: "**SDP {*bd_addr*} {*uuid*}**".

bd_addr	Bluetooth device address of the remote device.
uuid	Universally unique identifier. Refers to the Bluetooth profile to be discovered. For HSP-AG the ***uuid*** is 1112 and for HS 1108.

Below is an example how to perform a service discovery for HSP-AG device.

SDP 00:07:80:81:66:6f 1108

SDP 00:07:80:81:66:6f < I SERVICENAME S "**Headset**" > < I PROTOCOLDESCRIPTORLIST < < U L2CAP > < U RFCOMM I **04** > > >

SDP

Headset   = Service name

04   = RFCOMM channel for HSP

Below is an example how to perform a service discovery for HS device.

SDP 00:07:80:93:0c:aa 1112

SDP 00:07:80:93:0c:aa < I SERVICENAME S "**Voice Gateway**" > < I PROTOCOLDESCRIPTORLIST < < U L2CAP > < U RFCOMM I **04** > > >

SDP

Voice Gateway   = Service name

04   = RFCOMM channel for HSP

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4.2 Connection establishment

4.2.1 HSP control channel

With HSP, first a control channel needs to be established. The control channel is used for AT command signalling between the HF and HFP-AG devices.

The HSP control channel is opened, typical to iWRAP, with a **CALL** command:

"**CALL {*bd_addr*} 1112 HSP**"   - When opening connection from HS device to HSP-AG device

"**CALL {*bd_addr*} 1108 HSP-AG**"   - When opening connection from HSP -AG device to HS device

        bd_addr   Bluetooth device address of the remote device.

Below is an example how to set up a HSP connection from HS to HSP-AG.

```
CALL 00:07:80:93:0c:aa 1112 HSP
CALL 0
CONNECT 0 HSP 4
```

A typical indications of outgoing call and successful connection are received (CALL and CONNECT).

Below is an example how to set up a HSP connection from HSP-AG to HS.

```
CALL 00:07:80:81:66:6f 1108 HSP-AG
CALL 0
CONNECT 0 HSP 4
CONNECT 1 SCO
```


HSP-AG immediately opens SCO connection, which is indicated with "**CONNECT {*link_id*} SCO**" event.

4.2.2 HSP audio channel

Once the HSP control channel has been set up an audio channel can be created. Headset profile is much simpler then Hands-Free profile and therefore the connection establishment is also simpler.

There are two commands to manage the audio channel. The headset unit has a command **BUTTON**, which open the audio channel and the Headset audio gateway uses command:

SCO OPEN {*link_id*}

        link_id   Numeric connection identified

Opening the audio channel from HS device.

BUTTON
RING 1 00:07:80:93:0c:aa SCO

Opening the audio channel from HSP-AG device.

SCO OPEN 0
CONNECT 1 SCO

4.3 Connection termination

4.3.1 HSP audio channel

The only way to terminate the audio (SCO) connection is to use command:

CLOSE {*link_id*}

> ***link_id***   Numeric connection identifier

Termination of the audio connection from HS device

```
CLOSE 1
NO CARRIER 1 ERROR 0
```

Termination of the audio connection from HSP-AG device

```
CLOSE 1
NO CARRIER 1 ERROR 0
```

4.3.2 HSP control channel

The HSP control channel is simply closed with iWRAP command "**CLOSE {*link_id*}**"

> ***link_id***   Numeric connection identifier

HSP control channel termination.

```
CLOSE 0
NO CARRIER 0 ERROR 0
```

5 Audio configuration

5.1 Ringtones

In case the HFP-AG (f.ex. a mobile phone) does not support in-band ringtone it's possible to make iWRAP to play a ringtone instead. This can be done with command:

"SET CONTROL RINGTONE {*ringtone*}"

Please refer to iWRAP user guide for more information.

5.2 Audio notifications

To play simply audio tones, iWRAP supports a command called **PLAY** that allows simple tones to be played. Please refer to iWRAP user guide for more information.

5.3 Selection of audio interface

WT32 supports multiple audio interfaces such as analogue audio interface or digital PCM, I2S or SPDIF interfaces. The following iWRAP command can be used to select and configure the audio interface:

"**SET CONTROL AUDIO {*sco_routing*} {*a2dp_routing*} [EVENT] [KEEPALIVE] [AAx]**"

PCM interface features and data format is configured by modifying a PS-key called:

PSKEY_PCM_CONFIG32

I2S interface features and data format is configured by modifying a PS-key called:

PSKEY_DIGITAL_AUDIO_CONFIG

Please refer to iWRAP user guide or the *Bluetooth* modules data sheet for more information.

5.4 PCM capabilities configuration

It's possible to enable and disable different PCM features, such as SCO, eSCO or WBS support, retransmission mode and supported packet types. This can be done with the following iWRAP command:

"SET BT SCO {esco_latency} {esco_retx} {esco_packets} [msbc_latency msbc_retx msbc_packets] [NOWBS]"

Please refer to iWRAP user guide or the *Bluetooth* modules data sheet for more information.

Note: Keep this setting in the default value, unless you know what you are doing.

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6 Available AT-commands with Hands-Free Profile

The AT commands and indications that are available for the Bluetooth Hands-Free profile are listed below.

ATA

Standard call answer AT command.

ATDdd…dd;

Standard AT command intended for placing a call to a phone number. Only voice calls are covered in this specification.

ATD>nnn...;

Extension of the standard ATD command, intended for memory dialing. Only voice calls are covered in this specification.

AT+CCWA

Standard "Call Waiting notification" AT command. Within the AT+CCWA=[<n>[,<mode>[,<class>]]]command, only enabling/disabling of the Call Waiting notification unsolicited result code +CCWA , using the <n> parameter, is covered in this specification.

AT+CHLD

Standard call hold and multiparty handling AT command.

AT+CHUP

Standard hang-up AT command. Execution command causes the AG to terminate the currently active call. This command shall have no impact on the state of any held call.

AT+CIND

Standard indicator update AT command.

+CIND

Standard list of current phone indicators.

AT+CLCC

Standard list current calls command.

+CLCC

Standard list current calls result code

AT+COPS

The AT+COPS=3,0 shall be sent by the HF to the AG prior to sending the AT+COPS? command. AT+COPS=3,0 sets the format of the network operator string to the long format alphanumeric.

AT+CMEE

Standard AT command used to enable the use of result code.

AT+CLIP

Standard "Calling Line Identification notification" activation AT command. It enables/disables the Calling Line Identification notification unsolicited result code +CLIP.

+CLIP

Standard "Calling Line Identification notification" unsolicited result code.

AT+CMER

Standard event reporting activation/deactivation AT command.

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+CIEV

Standard "indicator events reporting" unsolicited result code.

AT+VTS

Standard DTMF generation AT command. Only the AT+VTS=<DTMF> command format is covered in this specification.

AT+CNUM

AT+CNUM (Retrieve Subscriber Number Information)

+CNUM

Standard Response used for sending the "Subscriber Number Information" from AG to HF.

AT+BIA

Bluetooth Indicators Activation. Command used by HF to activate / deactivate individual indicators.

AT+BINP

Command used for requesting some specific data input from the AG4. On reception of this command the AG shall perform the proper actions such that the requested information is sent back to the HF using the +BINP response.

AT+BINP

Command used for requesting some specific data input from the AG4. On reception of this command the AG shall perform the proper actions such that the requested information is sent back to the HF using the +BINP response.

AT+BLDN

Bluetooth Last Dialed Number

AT+BVRA

Bluetooth Voice Recognition Activation

+BVRA

Bluetooth Voice Recognition Activation. Unsolicited result code used to notify the HF when the voice recognition function in the AG is activated/deactivated autonomously from the AG.

AT+BRSF

(Bluetooth Retrieve Supported Features. Notifies the AG of the supported features available in the HF, and requests information about the supported features in the AG. The supported features shall be represented as a decimal value.

+BRSF

*Bluetooth Retrieve Supported Features).*Result code sent by the AG in response to the AT+BRSF command, used to notify the HF what features are supported in the AG. The supported features shall be represented as a decimal value.

AT+NREC *(Noise Reduction and Echo Canceling)*

Command issued to disable any Echo Canceling and Noise Reduction functions embedded in the AG.

Only support for execution command is mandated. Neither the read nor test commands are mandatory.

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AT+VGM

Gain of Microphone. Command issued by the HF to report its current microphone gain level setting to the AG. <gain> is a decimal numeric constant, relating to a particular (implementation dependent) volume level controlled by the HF. This command does not change the microphone gain of the AG; it simply indicates the current value of the microphone gain in the HF.

AT+VGS *(Gain of Speaker)*

Command issued by the HF to report its current speaker gain level setting to the AG. <gain> is a decimal numeric constant, relating to a particular (implementation dependent) volume level controlled by the HF. This command does not change the speaker gain of the AG; it simply indicates the current value of the speaker volume in the HF.

+VGM *(Gain of Microphone)*

Unsolicited result code issued by the AG to set the microphone gain of the HF. <gain> is a decimal numeric constant, relating to a particular (implementation dependent) volume level controlled by the HF.

+VGS *(Gain of Speaker)*

Unsolicited result code issued by the AG to set the speaker gain of the HF. <gain> is a decimal numeric constant, relating to a particular (implementation dependent) volume level controlled by the HF.

++BSIR *(Bluetooth Setting of In-band Ring tone)*

Unsolicited result code issued by the AG to indicate to the HF that the in-band ring tone setting has been locally changed. The HF may react accordingly by changing its own alert method.

AT+BTRH (Bluetooth Response and Hold Feature)

Command issued by the HF for the "Response and Hold" feature in the AG. This specification defines the use of the set and read command. The AT+BTRH? command shall be used by the HF to query the current "Response and Hold" state of the AG.

+BTRH (Bluetooth Response and Hold Feature)

Result code used to notify the HF when-ever the incoming call is either put on hold or accepted or rejected. The AG shall also respond back with this response for the AT+BTRH? command from the HF.

6.1 Phonebook specific AT commands

AT+CPBS=?

Lists the phonebooks that the phone contains. (Choose phonebook storage)

Returns: +CPBS: ("ME","SM","MT","ON","DC","MC","RC","EN","AD","QD","SD","FD")

+CPBS="ME" sets the "retrieve mode" to the internal phonebook.

+CPBS="SM" sets the "retrieve mode" to the SIM phonebook.

AT+CPBR=?

Describes the phonebook selected above. (Simple) This gives the max number of entries the phone can contain. It also gives the maximum phone number (or email address) length and name length.

NOTE: You can substitute +MPBR for any +CPBR command, but the phone returns a much more specific (and less intelligible) response containing more fields that may act as internal "programming" flags of some sort.

Returns: +CPBR: (1-1000),40,24

AT+CPBR=[beginning index],[ending index]

Returns a list of numbers with the index between the two numbers entered. Also denotes what TYPE of phonebook entry was selected.

Returns: +CPBR: 9,"18005555555",129,"Contact Name" – 129 refers to a phone number.

Returns: +CPBR: 18,"user@domain.net",128,"Contact Name" – 128 refers to an email.

AT+CPBR=[index]

Returns the specified index.

Returns: +CPBR: 18,"user@domain.net",128,"Contact Name"

AT+MPBF="Name"

Searches the phonebook for the Name or string.

AT+MPBR=?

Similar to above, but a more verbose result is displayed.

Returns: +MPBR: 1-1000,40,24,8,0-1,50,(0,2,4,6,9-30,255),(0),(0-1),(1-30),(255),25,(0-1,255),264,(0),0,0,0,0,0,0,0

- 1-1000 denotes the number of entries that can be stored on the selected (+CPBS) phonebook.

- 40 represents the number of characters that the email or phone number can have.

- 24 indicates the number of characters the "friendly" name can have.

- The 8 refers to the different "types" of phonebook entry (i.e. Mobile, Main, Email, Home, Fax, Work … etc).

- The +CPBR command does not list anything after the 24 (as seen above), so there are times when the +MPBR may be useful.

AT+MPBR=[index]

Returns: +MPBR: 18,"user@domain.net",128,"Contact

Name",6,0,255,0,0,1,255,255,0,"",0,0,"","","","","","","",""

6.1.1.1   SMS specific AT commands

AT+CMGF=1

This tells the phone to display the entries as text rather than binary. +CMFG=0 would display the data in binary format.

AT+CPMS=?

This displays all of the locations in which the phone can save the SMS messages.

Returns: +CPMS: ("MT","IM","OM","BM","DM"),("OM","DM"),("IM")

AT+CMGL=?

Returns the options on which messages you wish to display.

Returns: +CMGL: ("REC UNREAD", "REC READ", "STO UNSENT", "STO SENT", "ALL")

AT+CMGL="ALL"

Selects and displays all of the SMS messages on the selected source.

AT#PMODE=1

In order to retrieve text messages and other information, Samsung phones must be in this mode.

AT#PSRMR=?

Returns the parameters to obtain text messages (Samsung).

Returns: #PSRMR: (0-349)

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7 Apple specific AT commands with Hands-Free profile

7.1 HFP Command AT+XAPL

Enables custom AT commands from a headset.

Please refer to Apple's Bluetooth design guidelines for details [3].

7.2 HFP Command AT+IPHONEACCEV

Reports a headset state change.

Please refer to Apple's Bluetooth design guidelines for details [3].

8 Power saving

iWRAP offers two power saving options. Sniff mode, which can be used to save power for active Bluetooth connections and deep sleep more which puts the internal processor into a reduced duty cycle mode. Please refer to iWRAP user guide for more information about sniff and deep sleep modes.

One should also know that when Bluetooth connections are in active mode i.e. no power saving in use the master device uses 3-4 times less power then a slave device. Therefore for battery powered applications it might be useful to configure the device as a master rather then a slave, eventually considering role switching.

9 Echo cancellation and noise reduction

Cambridge Silicon Radio's Clear Voice Capture (CVC) is a modular suite of algorithms for enhancing voice communication products, including acoustic echo cancellation and noise suppression that can be applied in a granular fashion to suit the application and the processing resources available. Rather than suppressing noise like many competing technologies, CVC separates out the voice signals of interest using proprietary signal extraction techniques.

CVC runs on the Bluegiga's DSP-equipped WT32 Bluetooth module. It's seamlessly integrated into iWRAP firmware suite and will be active whenever SCO (audio) connections are used.

Learn more:

https://www.qualcomm.com/

10 References

[1]   The Bluetooth SIG, Hands-Free Profile overview, URL:
https://www.bluetooth.com/specifications/profiles-overview

[2]   The Bluetooth SIG, Headset Profile overview, URL:
https://www.bluetooth.com/specifications/profiles-overview

[3]   Apple Inc., Bluetooth Accessory Design Guidelines for Apple Products, URL:
https://developer.apple.com/hardwaredrivers/BluetoothDesignGuidelines.pdf

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