M16C Family
BlueFree™ reference design for Hands-Free application

1 Abstract

This application note describes the BlueFree™ reference design for automotive Hands-Free application.

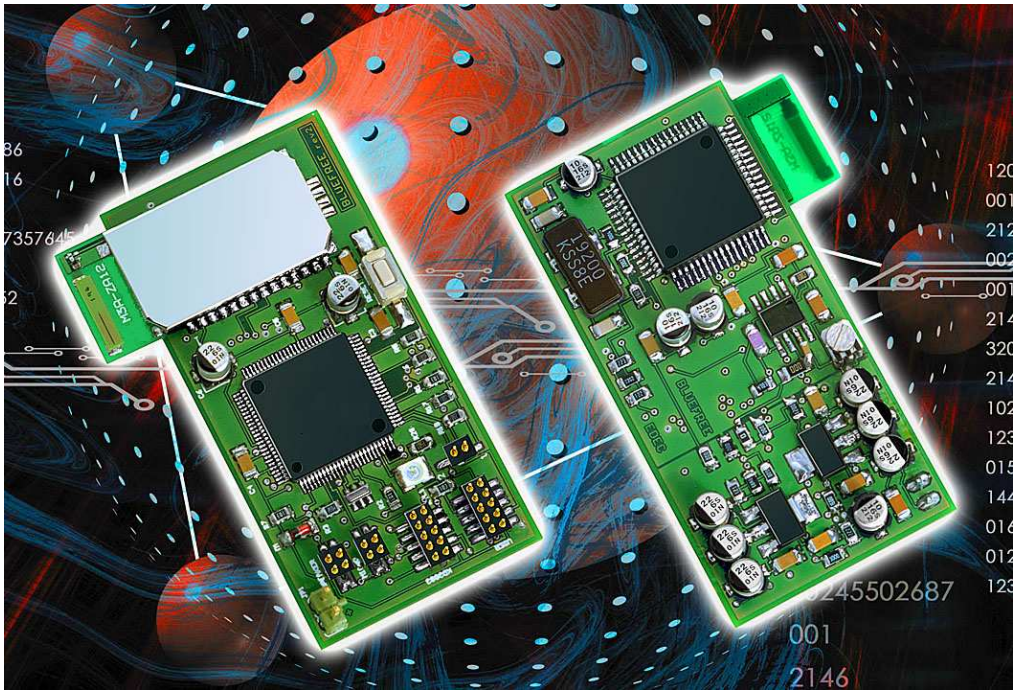

Image1: The BlueFree™ reference design

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3 Introduction

Due to strict legal restrictions in on car cell phone usage, Hands-Free operation is becoming a must in car designs. By using *Bluetooth™* * Hands-Free profile and the Renesas Technology Hands-Free reference design, automotive audio designers can meet these requests.
This reference design has been developed in order to give an idea of how the M16C family in co-operation with the Renesas *Bluetooth™* chipset can be used in the automotive Hands-Free application area. Basic of this reference design is the *Bluetooth™* Hands-Free Profile (HFP) specification, which defines the set of functions that a Mobile Phone provides at a *Bluetooth™* link to a Hands-Free device, which e.g. can be installed in the car stereo. This *Bluetooth™* link provides a bi-directional wireless remote control and voice connection between the Mobile Phone and the Hands-Free device.

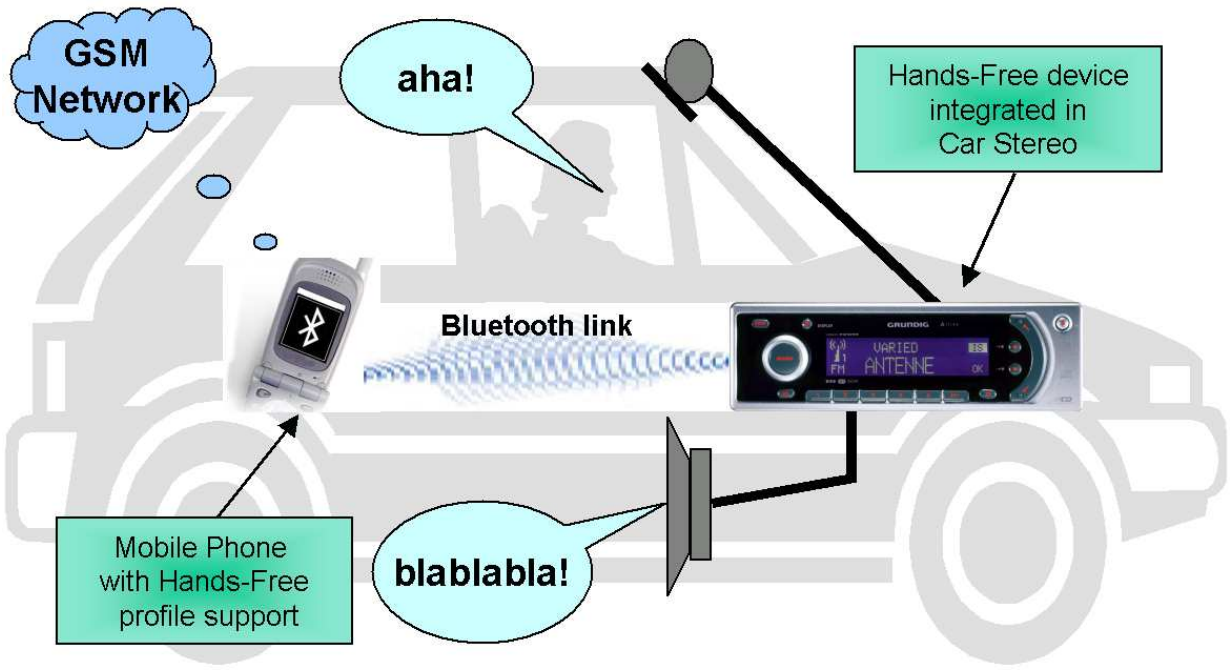

Figure1: General concept of in car Hands-Free application

In general the Hands-Free system should support an ad-hoc connection to your mobile, at the moment you enter the car, so any future call or action of the mobile will be handled by the Hands-Free system. Through this, your phone can stay in your pocket during your drive. The big advantage of such Hands-Free in car system is obviously safety. If you use a Hands-Free cell phone you are allowed to keep your hands on the wheel and your eyes on the road. You

can then get into features such as dialing with your voice instead of your fingers or by switches at your steering wheel.

4 Hardware description

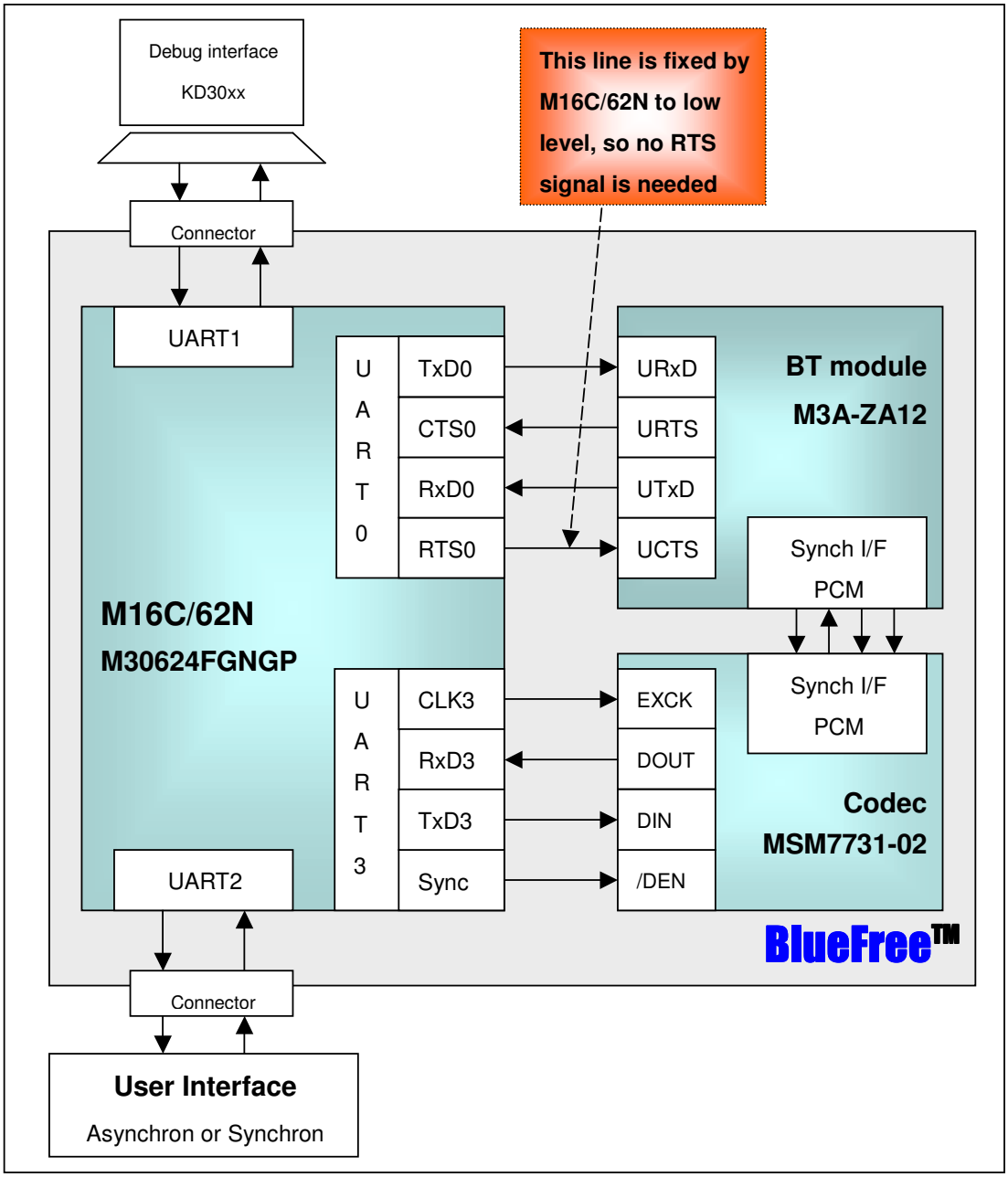

Figure2: Block diagram of BlueFree™ reference board

The smart 30mm x 60mm BlueFree™ board consists of the Renesas *Bluetooth™* module M3A-ZA12, a Renesas M16C/62N 16-bit microcontroller and a OKI Codec MSM7731-02 incl. echo cancellation and noise reduction. The ready to use *Bluetooth™* module M3A-ZA12 is based on the Renesas chipset of baseband IC M64110WG and the RF transceiver IC M64846FP plus an additional SMD antenna.
Two UART interfaces of the M16C/62N are utilized for external communication.

- **UART1** – Optional debug communication to a PC with KD30xx cable debugger, as well as for flash programming of the M16C/62N.
- **UART2** – User Interface for communication e.g. to the car stereo or to a PC application for demonstration propose.

Interface Connector	1	2	3	4	5	6	7	8	9	10
KD30xx	DVcc	BUSY	CLK1	RxD1	/WR	HOLD	DGND	/RESET	CNVSS	TxD1
User	DVcc	NC	CLK2	RxD2	NC	NC	DGND	/RESET	CNVSS	TxD2

Table1: Pinning of interface connector

Furthermore, two more UART interfaces are used for board internal communication.

- **UART0** – Used as asynchronous HCI interface to the *Bluetooth™* module M3A-ZA12
- **UART3** – Used as synchronous interface for Codec control

Interface	M16C/62N pin	M16C/62N name	Direction	BT-Module M3A-ZA12	Codec MSM7731-02
UART0	P6.3	TxD0	→	URxD	
	P6.0	CTS0	←	URTS	
	P6.2	RxD0	←	UTxD	
	P6.1	RTS0	→	UCTS	
UART3	P9.0	CLK3	→		EXCK
	P9.1	RxD3	←		DOUT
	P9.2	TxD3	→		DIN
	P9.3	Synch	→		/DEN

Table2: Pinning of board internal interface

Please note that the UART0 - RTS0 signal of the M16C/62N is not generated automatically by the MCU, therefore the RTS0 signal is set to fixed low level just by port setting, to show the BT module a continuous ready signal.

In the end, there is an interface for PCM communication between the BT Module and the Codec, whereby the M3A-ZA12 is the BCLK and SYNC master.

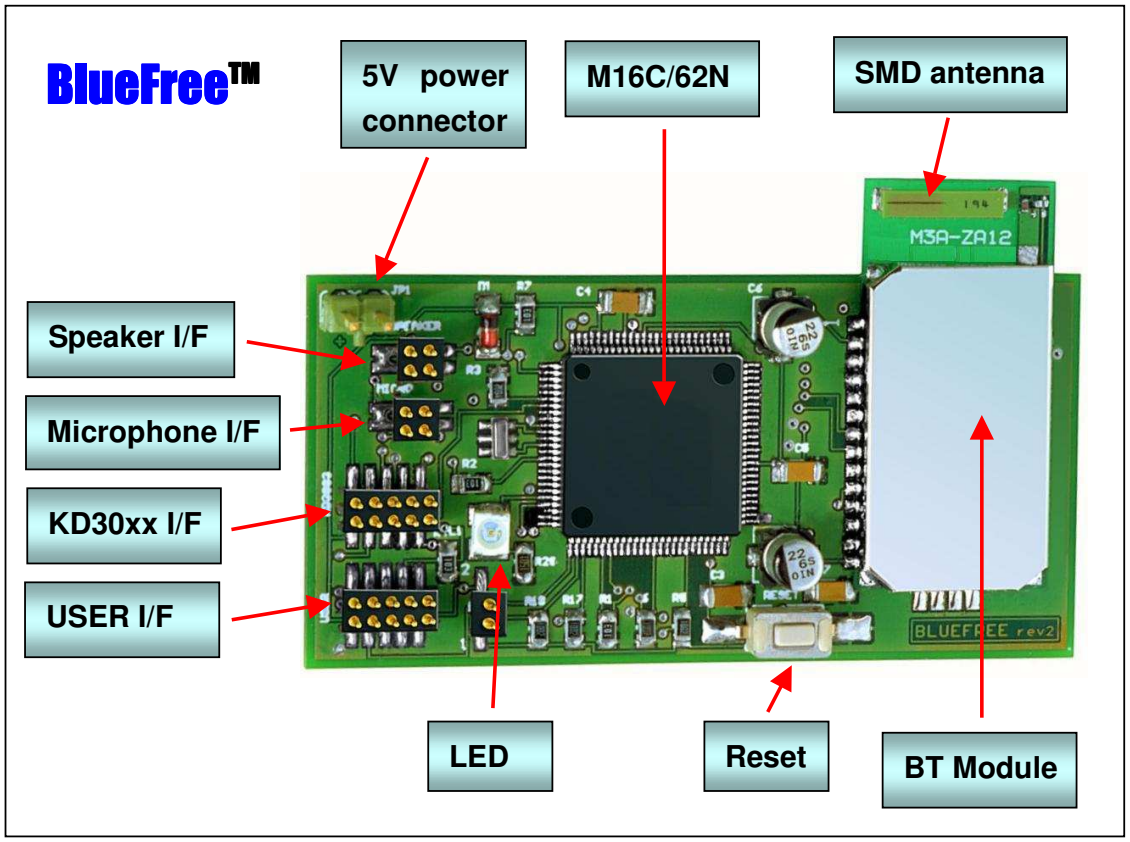

Figure3: Top view of BlueFree™

The audio connector for microphone and speaker can be directly connected to a suitable device or can be routed to the car stereo system for further processing, which is actually the more likely case for a final product, because audio adaptation and muting can be done by this concept very easy.

For demonstration purpose a standard active loudspeaker system and a microphone is recommended, which have to be connected to the apposite socket at the board. For this issue may the is not needed anymore, Therefore, all components regarding the amplifier circuit for the loudspeaker can be taken out and can be bridged e.g. by a Zero Ohm resistors. Due to this the occupancy connector can still be used to connect the peripheries.

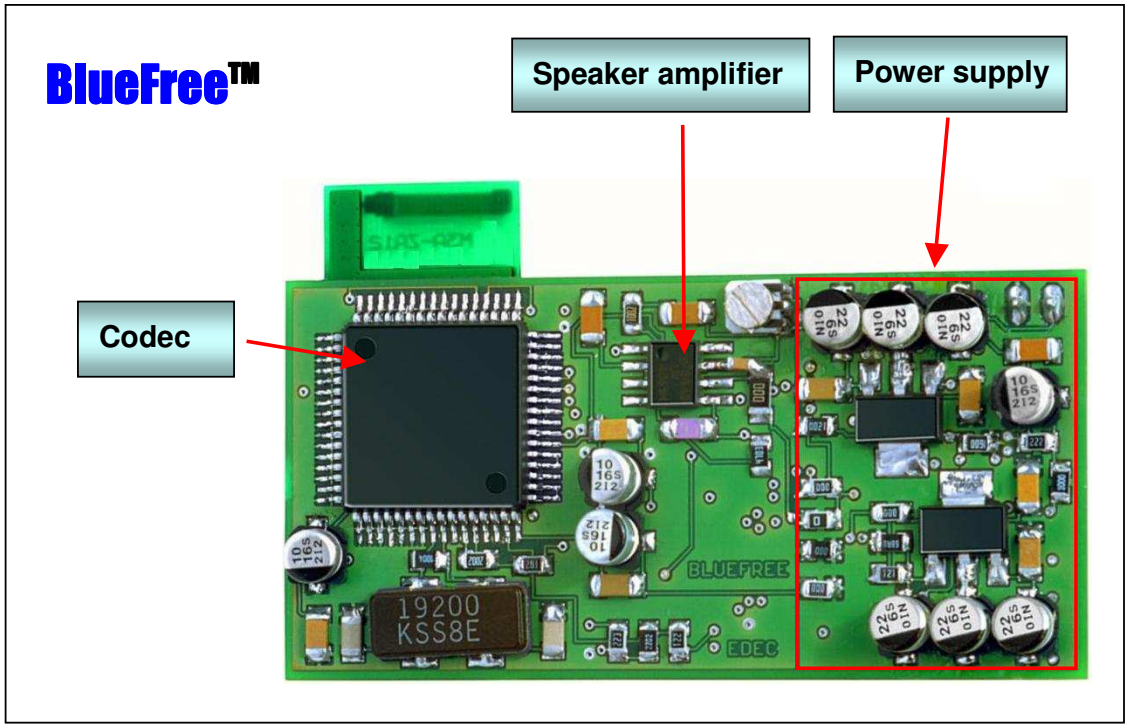

Figure4: Bottom view of BlueFree™

5 Software description

The M16C software is utilizing the very compact and easy to configure embedded software stack of IAR Systems. The IAR Systems Embedded *Bluetooth™* Protocol Stack is already BQB qualified for Renesas M16C Microcontroller and supports the *Bluetooth™* Hands-Free profile. Furthermore IAR Systems offers all *Bluetooth™* car profiles as special software package.

An easy UART3 API serves as connection between the car stereo and this BlueFree™ add-on module. Please note that for a final product, it is possible to implement the *Bluetooth™* host stack also within the main controller software of the car stereo. Due to Renesas's MCU family concept you could easily choose another M16C as host MCU out of the wide range of memory and package variations, as well.

Anyway, to realize a transparent reference setup, the UART3 connecter of the BlueFree™ board has to be connected to a PC, where the WinStereo application simulates the communication between the BlueFree™ and a car stereo. Because BlueFree™ need TTL level, a cable with integrated RS232 level converter is recommend, as e.g. the Renesas Technology TenNine cable.

Figure5: The WinStereo application

The WinStereo allow the user to do various actions of the mobile phone just by a mouse click. In principle, this should just simulate the environment of a real Hands-Free application. Please keep in mind that these features should actually be supported by a car stereo system, by using additional buttons or a command by voice feature.

Anyway, e.g. a phone call can be done, if a valid phone number is been keyed in and the DialRequest button is pressed. In almost the same matter, a phone call, based on a memory location of the mobile phone, can be released, with help of the MemoryDialRequest button and the related position number field. Many other actions are supported as e.g. Redial, Hangup and Reject Requests.

6 Demo Setup

Various peripheries should be connected to be the BlueFree™ board for the Demo Setup.

- Power Supply
- Loudspeaker
- Microphone
- Mobile phone by Bluetooth link
- PC for WinStereo application (incl. TenNine cable)

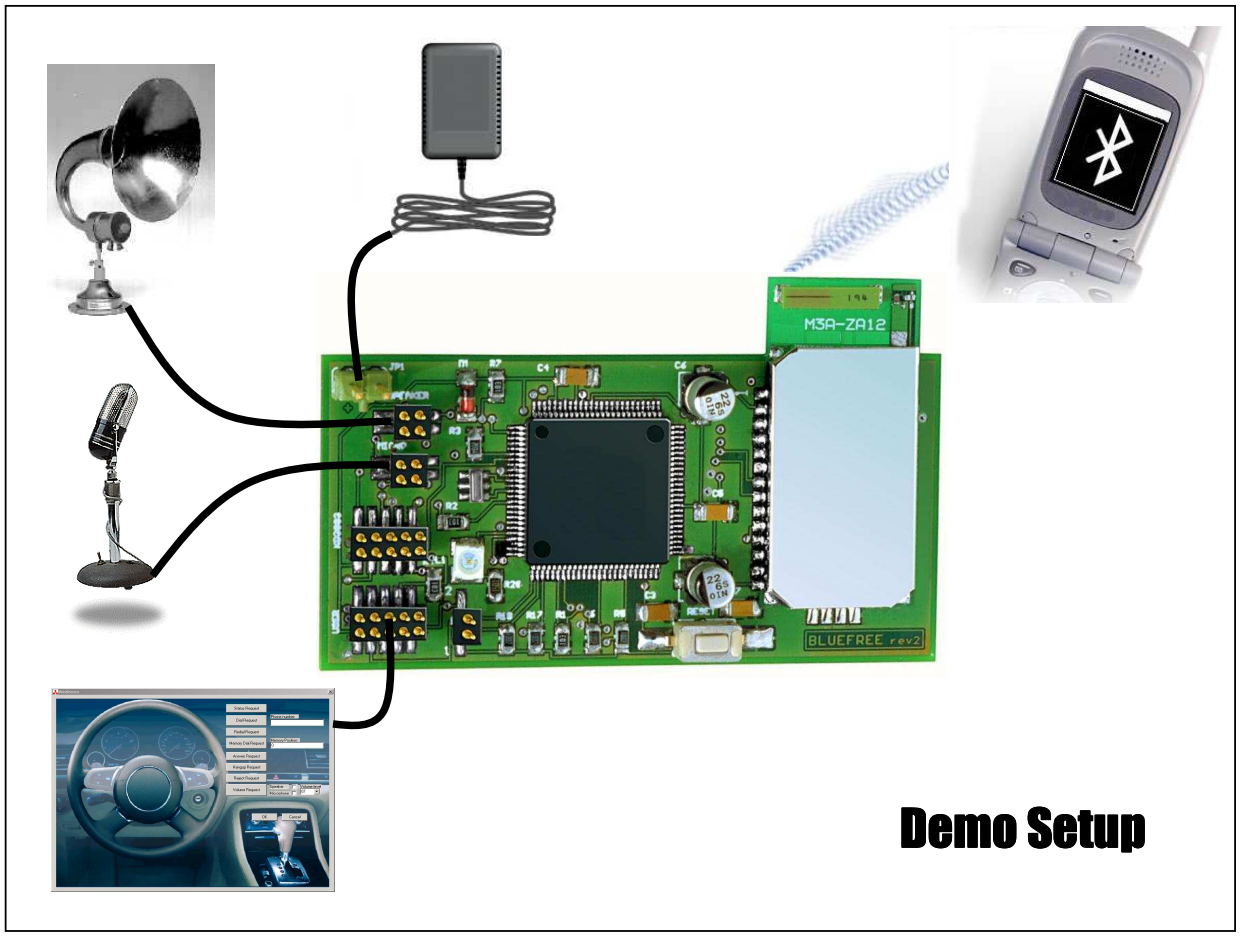

Figure6: Demo Setup for BlueFree™ demonstration

A detailed overview of the connectors and the related pins can be found in the following figure.

Power Supply	Description
+	+5V - 9V
-	GND

Loudspeaker	Description
1 and 2	Output
3 and 4	AGND

Microphone	Description
1 and 2	Input
3 and 4	AGND

KD30xx I/F	Description
all	Not used for demo setup, pls. refer to chapter 4. Hardware description

User I/F	Description
1	Vcc
4	RxD2
7	DGND
10	TxD2
other	Not used for demo setup, pls. refer to chapter 4. Hardware description

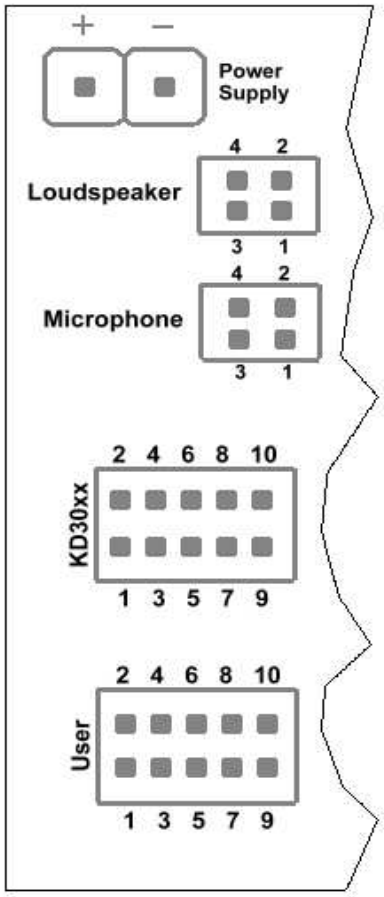

Figure7: Detailed connector plan of BlueFree™ demo setup

For demonstration purpose a *Bluetooth™* link between the *Bluetooth™* enabled mobile phone and the BlueFree™ board has to be established. In order to allow the GSM phone to find and use the BlueFree™, it is always discoverable and connectable, and has a fixed pin code of ”0000”. Furthermore, it provides a Hands-Free service as a server.

7 User specific car stereo API

The car stereo host system communicates with the BlueFree™ is done by using a UART cable connection with following characteristics:

- 19200 baud
- 8 databits
- 1 stopbit
- no parity.

- No H/W or S/W flow control is being used

The BlueFree™ device accepts commands and returns status information to the host system using the UART link. The protocol is very simple with no checksums or re-transmissions of erroneous packages. A very simple binary UART protocol, that waste minimum memory space in the BlueFree™ target system is used, with following format:

<LENGTH_BYTE><ID_BYTE><DATA_BYTE_1>…<DATA_BYTE_N>

The length byte determines the package length including the length byte itself.

The following table outlines the commands that can be sent from the car stereo equipment to the BlueFree™ device:

Command	ID_BYTE	Description
STATUS_REQ	0x00	Ask the HFPF for its status
DIAL_REQ	0x01	Dial phone number
REDIAL_REQ	0x02	Redial the last phone number
MEMORY_DIAL_REQ	0x03	Dial phone number in memory position #x in the phone book
ANSWER_REQ	0x04	Answer incoming call
HANGUP_REQ	0x05	Hang-up ongoing call
REJECT_REQ	0x06	Reject incoming call
VOLUME_REQ	0x07	Adjust volume
AUDIO_TRANSFER_REQ	0x08	Ask the HFPF to transfer the audio paths of the ongoing call to/from the AG

Table3: Command from car stereo equipment to BlueFree™

The following table outlines the indications that can be sent from the BlueFree™ device to the car stereo equipment:

Indications	ID_BYTE	Description
STATUS_IND	0xF0	Send status to the host
CALL_OPEN_IND	0xF1	Phone call opened
CALL_CLOSE_IND	0xF2	Phone call closed
CLI_IND	0xF3	Calling Line Identification (CLI)
RING_IND	0xF4	Ring signal
AUDIO_TRANSFER_IND	0xF5	AG has transferred the audio paths of the ongoing call to/from the AG

Table4: Indications from BlueFree™ to car stereo equipment

● Status check

The STATUS_REQ command is sent from the host system to check the BlueFree™ for its status. BlueFree™ returns a STATUS_IND indication with the status code. BlueFree™ may choose to send a STATUS_IND indication to the host at any time, also without the host sending the STATUS_REQ command (i.e. it supports both “polled” and “event driven” status updates).

STATUS_REQ

Byte	Value	Description
1	0x02	Length byte
2	0x00	STATUS_REQ command id

Table5: Status request

STATUS_IND

Byte	Value	Description
1	0x03	Length byte
2	0xF0	STATUS_IND command id
3	0x00 = OK 0xFF = ERROR	Status code

Table6: Status indication

● Dialling

The DIAL_REQ command is sent from the host system to dial a phone number. REDIAL_REQ can be used to re-dial the last used phone number, and the MEMORY_DIAL_REQ command is used to dial the number in memory position #x in the GSM phone book. Once the phone call is opened, a CALL_OPEN_IND indication is sent from BlueFree™ to the host.

DIAL_REQ

Byte	Value	Description
1	N	Length byte
2	0x01	DIAL_REQ command id
3..N	String	Phone number

Table7: Dial request

REDIAL_REQ

Byte	Value	Description
1	0x02	Length byte
2	0x02	REDIAL_REQ command id

Table8: Redial request

MEMORY_DIAL_REQ

Byte	Value	Description
1	0x03	Length byte
2	0x03	MEMORY_DIAL_REQ command id
3	?	Number of the memory position entry in the address book

Table9: Memory dial request

CALL_OPEN_IND

Byte	Value	Description
1	0x02	Length byte
2	0xF1	CALL_OPEN_IND command id

Table10: Call open indication

● Hanging-up

The HANGUP_REQ command is sent from the host system to hang-up an ongoing phone call. When the call is closed by either end, the BlueFree™ returns CALL_CLOSE_IND.

HANGUP_REQ

Byte	Value	Description
1	0x02	Length byte
2	0x05	HANGUP_REQ command id

Table11: Hangup request

CALL_CLOSE_IND

Byte	Value	Description
1	0x02	Length byte
2	0xF2	CALL_CLOSE_IND command id

Table12: Call Close indication

● Incoming calls

The REJECT_REQ command is sent from the host system to reject an incoming call. When an incoming call is detected, the RING_IND indication is sent repeatedly to the host and the CLI_IND indication is also sent to the host.

REJECT_REQ

Byte	Value	Description
1	0x02	Length byte
2	0x06	REJECT_REQ command id

Table13: Reject request

CLI_IND

Byte	Value	Description
1	N	Length byte
2	0xF3	CLI_IND command id
3…N	String	Phone number of incoming call

Table14: CLI indication

RING_IND

Byte	Value	Description
1	0x02	Length byte
2	0xF4	RING_IND command id

Table15: Ring indication

● Volume

The VOLUME_REQ command is sent from the host system to adjust the volume.

VOLUME_REQ

Byte	Value	Description
1	0x03	Length byte
2	0x07	VOLUME_REQ command id
3	0x00 = Microphone 0x01 = Speaker	Target
4	0x00-0x0F	Volume level

Table16: Volume request

● Audio transfer

AUDIO TRANSFER_REQ

Byte	Value	Description
1	0x02	Length byte
2	0x08	Ask the BlueFree™ to transfer the audio paths of the ongoing call to/from the AG

Table17: Audio transfer request

AUDIO TRANSFER IND

Byte	Value	Description
1	0x02	Length byte
2	0xF5	AG has transferred the audio paths of the ongoing call to/from the AG

Table18: Audio transfer indication

8 Schematic

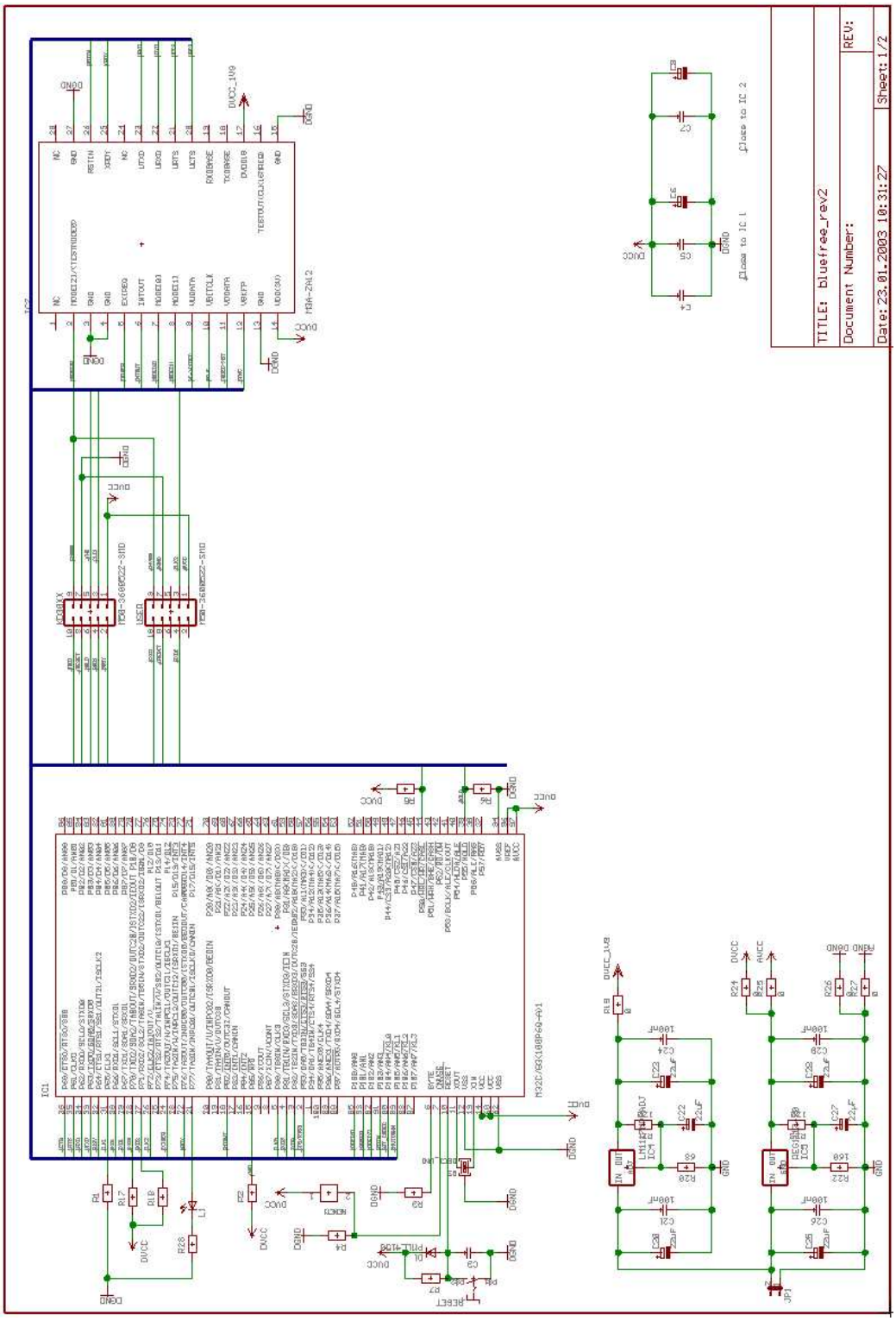

Figure 8: Schematic of Microcontroller, *Bluetooth™* module and power supply

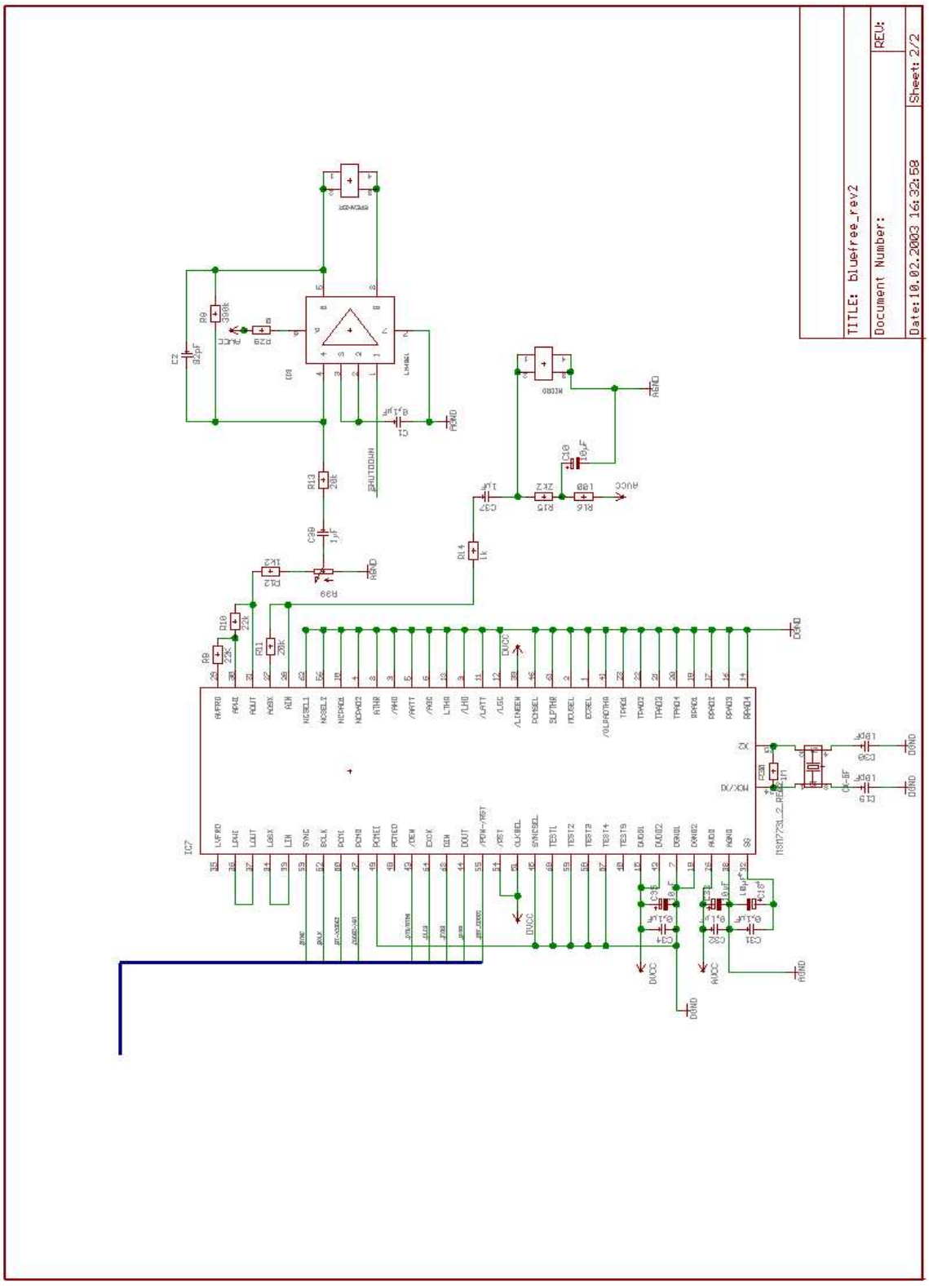

Figure 9: Schematic of codec and audio I/F

9 Component placement specification

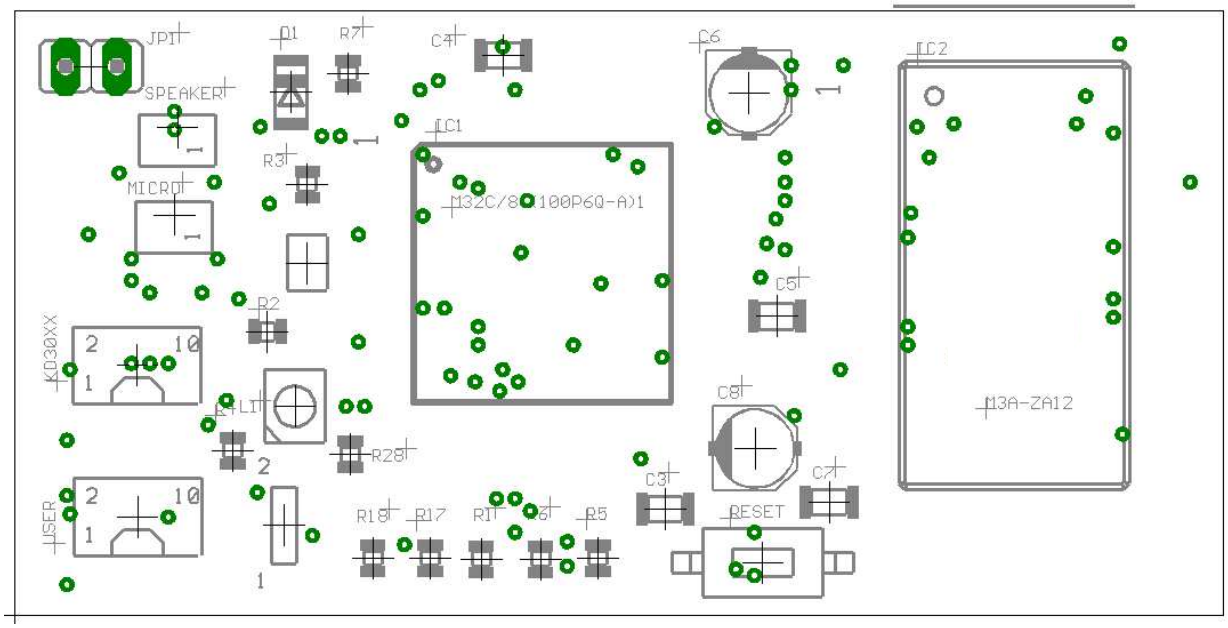

Figure 10: Component placement top layer

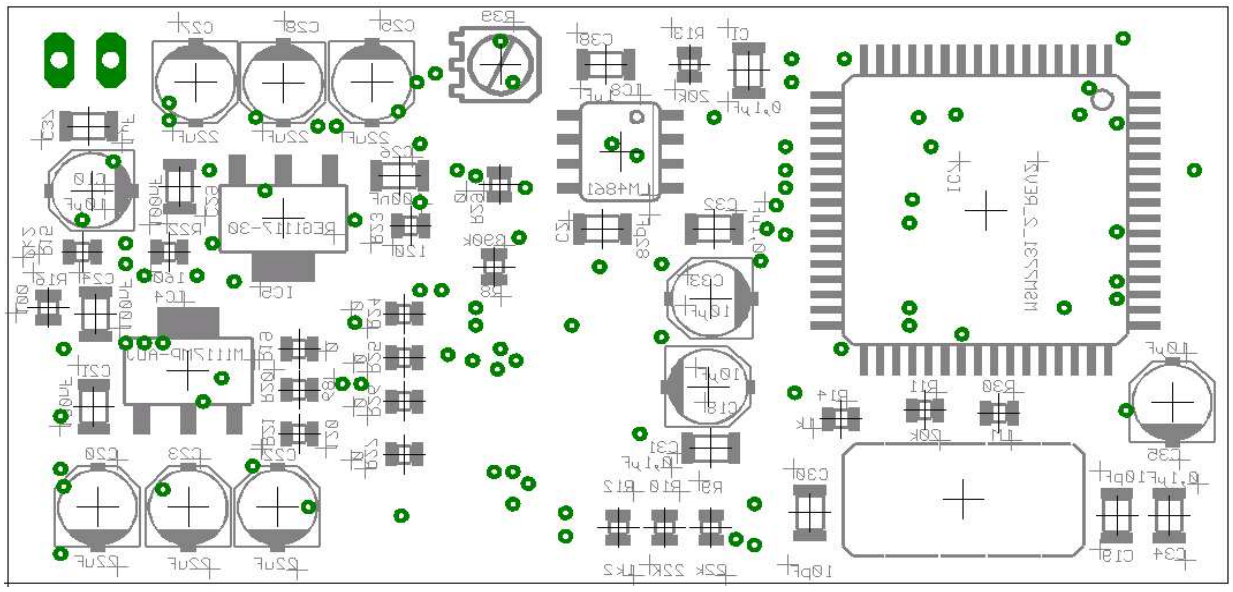

Figure 11: Component placement bottom layer

10 Reference

Renesas Technology Corporation Semiconductor Home Page
http://www.renesas.com

Contact for Renesas Technical Support
E-mail: support_apl@renesas.com

Data Sheet & User's Manual
M16C/62N Datasheet, User's Manual, Bluetooth documents
(Use the latest version, please check: http://www.renesas.com)

IAR Systems Embedded *Bluetooth™* Protocol Stack
http://www.iar.com

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