Fujitsu Microelectronics Europe
Application Note

FMEASM-AN-AB0002-10

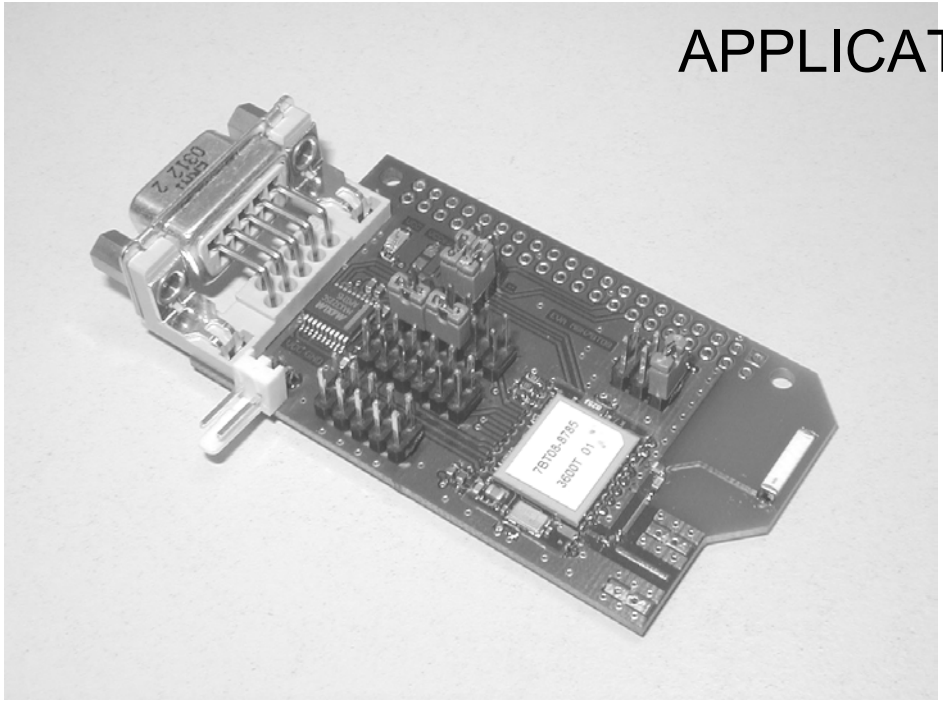
BLUETOOTH™ APPLICATIONS BOARD

FOR EMBEDDED STACK MODULES

MBH7BT08

DESIGN EXAMPLE AND REFERENCE LAYOUT

APPLICATION NOTE



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Revision History

Date	Issue
24-Sep.-03	V0.0, First draft
10-Oct-03	V0.1, Update BOM & title-photo, add figure 7
23-Oct-03	V0.9, Layout changed, antenna diagram added
27-Oct-03	V1.0, First release, trimming components revised

This document contains 29 pages.

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Contents

1 Introduction

This note shows an example how to integrate the Bluetooth module MBH7BT08 into a printed circuit board. The intention of this board is to provide our customers a proven design and layout. The board is already in use for internal tests and demonstrator devices.

Some interfaces of this reference board are designed to fit into Fujitsu Microelectronics internal systems.

It is recommended to use this design as a starting point for own developments and integration tasks, where parts of the proven layout (e.g. Antenna area or Module supply connections) can be used without changes while others may be not needed at all.

The appendix contains a list of essential rules for adaptation and use of the application board. The listed page number links to the details of each rule. These rules are marked as follows:

Rule X: A text, which summarises recommendations or restrictions.

Note that numbering of rules can change with next version of this document.

The document also contains "infoboxes", which explain terms, which are not directly related to the subject of that document.

Infobox X: Term

Some explanation

2 MBH7BT08 Module

This Chapter summarises the characteristics and attributes of the MBH7BT08 Bluetooth Module.

2.1 Introduction to the MBH7BT08 Module

MBH7BT08 is a Power Class 2 module conforming to Bluetooth Specification Version 1.1. MBH7BT08 transmits and receives in the 2.4 GHz ISM band. Although upper layer protocol stack and Profiles have to be embedded on the user's host system when user uses conventional HCI module, MBH7BT08 includes upper layer protocol stack and several Profiles. Therefore, MBH7BT08 makes it possible to reduce the resources of the user's host system required to process for Bluetooth.

MBH7BT08 has the following features:

- Bluetooth Specification Version 1.1 Compliant
- Built-in upper layer protcol stack (L2CAP, SDP, RFCOMM)
- Built-in profiles (GAP, SDAP, SPP)
- Transmit Power Class 2 (+4 dBm max.)
- Hardware interface: UART interface (up to 921.6 kbps)
- Software interface: Zerial interface (AT command-like)
- 3.3 ± 0.3 V Operation
- Bluetooth Qualification Program approved (planned)
- Microminiature: 19.5 x 13 x 2.2 mm
- Surface mount type

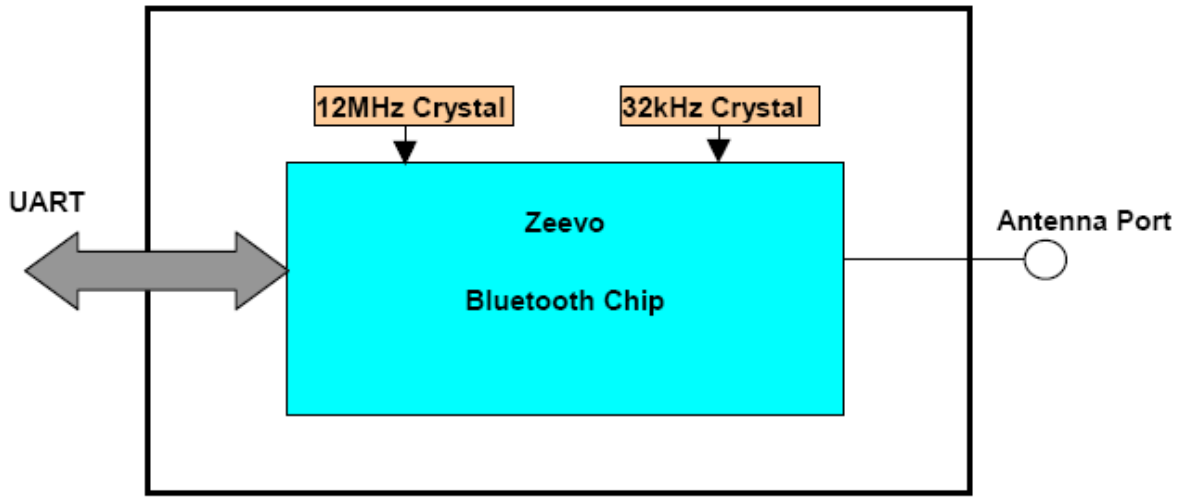


Figure 1 MBH7BT08 Module Block diagram

2.2 Electrical Characteristics

2.2.1 General Specification

Bluetooth™ Specification Version 1.1 Compliant
Carrier Frequency 2400MHz ~ 2483.5MHz
Modulation 0.5 BT Gaussian-filtered 2FSK at 1Msymbol/s
Modulation index: 0.25 to 0.35
Symbol Rate 1Mbps
Channel 79ch
Channel Space 1MHz
Transmit Power Power Class 2

2.2.2 Absolute Maximum Rating

Items	Symbol	Value	Unit
Supply Voltage	Vcc	+3.6	V
Input Voltage	Vin	-0.3 ~ Vcc+0.3	V
Storage Temperature	Tstg	-30 ~ +85	°C
RF input power	-	+15	dBm

2.2.3 Recommendable Operating Condition

Items	Symbol	Min	Typ	Max	Unit
Supply Voltage	Vcc	3.0	3.3	3.6	V
Operating Temperature	Topr	0		+70	°C

2.2.4 I/O Terminal Characteristics

Vcc=3.3V, Ta=25°C

Items	Symbol	Min	Max	Unit	Test Conditions
Low-Level Input Voltage	V_{IL}	-	0.8	V	Vcc=Vcc Min
High-Level Input Voltage	V_{IH}	2.0	-	V	Vcc=Vcc Max
Low-Level Output Voltage	V_{OL}	-	0.4	V	Vcc=Vcc Min, I_{OL}=100µA
High-Level Output Voltage	V_{OH}	2.4	-	V	Vcc=Vcc Min, I_{OH}= -100µA
Low-Level Output Current	I_{OL}	-	2.2	mA	V_{OL}=0.4V
High-Level Output Current	I_{OH}	-	3.1	mA	V_{OH}=2.4V

2.2.5 Power Consumption

Vcc=3.3V, Ta=25°C

Mode	Min	Typ	Max	Unit
Power during Inquiry / Page scan	-	1.5	-	mA
Power during Inquiry / Page	-	20	-	mA
Power during connection (DH5 TX followed by DH1 RX)	-	55	-	mA
Power during connection (DM3 TX followed by DH1 RX)	-	50	-	mA

2.2.6 Transmitter Specification

Vcc=3.3V, Ta=25°C

Items	Condition	Min	Typ	Max	Unit
RF transmit power	Maximum output	-2	1	4	dBm
RF power control range		-	30	-	dB
RF power range control resolution		-	3	-	dB
20dB bandwidth for modulated carrier		-	-	1	MHz
Initial Carrier Frequency Tolerance	DH1 mode	-75	-	+75	kHz
Carrier Frequency Drift	1 Slot 3 Slot 5 Slot	-25 -40 -40	- - -	+25 +40 +40	kHz kHz kHz
Modulation Characteristics	8 bit sequence 01010101	±115	-	-	kHz
	8 bit sequence 00001111 (Avg)	±140	-	±175	kHz
Adjacent Channel Power	|M-N|=2 |M-N|>=3	- -	- -	-20 -40	dBm dBm
Out of Band Spurious Emissions	30MHz --- 1GHz 1GHz --- 12.75GHz 1.8GHz --- 1.9GHz 5.15GHz --- 5.3GHz	- - - -	- - - -	-36 -30 -47 -47	dBm dBm dBm dBm

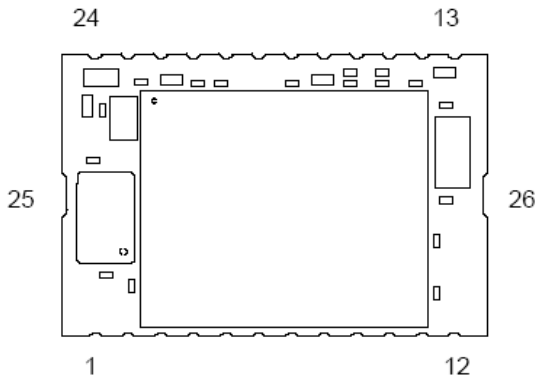
2.2.7 Receiver Specification

Vcc=3.3V, Ta=25°C

Items	Condition	Min	Typ	Max	Unit
Sensitivity at 0.1% BER	DH1 mode	-	-75	-70	dBm
Sensitivity (single slot packets)	Input level = -70dBm DH1 mode	-	-	0.1	%
Sensitivity (multi-slot packets)	Input level = -70dBm DH5 mode	-	-	0.1	%
C/I performance		-	-	0.1	%
Blocking performance	30MHz ~ 12.75GHz Interferer signal	-	-	0.1	%
Intermodulation Performance	5^{th} order intermodulation	-	-	0.1	%
Maximum Input Level	Input level = -20dBm	-	-	0.1	%

2.3 Pin descriptions

Name	No.	I/O	Description	External connection
GPIO3	1	I/O	General Purpose Input / Output	NC
GND	2	---	Ground	Ground
ANT	3	I/O	Antenna RF port (50Ω)	Antenna (50Ω)
GND	4	---	Ground	Ground
TXD	5	O	UART data output	UART RxD
RXD	6	I	UART data input	UART TxD
PCM_SYNC	7	O	PCM Synchronous data strobe (This function is not available.)	NC
USB_D-	8	I/O	USB D- data input/output (This function is not available.)	NC
PCM_CLK	9	O	PCM Synchronous data clock (This function is not available.)	NC
RTS#	10	O	UART Ready To Send to DTE	UART CTS#
CTS#	11	I	UART Clear To Send from DTE	UART RTS#
USB_D+	12	I/O	USB D+ data input/output (This function is not available.)	NC
PCM_IN	13	I	PCM Synchronous data input (This function is not available.)	NC
PCM_OUT	14	O	PCM Synchronous data output (This function is not available.)	NC
RESET#	15	I	Reset input: active low for 5 ms (It is required for firmware update.)	Reset output or NC
GPIO0	16	I/O	General Purpose Input / Output	NC
GPIO2	17	I/O	General Purpose Input / Output	NC
GPIO1	18	O	CPU Activity (This terminal outputs high when the on-chip CPU is running and low when the device is in deep-sleep.)	Monitor input or NC
GPIO5	19	I/O	General Purpose Input / Output	NC
GPIO4	20	O	Baseband Activity (This terminal is high if there is any baseband activity.)	Monitor input or NC
GPIO6	21	I/O	General Purpose Input / Output	NC
GPIO7	22	I/O	General Purpose Input / Output	NC
GND	23	---	Ground	Ground
VCC	24	---	DC power (3.3V)	DC Power
GND	25	---	Ground	Ground
GND	26	---	Ground	Ground



Rule 1: Complete documentation can be found in the MBH7BT08 datasheet.

3 Applications Board

This chapter introduces the Application Boards with a mounted MBH7BT08 module. The board usage and appropriate configurations are explained. It is expected that the user is familiar with terms and expressions of Bluetooth technology in general and the datasheet of the Bluetooth Module MBH7BT08

3.1 Introduction to the Applications Board

The Applications board is a 4-layer FR4 PCB with an MBH7BT08 Bluetooth module and a UART transceiver IC on the top-layer and two 3.3 V voltage regulators on the bottom layer. One of the regulators (U1) provides the supply voltage for the Bluetooth module and the UART transceiver. The other regulator (U2) could be used as a power supply for a microcontroller connected to the system interface.

The Applications board offers a 16550 UART interface. Using the 9-pin D-type connector, the board can be connected to the serial port of a PC via a NULL modem serial cable. Alternatively, it can be connected to a microcontroller via the system interface.

If the board has been connected to a PC and the jumper settings are set appropriately, the module can be controlled with software.

Power is indicated by LED D1 & D2. LED D3 can be used as status-indicator for a microcontroller.

The Application board can operate with a surface mount chip antenna or a Bluetooth antenna with a SMA connector.

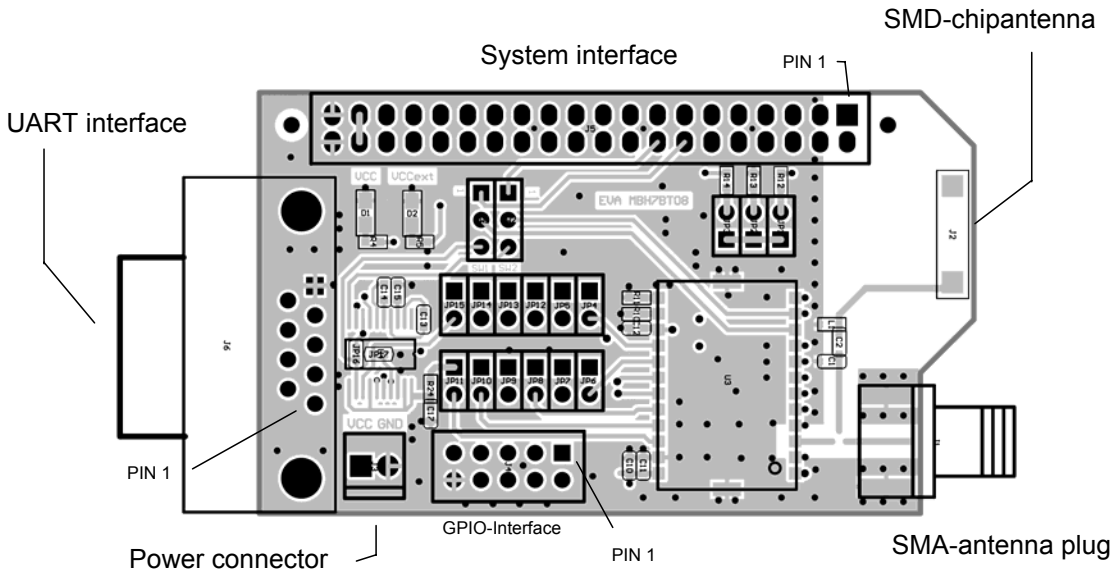


Figure 2 Application Board

3.2 Operating conditions

Parameter	Symbol	Value			Unit	Remark
		Min.	Typ.	Max.		
Power supply voltage	Vcc	3.75	5.0	12.0	V	Regulated down to 3.3 V
Current consumption	Icc				mA	Only regulator U1 in use.
Current consumption			13.7		mA	Current consumtion D1: 6 mA Current consumtion U4: 0.7 mA
Current consumption “Discovery-mode”			68.0		mA	Current consumtion D1: 6 mA Current consumtion U4: 1.6 mA
Current consumption “Connect mode”			36.5		mA	Current consumtion D1: 6 mA Current consumtion U4-: 1.2 mA
Operating temp.	Ta	0	-	+70	°C	

3.3 PCB Connectors Description

Connector	Schematic Text	Function	PIN #	Comment
J3		Power connector	1	VCC (+3.75 V … + 12 V)
			2	GND
J6	Conn SUB-9	Serial UART-interface	1, 4, 6	connected to each other
			2	RX host side (module TX data -> RX host)
			3	TX host side (module RX data <- TX host)
			5	GND
			7	Ready to send, host side (module CTS <- RTS host)
			8	Clear to send, host side (module RTS -> CTS host)
			9	NC
J4	Conn10	GPIO Interface	1	GPIO 0
			2	GPIO 2
			3	GPIO 4
			4	GPIO 6
			5	VCC
			6	GPIO 1
			7	GPIO 3
			8	GPIO 5
			9	GPIO 7
			10	GND
J5	Conn40	System interface	12	Power Control regulator U1
			14	RTS module
			15	Reset module
			16	CTS module
			18	GND for LED D3
			26	RX module
			28	TX module
			30	TX UART host (serial-interface)
			32	RX UART host (serial-interface)
			33, 37, 38	VCC
			39, 40	GND

3.4 Jumper Configuration

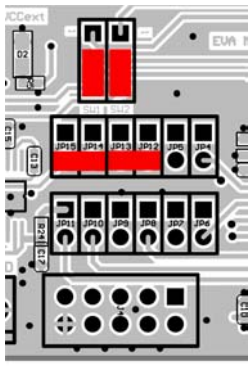
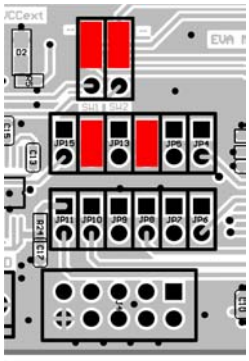
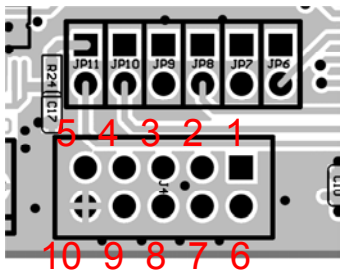
UART-programming via serial-interface • SW1 links the module RTS with the SUB 9-plug • SW2 links the module CTS with the SUB 9-plug • The connection between Jumper 12 and 13 links the module RXD with the UART Transceiver IC (U4) • The connection between Jumper 14 and 15 links the module TXD with the UART Transceiver IC (U4)	
UART-programming via system-interface (microcontroller) • SW1 links the module RTS with the system-interface • SW2 links the module CTS with the system-interface • Jumper 12 links the module RXD with the system-interface • Jumper 14 links the module TXD with the system-interface	
PCM/GPIO programming via 10-pin plug • Pin 1: GPIO 0 • Pin 2: GPIO 2 • Pin 3: GPIO 4 • Pin 4: GPIO 6 • Pin 5: VCC • Pin 6: GPIO 1 • Pin 7: GPIO 3 • Pin 8: GPIO 5 • Pin 9: GPIO 7 • Pin 10: GND	

Figure 3 Jumper Settings

JP 1: Connects MBH7BT08 Reset-port (Pin# 15) to VCC
JP 2: Connects MBH7BT08 Reset-port (Pin# 15)to GND
JP 3: Connects MBH7BT08 Reset-port (Pin# 15) to J5-Pin15 (System Interface)
JP 4: Connects GPIO 0-port with VCC
JP 5: Connects GPIO 1-port with VCC
JP 6: Connects GPIO 2-port with VCC
JP 7: Connects GPIO 3-port with VCC
JP 8: Connects GPIO 4-port with VCC
JP 9: Connects GPIO 5-port with VCC
JP 10: Connects GPIO 6-port with VCC
JP 11: Connects GPIO 7-port with VCC

4 Establish a connection

This chapter shows how the Term program is used on a PC to set the parameters of the Module, establish a link to a remote device, then transfer into *Bypass* mode and transfer text transparently.

Rule 2: Before running the programming software the Applications boards should be connected to PCs via a serial null modem cable. Ensure the jumper settings on the Applications boards are set to use the 9-pin D-type connector.

Term is a windows terminal program used to access the serial port on a PC running a MS Windows operating system. It is similar in usage to the more commonly known HyperTerminal application.

4.1 Communication Set-up of Term

To set-up the communication parameters select *CommPort* → *Properties*… from the Menu bar.

Select to COM port that the host will use and set the baud rate to match the baud rate of the Module. (Default baud rate of Module is 115.2 kbps). Set the Connection Preferences as Data bits = 8, Parity = None, Stop Bits = 1.

As hardware flow control is required, Flow Control should be set to *RTS*. Finally, set Echo to *On*. See Figure 4

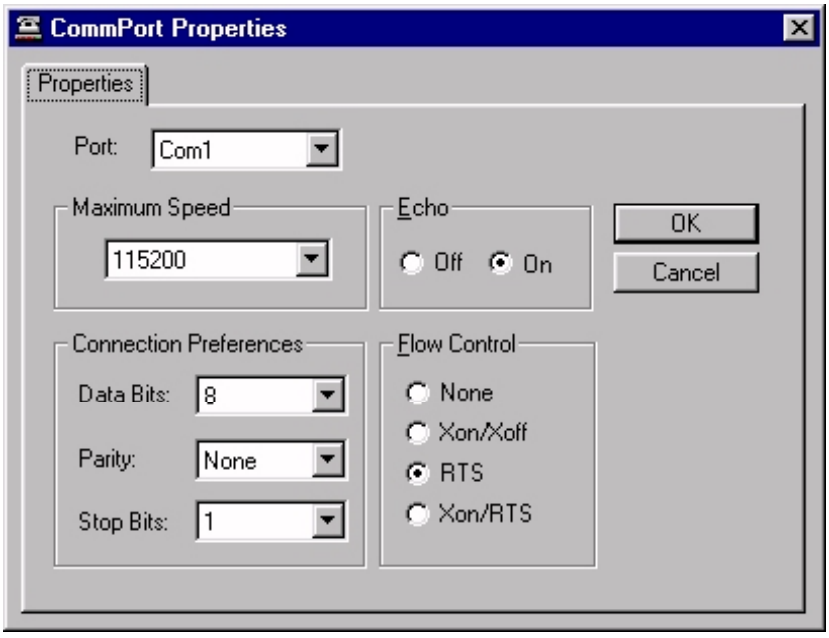


Figure 4 Term Communications Port properties

4.2 Establishing the Connection

Term is now ready to communicate with the module. Open the COM port by selecting *CommPort → Port Open* then switch on the Applications board.

On Power-up you should receive notification of the mode and Bluetooth device address of the module. See Figure 5.

Note: There may be some unintelligible characters before the notification text. This is a result of data previously in the Host's UART buffer.

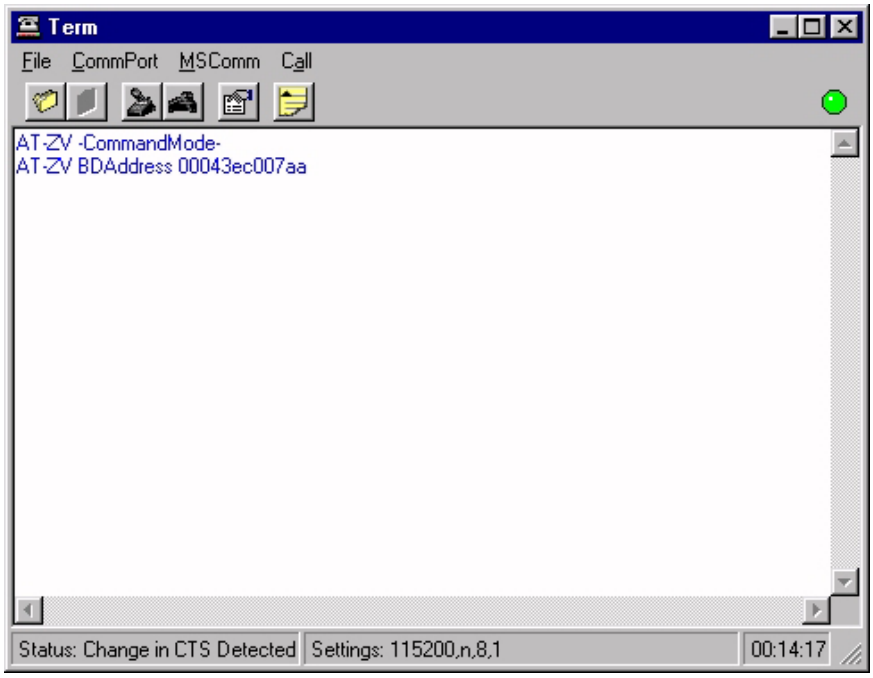


Figure 5 Status after Power-up or Reset

4.2.1 Device Set-up

To set up the Name, Class of Device & Security settings we use Term to send the appropriate commands to the Module. See Figure 6.

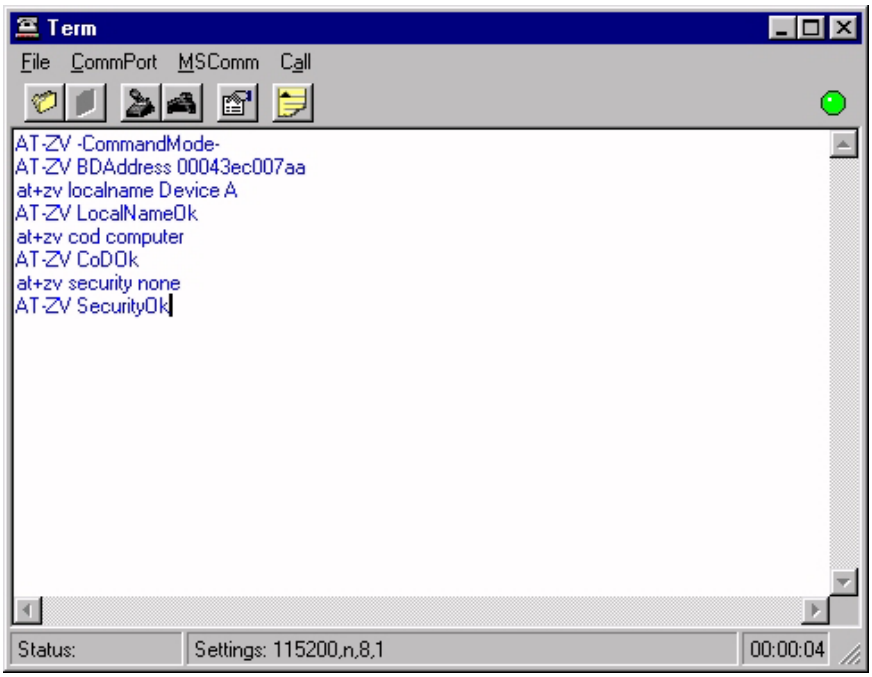


Figure 6 Configuring the local MBH7BT08 Module

4.2.2 Remote Device Discovery

It is possible that the local host does not know the Bluetooth Device address of the remote Bluetooth device with which it wants to connect. In that case, the local host can perform a device discovery using the Zerial interface. The Zerial interface can also filter responses to show only particular classes of devices.

On issuing the discovery command the local device first does inquiry and displays all the remote devices which responded to the inquiry procedure. The local device then performs a name request procedure on all the remote devices found in the inquiry procedure in the order in which they responded to the inquiry procedure. The name request procedure consists of establishing a connection, performing the name request and then disconnecting. This can fail if:

1) The local device is unable to page the remote device and is not able to establish a connection.

2) A connection is established but the remote device does not have a valid name registered by its host.

If this occurs, the system will return the message: “Unknown”.

Once name discovery is complete, the device performs service discovery on the same remote device. The device: a) inquires for the remote device, b) pages the remote device and establishes a connection, c) performs service discovery and then d) disconnects. Service discovery is done for locating a SPP server by default. Service discovery procedure can fail if:

1) The local device is unable to locate the remote device during inquiry.

2) The local device is unable to page and establish a connection.

3) The remote device does not have a registered SPP server.

If this occurs, the system will return the message: “No Svcs”.

Once name discovery and service discovery are performed on one device, the same procedure can be repeated for all devices that responded to the global inquiry.

Figure 7 shows a general device discovery that returns two devices.

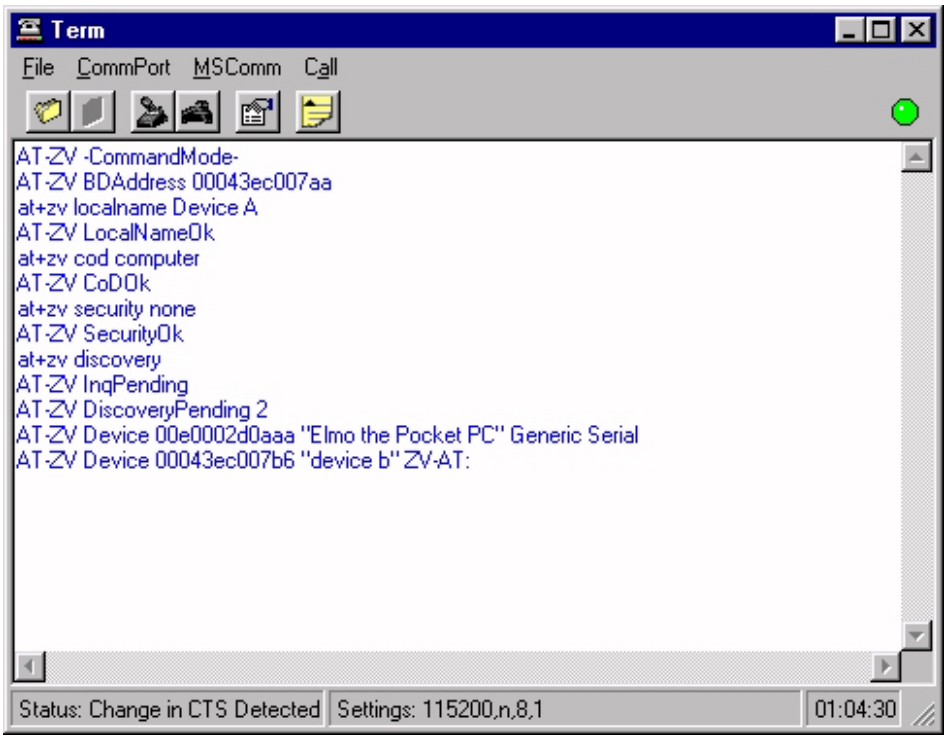


Figure 7 Discovering the Bluetooth devices within the range of the MBH7BT08

4.2.3 Connection

In order to create a connection with a remote device, the host issues a command string to the Zerial interface. This command may only be sent while in the command mode and when there is no active connection. The Bluetooth Device address of the remote device must be known at the time the connection is requested. Once the connection is established, the MBH7BT08 goes into bypass mode.

If the connection request is successful, the MBH7BT08 will go to the bypass mode. The response can take a few seconds. If the connection request is not successful, the MBH7BT08 will remain in command mode. A response can take a few seconds. There are numerous reasons a connection may not be established including poor RF quality and remote device rejection.

See Figure 8 for an example of establishing a connection and transferring some sample text while in Bypass mode.

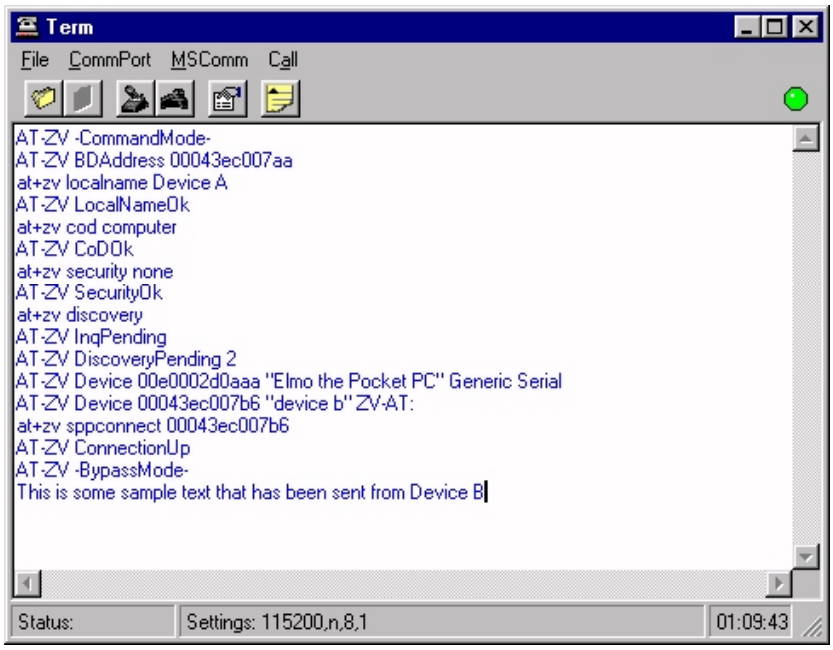


Figure 8 **Connecting to one of the discovered devices then transparently receiving text from that device**

4.2.4 Escape from Bypass mode

Once a connection has been established between host and remote device, the host can put the Zerial interface back into *Command* mode. Once the Zerial interface is back in *Command* mode, new commands (including termination of connection) can be issued. To move Zerial interface out of *Bypass* mode and into the *Command* mode, the Escape sequence is used. See Figure 9.

The Escape sequence is an escape string, ^#^$^%, followed by 2 seconds of no data. The Bluetooth connection to a remote device is not affected.

Rule 3: Any data received from the remote device while in Command *mode will be discarded by the local MBH7BT08 and not passed to the local host.*

Rule 4: The escape string must not be followed by a line-feed or carriage return.

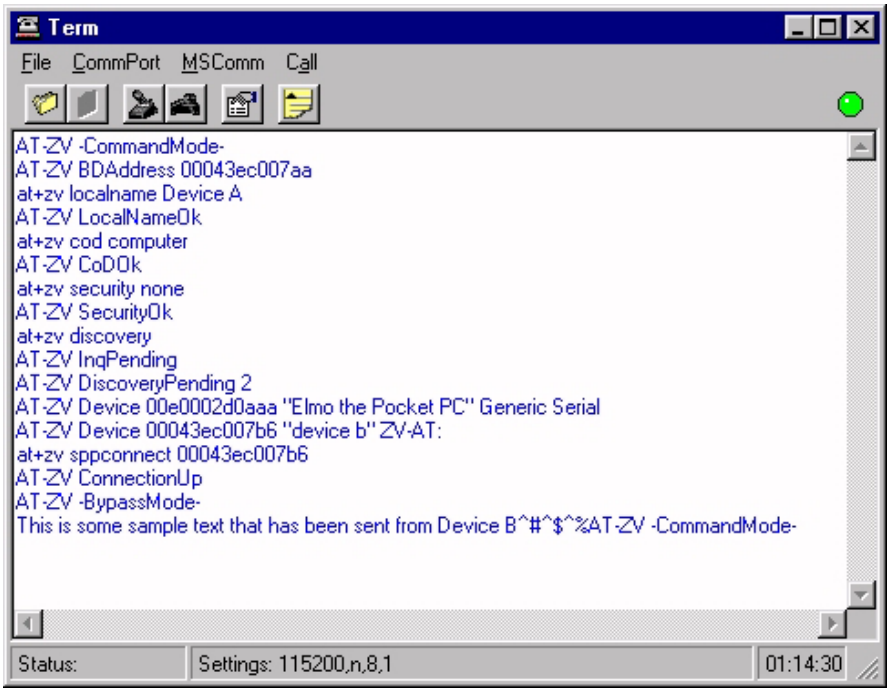


Figure 9 **Using Escape sequence to move out of Bypass mode and back into Command Mode. Device A(local MBH7BT08) is still connected to Device B(remote Device)**

4.2.5 Disconnection

Once a connection is made, either device may request to disconnect. In order to disconnect an existing connection with a remote device, the host issues a command string. However, once a connection to a remote device has been established, the MBH7BT08 is in bypass mode. The host must first put the Zerial interface in *Command* mode before it can close the connection. The Escape sequence is sent to begin this process.

Once the Zerial interface is back in command mode, the host sends the Disconnect command string. The Zerial interface notifies the host when the connection is broken and returns to *Command* mode. See Figure 10.

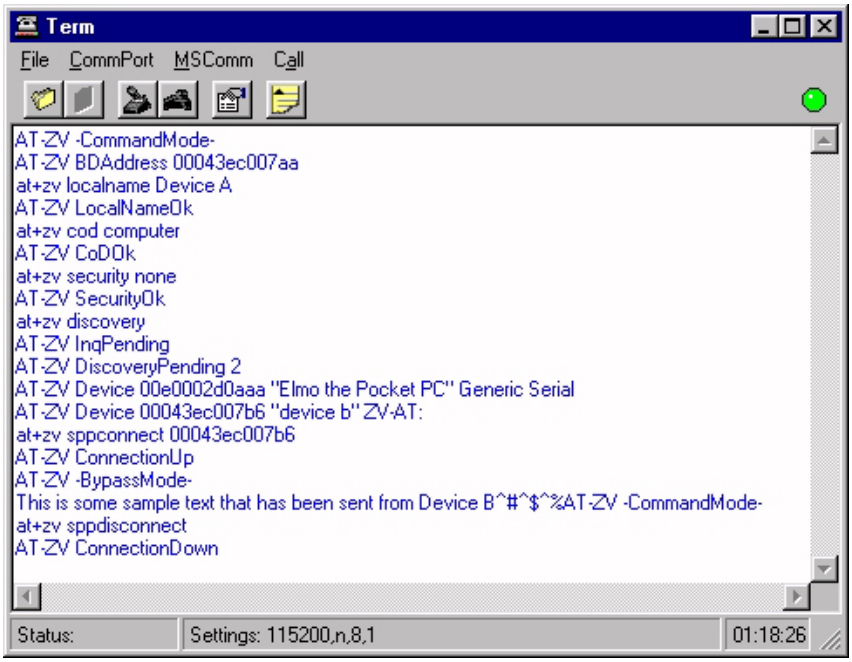


Figure 10 While in Command mode, Device A disconnects from Device B

5 Reference Design

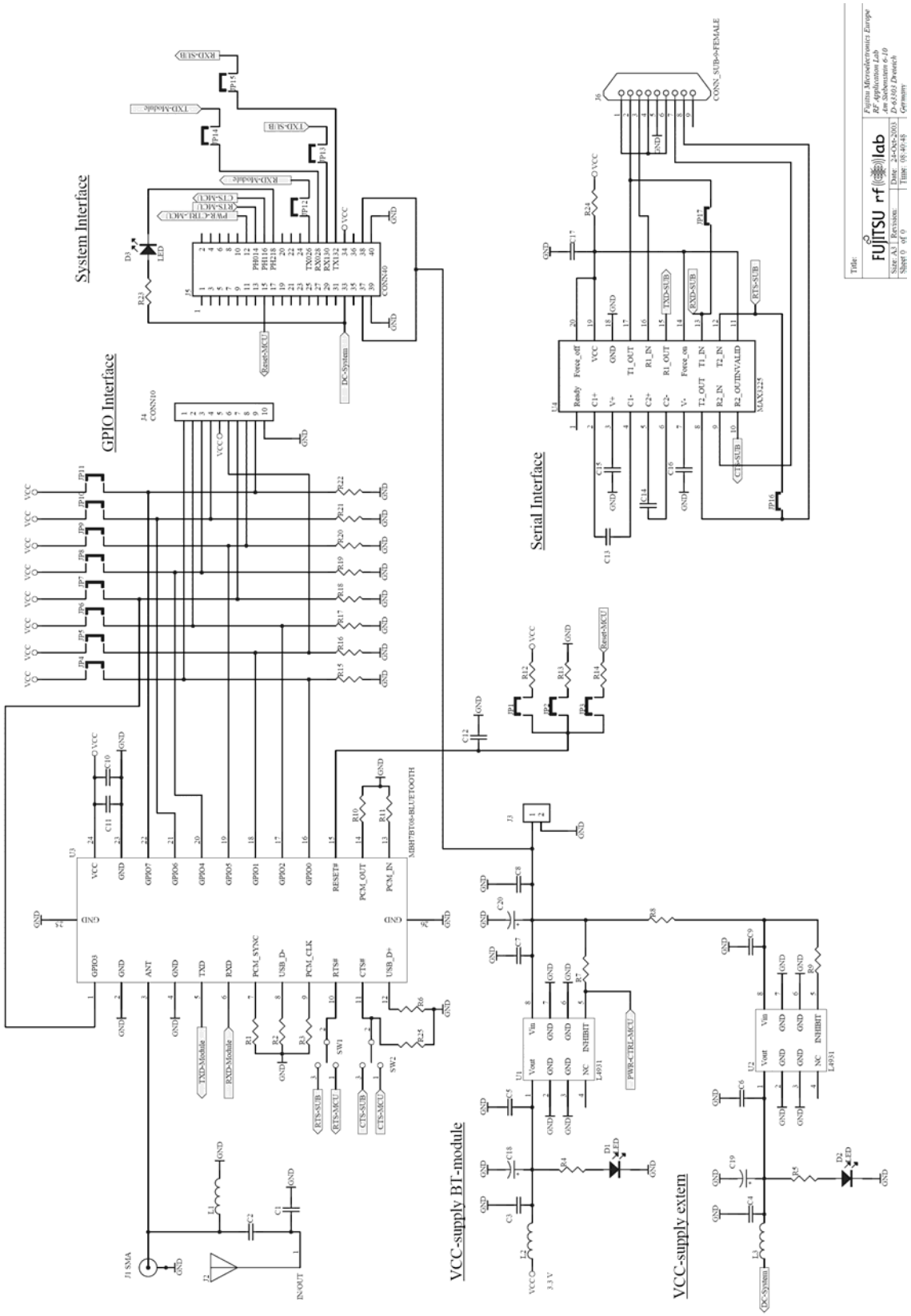


Figure 11 Applications Board Schematic

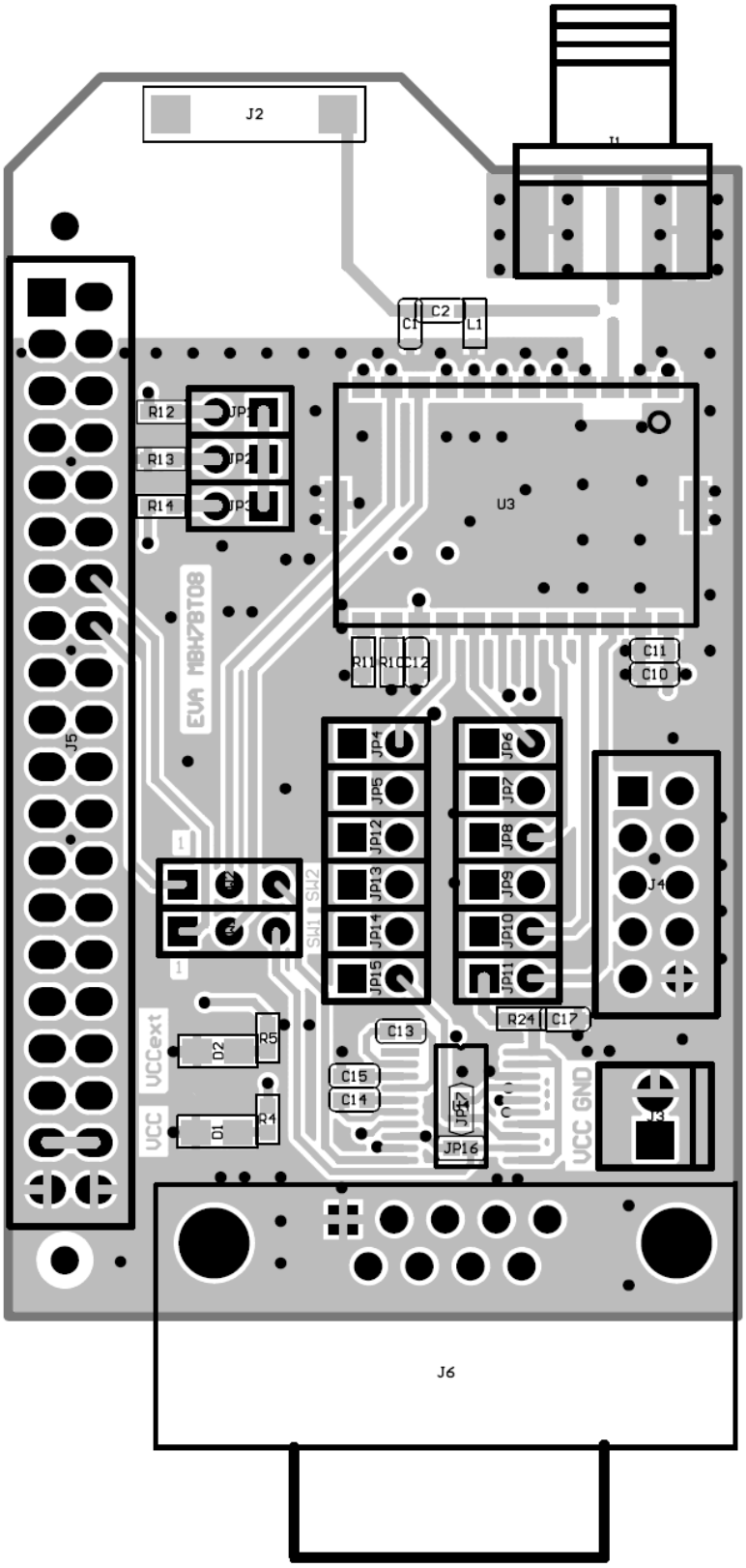


Figure 12 Applications Board Top Layer (original size: 67 mm * 40 mm)

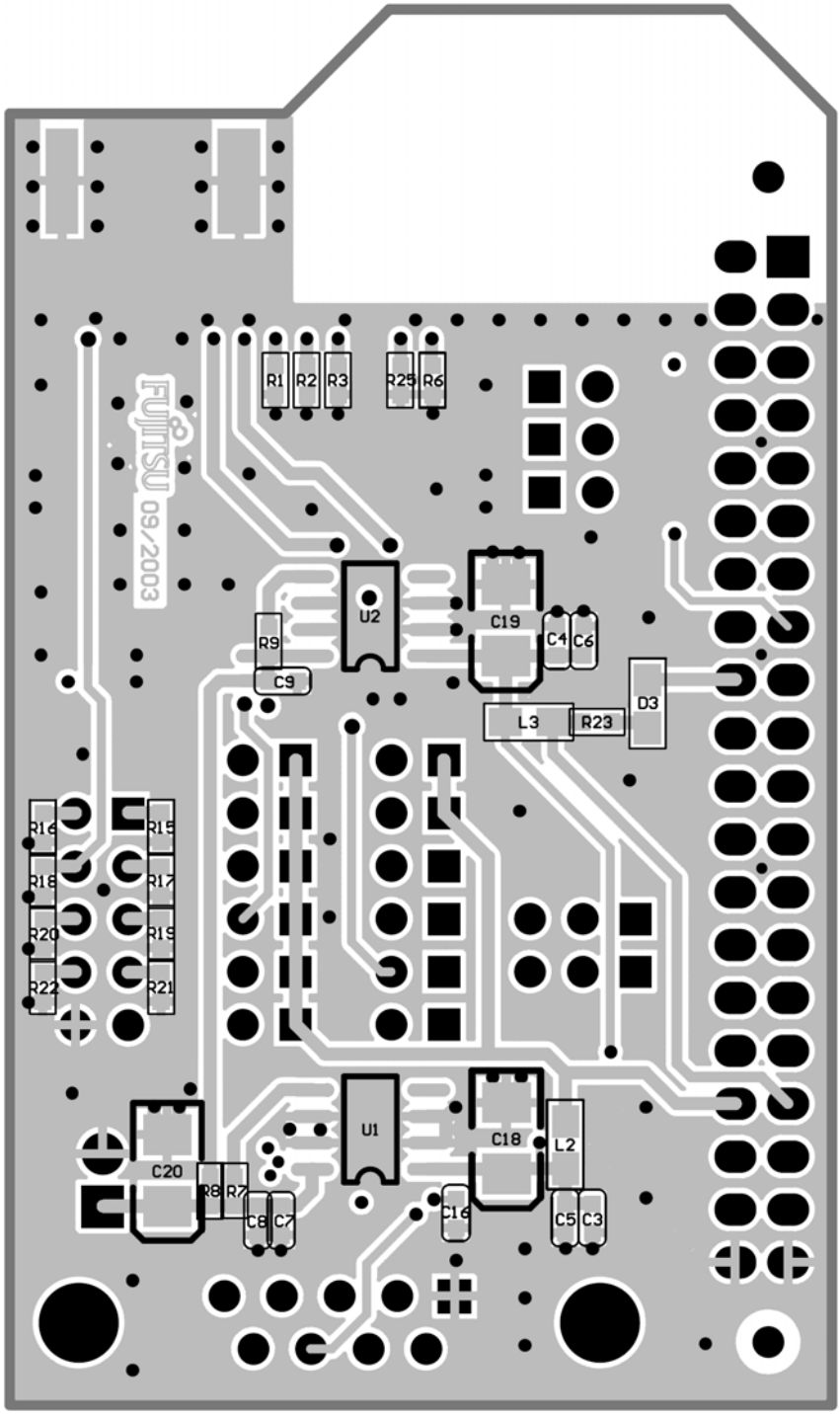


Figure 13 Applications Board Bottom Layer (original size: 67 mm * 40 mm)

5.1 Bill of Material

Designator	Value	Footprint
C1->L	5n6 (inductor)	0603_C *
C2	0p5	0603_C *
C3	100 p	0603_C
C4	100 p	0603_C
C5	10 n	0603_C
C6	100 p	0603_C
C7	10 n	0603_C
C8	100 p	0603_C
C9	10 n	0603_C
C10	100 n	0603_C
C11	1 u	0603_C
C12	1 n	0603_C
C13	100 n	0603_C
C14	100 n	0603_C
C15	100 n	0603_C
C16	100 n	0603_C
C17	10 n	0603_C
C18	10 u	3528
C19	10 u	3528
C20	10 u	3528
R1	10 k	0603_R
R2	10 k	0603_R
R3	10 k	0603_R
R4	220 Ohm	0603_R
R5	220 Ohm	0603_R
R6	10 k	0603_R
R7	Open	0603_R
R8	Open	0603_R
R9	Open	0603_R
R10	10 k	0603_R
R11	10 k	0603_R
R12	10 k	0603_R

Designator	Value	Footprint
R13	10 k	0603_R
R14	10 k	0603_R
R15	10 k	0603_R
R16	10 k	0603_R
R17	10 k	0603_R
R18	10 k	0603_R
R19	10 k	0603_R
R20	10 k	0603_R
R21	10 k	0603_R
R22	10 k	0603_R
R23	10 k	0603_R
R24	short	0603_R
R25	open	0603_R
L1	4n7	603 *
L2	220 n	805
L3	220 n	805
D1	LED	805
D2	LED	805
D3	LED	805
J1	SMA	SMA-END-LAUNCH
J2	SMD-antenna WE-MCA 7488910245	Würth Elektronik www.we-online.de
J3	CONN2	POWER2
J4	CONN10	CONN10
J5	CONN40	CONN40
J6	CONN_SUB-9-FEMALE	Sub-D-9-female
JP1	JUMP_KLEIN	BRIDGE1
JP10	JUMP_KLEIN	BRIDGE1
JP11	JUMP_KLEIN	BRIDGE1
JP12	JUMP_KLEIN	BRIDGE1

Designator	Value	Footprint
JP13	JUMP_KLEIN	BRIDGE1
JP14	JUMP_KLEIN	BRIDGE1
JP15	JUMP_KLEIN	BRIDGE1
JP16	JUMP_SOLD	Solderbridge
JP17	JUMP_SOLD	Solderbridge
JP2	JUMP_KLEIN	BRIDGE1
JP3	JUMP_KLEIN	BRIDGE1
JP4	JUMP_KLEIN	BRIDGE1
JP5	JUMP_KLEIN	BRIDGE1
JP6	JUMP_KLEIN	BRIDGE1
JP7	JUMP_KLEIN	BRIDGE1
JP8	JUMP_KLEIN	BRIDGE1
JP9	JUMP_KLEIN	BRIDGE1
SW1	SW_UM1	SW_JUMP
SW2	SW_UM1	SW_JUMP

Designator	Value	Footprint
U1	L4931 Voltage regulator Vout = 3.3 V	SO-8 ST-Microelectronics www.stm.com
U2	L4931 Voltage regulator Vout = 3.3 V	SO-8 ST-Microelectronics www.stm.com
U3	MBH7BT08 Bluetooth-module	Fujitsu
U4	MAX3225CAP UART-Transceiver IC	SSOP20 MAXIM www.maxim.de

*) See Rule below for details regarding impedance match and trimming components

Rule 5: Changing the type of the microchip antenna requires new RF measurements to adjust the values of the trimming components (C1, C2, L1) to match the impedance controlled track with the antenna.
E.g. changing the antenna (descriptor J2) in the bill of material above.
**) A board version with Centurion microchip antenna CAF95901 results in:*
C1: N/A, not mounted
C2: 1.8 pF
L1: 2.7 nH

5.2 Antenna diagrams

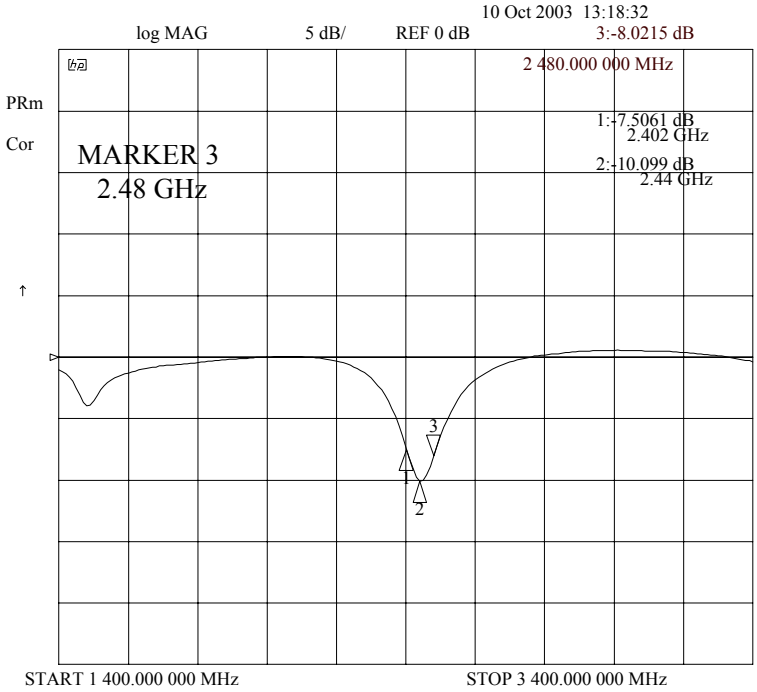


Figure 14 Matching Würth microchip-antenna

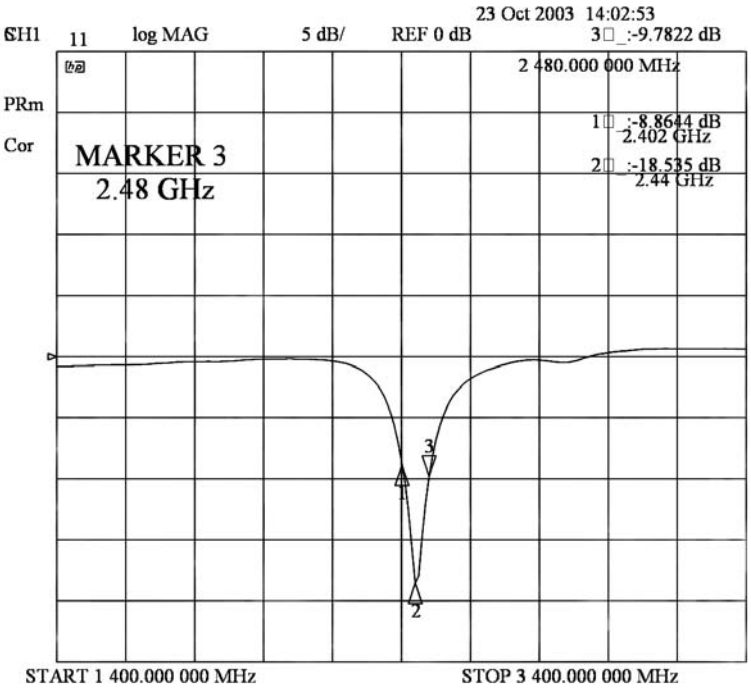


Figure 15 Matching Centurion microchip-antenna

6 Appendix

6.1 Rules

The List of rules gives an overview of the more or less strict requirements when using the application board example. It can be used as a kind of checklist. For details go to the given page. Note that numbering can change with next version of this document.

6.2 Figures

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