Medianut User's Manual

Contents

1 About the Medianut Board

MP3 for Embedded Ethernet Applications.

Medianut is a small (40 x 98 mm) add-on for the Ethernut board combining VLSI's VS1001K MP3 decoder with Ethernut's embedded Ethernet, which is well suited for developing a wide range of applications.

Some areas are:

- Internet radios, also known as WebRadios
- Talking Ethernet devices
- Ethernet enabled MP3 players

Medianut Features

The Medianut board provides the following features:

- VS1001K MP3 hardware decoder
- MPEG audio layer 1, 2, and 3, ISO 11172-3
- MPEG 1 & 2 for all layers, and layer 3's 2.5 extensions, and all their sampling rates and bitrates, in mono and stereo
- Variable MP3 bitrates
- Stereo earphone output capable of driving a 30 Ohm load
- 40 kHz infrared remote control receiver, easily replaceable by 36 or 38 kHz receivers.
- Standard 16 pin LCD interface with LED backlight control

2 Quick Start

This chapter will help you quickly set up and start using the Medianut board.

Prerequisites for Operation

The following hardware items are necessary to run the Medianut board:

- An Ethernut Starter Kit or an Ethernut Board plus programming adapter and a straight through serial communication cable with a DB-9 female on one end and a DB-9 male connector on the other. Your Ethernut board should be equipped with an ATmega128 (red colored board). It is possible to run MP3 applications on ATmega103 equipped boards (green color), but the lower performance limits its use and not all function may work as expected.
- Two straight-through twisted pair cables together with 10 Base-T hub or switch or a twisted pair cross cable, if you don't got a hub or switch. If you want to run the Nutpiper Internet Radio, you need a local LAN with Internet access, typically provided by a router with NAT support.
- An unregulated power supply matching your local mains. It should supply DC 8-12V, on a standard 2.1 mm barrel connector. The total power consumption depends on the display used, but 500 mA should do in most cases.
- A standard PC equipped with Linux or Windows 98/NT/2000/XP, an available serial COM port and a twisted pair Ethernet adapter card.
- An AVR development environment, either AVR-GCC for Linux or WinAVR or ICCAVR for Windows.
- An active speaker set or a stereo headphone with 30 Ohm minimum impedance. A high end amplifier with some bulky JBL speakers will do as well.
- A standard LCD or LCD-compatible display and a Sony TV remote control would be more fun and are required to run the Netpiper application sample. An adapter may be required to connect the LCD. You may also need a tiny soldering iron to mount two SMD resistors in order to enable LED backlight control.
- A 4-bit port to optionally attach a simple keyboard.

Board Installation

1 Remove the board from the antistatic bag. Visually inspect the board to verify that it was not damaged during shipment.

> WARNING: As with all computer equipment, the Medianut board may be severely damaged by electrostatic discharge (ESD). Be sure to take proper precautions before removing the Ethernut board from the anti-static bag.

2 Setup the Ethernut as explained in your Ethernut hardware manual. Do not switch on the power supply before attaching the Medianut board.

3 Attach you programming adapter to the Ethernut board.

4 Plug the infrared decoder to the IR socket (near R10) on the Medianut. The lense of the decoder must point to the board's edge.

5 Attach the speakers or earphones to the Medianut audio output connecter X9. When using earphones, never put them on while switching on or off your equipment. Because of the risk of hearing damage, we strictly recommend to use speakers.

6 Optionally attach the LCD or LCD-compatible display to the Medianut LCD connector X7.

7 Attach the Medianut to the Ethernut expansion connector. Make sure, that smaller connector X2 of the Medianut board is placed near the Ethernut serial port and that both ends do exactly fit to the Ethernut expansion connector.

8 Connect the power supply to the barrel connector on the Ethernut board.

You are now ready to upload your application code to the Ethernut or use the Nutpiper radio application sample. See the next chapter for a detailed description of the Nutpiper program.

3 Nutpiper Internet Radio Application Sample

Listening to the worl wide web.

The Nutpiper application turns your Ethernut/Medianut system into an Internet Radio by using the Shoutcast protocol. The application is still limited and experimental. For example, there is no other way to add new radio stations than to modify and recompile the code. Only LCDs with 2 lines and 16 characters each had been tested and only Sony TV remote controls are currently supported. So do not expect a full fledged radio but take it as a basis for your own creativity.

When running on Ethernut 1.3, listening to Internet bitstreams above 56 kBit may not be possible. With 32 kByte memory, only a fraction of a second is available for buffering the stream. The new Ethernut 2.0 is equipped with 512 kByte RAM and can even take 320 kBit streams, if the server delivers the MP3 data at a sufficient rate.

Note, that Nutpiper requires Internet access, your local network must support this.

Network Configuration

If your local network supports DHCP, no code modifications are required to give it a first try. Nutpiper will query its IP address, network mask and default gateway from the DHCP server.

If DHCP is not available, you need to edit the file nutpiper.c.

```
/* Unique MAC address of the Ethernut Board. */
u_char mac[6] = { 0x00, 0x06, 0x98, 0x00, 0x00, 0x00 };
```

Change this to the unique MAC address of your Ethernut board.

```
/* Unique IP address of the Ethernut Board. Ignored if DHCP is
used. */
u_long ip_addr = inet_addr("192.168.192.100");
```

This must be replaced by a unique IP address within your local network. Make sure, that this address is able to access the Internet.

```
/* IP network mask of the Ethernut Board. Ignored if DHCP is
used. */
u_long ip_mask = inet_addr("255.255.255.0");
```

Replace with the IP mask used in your local network.

```
/* Gateway IP address for the Ethernut Board. Ignored if DHCP
is used. */
u_long ip_gate = inet_addr("192.168.192.3");
```

This must be replaced by the IP address of the Internet gateway, normally the IP address of your Internet router.

Radio Station Configuration

In the current version there is no user interface for adding or removing radio stations. The code comes with various predefined stations, some of which offer terrible music. To add your own stations, edit the file config.c. When started for the first time or after a previously erased EEPROM, Nutpiper will not find a valid configuration in the EEPROM and call the routine ConfigResetFactory(), which contains several calls similar to

```
ConfigStation(MAXNUM_STATIONS, "129.217.234.42/128:8000");
```

Each call adds a radio station to the list and requires two parameters. The first one is the index of the entry, ranging from 0 to MAXNUM_STATIONS. Any index from 0 to MAXNUM_STATIONS - 1 will replace that entry. If MAXNUM_STATIONS is given, the entry will be put the first unoccupied space.

The second parameter specifies the URL without leading http://. In the above example Nutpiper will connect IP address 129.217.234.42 on port 8000 and request /128. Btw. it looks like this is a 128 kbit stream, but in fact it's 56 kbit only. Some time ago this station, which is located at the University of Dortmund, Germany, and named elDOradio, reduced the bitrate.

You can add upto 128 stations, as long as the whole configuration fits into 3.5 kByte, leaving 19 bytes for each URL parameter excluding the IP address, the first slash, the colon and the port number. The above sample would consume 3 out of 19 bytes available.

After recompiling and before uploading the code to an ATmega128 board, make sure, that the fuse "Preserve EEPROM" is off. Otherwise Nutpiper will still load the old configuration from EEPROM and ignore ConfigResetFactory(). On the ATmega103 there is no such fuse and the EEPROM is cleared on each chip erase.

Storing the configuration into the EEPROM is done by pressing the power off button on your remote control.

Using the Remote Control

Only Sony TV remote controls are currently recognized. The supported code are defined in the driver dev/irsony.h.

The ten channel buttons 1 to 9 select the radio station entries 1 to 9. If Ethernut fails to connect the selected station, the display will show the IP address and the message "not available".

Channel selects plus and minus can be used to select the next or previous entry. If the connection fails, Nutpiper will automatically try the next or previous entry.

As soon as a station is connected, Nutpiper will start buffering the stream and start the MP3 decoder as soon as the buffer is filled. On Ethernut 2 this may take a while and you can force the decoder to start by pressing a volume button.

When Ethernut received a valid ICY header from the server, it will display the name of the station in the first line of the LCD. If the server provides meta data (most Shoutcast servers do), the second line will display the stream title, typically the interpret and the title of the track.

As you may know from other Ethernut applications (or your webbrowser), connecting a station which is not available may take upto a minute or more. That's annoying but no solution is available yet.

Pressing power off will display the message "Shutdown" while the current configuration is stored in EEPROM. When done, the display will be cleared, but no part of the system will be powered down.

More remote control features are available when enabling the background scanner.

Scanning Stations in the Background

The code includes a highly experimental part, called scanner, which is disabled by default. To enable it, uncomment the line

```
ScannerInit();
```

in the file nutpiper.c. This will start an additional thread, which scans the list of stations in the background.

The user may press the Videotext button on the remote control and wlak through the list of stations using the channel plus/minus buttons. When pressing the input select button, the radio will switch to the currently displayed station. Pressing the Videotext button will return to the normal display.

4 Creating Your Own Applications

Make your wildest ideas come true.

As explained in the previous chapter, the Nutpiper application is just an example for building your own Ethernet enabled MP3 devices. Fortunately almost all low level functions are provided by Ethernut's operating system Nut/OS. This chapter contains some basic introduction, more details are available in the Nut/OS API documentation.

Network API

Ethernut's TCP/IP stack named Nut/Net provides the required socket API. Check the Ethernut manuals and samples to become familiar with it.

While Nut/OS can map socket I/O to C standard I/O functions like _read() and fscanf() or _write and fprintf(), these functions are not very usefull for MP3 streaming because of their additional overhead. It is recommended to use the native Nut/Net TCP Socket API instead, like NutTcpReceive(). These functions are similar to the BSD socket library.

Segmented Memory Management

MP3 decoding by software requires at least a 32 bit CPU with more than 100 Mips. But even with a hardware decoder like the one used on the Medianut Board, moving all the data in realtime from a TCP/IP network to the decoder requires some special techniques to make it work on a tiny 8 bit system.

The key to success is avoidance of data copying. Usually data streams are moved from the Ethernet Controller to the Ethernet's driver buffer, then moved to the TCP buffer, again moved to the application buffer and finally from the application buffer to the MP3 decoder buffer. Some systems may use additional steps.

Nut/OS tries to avoid these copies. In extreme, the data may be moved directly from the Ethernet controller to the MP3 controller. In reality this will fail, because TCP isn't realtime, but playing MP3 is. So at least one buffer stage is required to compensate the non deterministic arrival of TCP data.

Each packet received is moved from the Ethernet controller into a so called NETBUF. Each NETBUF is added to a connection specific queue until the application request data from the connection. For portability reasons and to keep things simple, the application provides a buffer and calls NutTcpReceive() to get that buffer filled with application data out of the queued NETBUFs. This is another copy, but frees the application from dealing with system specific NETBUF structures.

The smart part is, that Nut/OS offers a special buffer management to avoid the final copy into the decoder buffer and that the Nut/OS MP3 decoder driver makes use of this buffer management. As stated, normally the application buffer is filled by some kind of read statement (first copy) and transfered to the driver by some kind of write statement (second copy). When using the segmented memory management, the application will query the driver for buffer space first and then pass this buffer to the TCP read routine. This way the TCP read routine will directly fill the buffer of the decoder driver. When this has been done, the application commits the buffer filled and requests a new one and so on. This technique is used in the Nutpiper application file player.c inside THREAD(Player).

The important statements are:

```
mp3buf = NutSegBufWriteRequest(&rbytes);
```

Requests buffer space for writing, rbytes will receive the number of bytes available and the function returns a pointer to the beginning of the buffer space.

```
got = NutTcpReceive(player.psi_sock, mp3buf, rbytes);
```

Calls the TCP/IP receive routine to copy the application data into the buffer. The function returns the number of bytes copied, which may be less than the number of bytes requested.

```
NutSegBufWriteCommit(got);
```

The number of bytes filled into the write buffer are commited and hence available for the driver.

The memory management routines are not interrupt or thread save and currently support one system wide buffer only. But they are fast and simple to use. Typical Nut/OS drivers use a very simple interrupt routine which posts an event to a worker thread. For performance reasons the MP3 decoder driver accesses the buffer directly within its interrupt routine. Otherwise the decoder may run out of MP3 data due to the latency between posting an event and waking up the worker thread. The application has to disable interrupts each time it calls a segmented memory management API.

While reading this chapter, you may have asked yourself, why it's called segmented memory. The API can not only handle a continuos memory space, but also one that is divided into several segments. This is usefull with banked memory hardware provided by Ethernut 2 boards.

MP3 Decoder Driver

This interrupt driven driver does all the low level handling of the VS1001K chip. In order to use it, an application must call VsPlayerInit() once during initialization and VsPlayerReset() each time before playing a stream. As soon as some MP3 data has been filled into the buffer (see previous chapter), the application will call VsPlayerKick() to start the driver feeding the decoder. From that point on the driver expects the application to keep the buffer filled. If it runs out of data, the driver will stop feeding the decoder and the application must call VsPlayerKick() again as soon as more data is available again. By calling VsGetStatus() the application can query the status of the decoder. It returns any of the following values:

- VS_STATUS_STOPPED Player is ready to be started by VsPlayerKick().
- VS_STATUS_RUNNING Player is running.
- VS_STATUS_EOF Player has reached the end of a stream after VsPlayerFlush() has been called.
- VS_STATUS_EMPTY Player runs out of data. VsPlayerKick() will restart it.

A call to VsPlayerFlush() mentioned above will move all remaining MP3 data to the decoder and stop gracefully. In the Nutpiper application this isn't used, instead the decoder is reset when changing the radio station. When playing single tracks from some external media or, more important, short samples from internal memory, you should call it to make sure, that all data left the audio output before resetting the decoder.

Some additional routines are provided for volume control (zero of maximum volume!), querying MP3 information (AVRGCC only), setting special decoder modes (see VS1001K datasheet) or testing the internal decoder memory.

LCD Interface

The LCD driver currently supports HD44780 compatible display controllers only, but the majority of alphanumeric displays follow this standard.

On the other hand the display support provided by Nut/OS is very comfortable when compared to other LCD implementations. Except for initialization no special calls are required, the driver is fully integrated into stdio library and features a superset of VT52 emulation for cursor and write position control. This makes it for example very easy to switch from RS232 terminal output to LCD output and vice versa. See the Nutpiper application for how to use the LCD.

Infrared Remote Control

A first attempt to provide a unified IR driver interface had been made for the Sony protocol.

In general, decoding IR commands is a very time sensitive task, which easily conflicts with other realtime demands like MP3 streaming or Ethernet I/O. The Nutpiper application proofs, that all task could be done on one ATmega128 CPU concurrently. Ethernuts running on ATmega103 may face problems, though.

The corresponding API interface is very simple. Beside standard Nut/OS device registration, which initalizes the driver, NutIrGet() is the only routine and will return the raw code received from the decoder.

5 Functional Hardware Description

This chapter explains the hardware of the Medianut board.

Infrared Decoder Interface

Use a tiny screw driver to attach the infrared decoder, which comes with your board. The lense should point down when plugging it into the terminal. The decoder is working optimal with 40 kHz signals, mostly used by Sony. Decoders for 36 or 38 kHz are available upon request.

MP3 Decoder

Generally the MP3 decoder is connected via two serial busses. The first one, the data bus, is used to transfer the MP3 data stream from the Ethernut board to the decoder. This bus will be driven by the Ethernut hardware SPI. The second bus is used by the Ethernut board to read register contents from and write register values to the MP3 decoder. Of course, this is a bidirectional bus and has to be managed by software.

In order to save I/O lines, both busses share the same data line from the Ethernut board to the MP3 decoder. However, the paranoid designer spent an additional port bit to control the decoder's hardware reset line.

Note, that all port bits are routed via a 74LVC245 bus driver to convert the signal levels between the 5 Volt logic of the Ethernut board and the 3 Volt logic of the MP3 decoder.

IR Receiver

The infrared receiver requires just a single port bit. Falling and rising edges from the receiver output will generate interrupts.

Pin	IR Receiver Signal	Ethernut Connection
1	Data output	PE4 interrupt 4 input
2	Power supply (GND)	DC and GND via on-board 5 Volt regulator
3	Power supply (+5V)	

Power Supply

Medianut takes its power supply from the regulated 5 Volts line of the Ethernut expansion connector and provides its own regulator (IC6) to create the required 3.3 Volts for the MP3 decoder.

Expansion Port

The board is equipped with two connector groups to be attached to the Ethernut expansion port. Each connector group is located on one side of the board and divided into two connectors. Address and data bus lines are not routed to the board to avoid interference with the sensitive analog audio part.

Connector group X1/X2 is used to attach the board in a compact way to the Ethernut. However, this makes a large part of the board inaccessible for measuring equipment in case of hardware problems. With connector group X3/X4 the board can mounted in a 90° angle, which makes it possible to easily access all parts on both boards. This is very useful for tracing hardware problems. By default, X3 and X4 are not mounted.

Pin	MP3 Decoder Signal	Ethernut Connection
1	DREQ: Data request output	PE6 interrupt 6 input
2	DCLK: Data input clock input	PB1 (SCK) output
3	SDATA: Serial data input	PB2 (MOSI) output
4	BSYNC: Byte synchronization input	PB5 output
11	XCS: Chip select input	PB4 output
12	SCLK: Control bus clock input	PB0 output
13	SI: Control bus input	PB2 (MOSI) output
14	SO: Control bus output	PB3 (MISO) input
26	XRESET: Asynchronous reset input	PB7 output
18	AGND: Analog ground	DC and GND via on-board 3.3 Volt regulator
21		
25		
19	AVDD: Analog power supply	
23		
6	DGND: Digital ground	
10		
27		
5	DVDD: Digital power supply	
9		
28		

LCD Interface

The 16 pin connector can be used to attach standard alphanumeric displays. However, most LCDs require a 14/16 pin single line connector while Medianut offers a 16 pin connector with 2 lines of 8 pins. 14 pins are typically used for LCD control, two additional lines are used for backlight supply.

In order to save Ethernut port pins, Medianut drives the LCD in 4 bit mode and doesn't support reading LCD registers. Instead one port bit has been spend to switch the backlight on or off.

Display backlights differ and you need to check your datasheet before enabling this feature. Carefully check the schematics for correct polarity and either mount R13 and R14 (most common) or R12 and R15 (reverse polarity). While R14 and R15 are 0 Ohm and may be replaced by a simple wire, the values of R12 and R13 require some calculation first to fit your display.

In most cases the LCD will not show any characters when used with Medianut for the first time. You need to adjust the potentiometer R16 for optimum contrast.

In any case we recommend LCD compatible VFDs. Allthough costly, these are very bright displays with high contrast and do not require backlit supply or contrast adjustment.

Pin	LCD Signal	Ethernut Connection
1	Power supply (GND)	DC and GND via LCD on-board regulator
2	Power supply (+5V)	
3	Contrast adjust	None

4	L = Instruction register
	H = Data register
		PE2 output

5	Read/Write control
	L = Write to LCD
	H = Read from LCD
		None, tied to GND

6	Enable (data strobe)	PE3 output
7	Data line bit 0	None, tied to GND in 4-bit mode
8	Data line bit 1	
9	Data line bit 2	
10	Data line bit 3	
11	Data line bit 4	PD4 output
12	Data line bit 5	PD5 output
13	Data line bit 6	PD6 output
14	Data line bit 7	PD7 output
15	Backlight supply +	DC and GND via on-board 5 Volt regulator and power MOSFET controlled by PB6 output
16	Backlight supply -	

Keyboard Interface

The keyboard is currently not supported by the software, but may be useful for your own application. Four switches may be attached, each of which will connect one of the four lower port bits of port D to ground when pressed.

Audio Output Connector

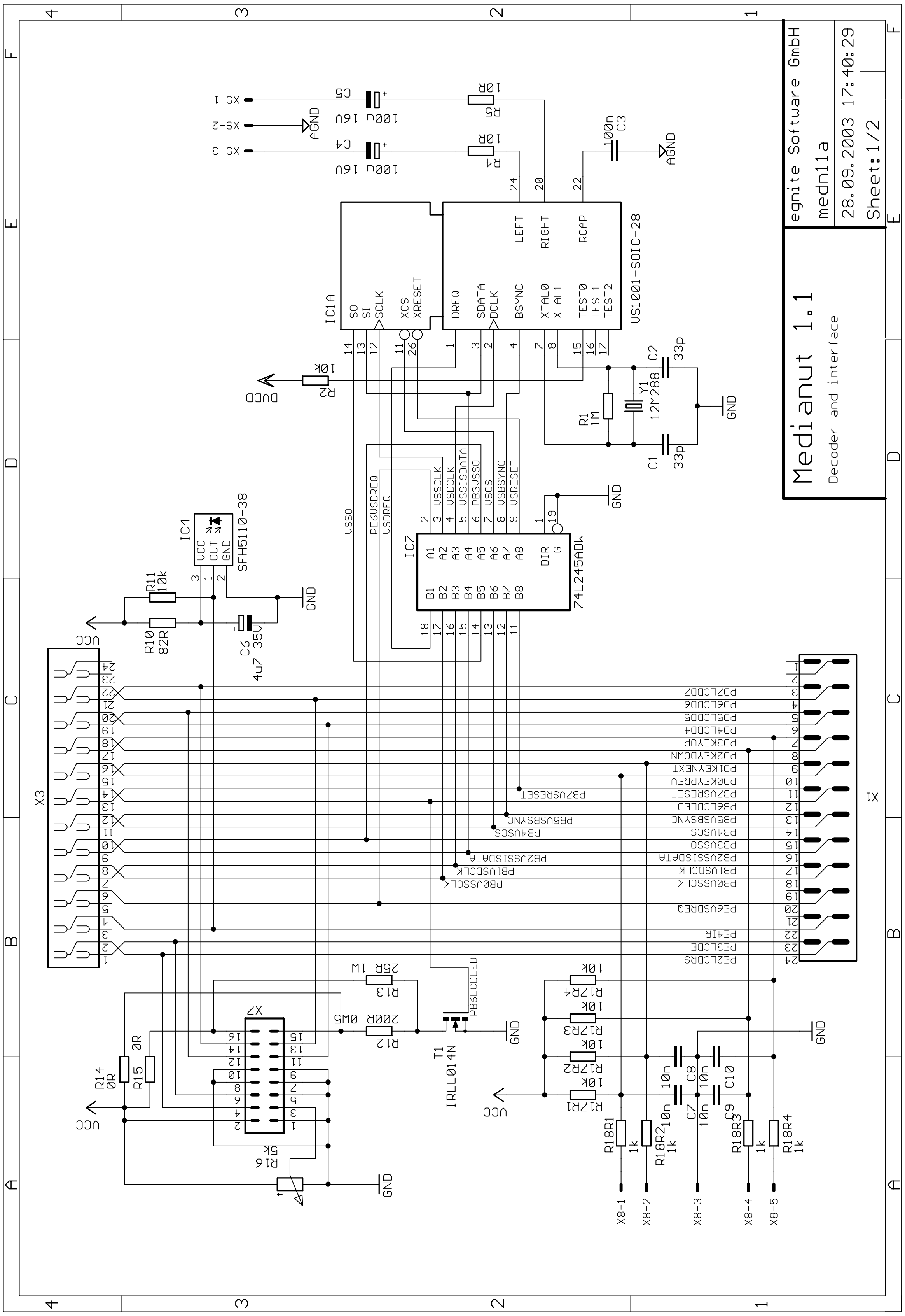
The stereo output may be connected to an earphone, an amplifier line input or active speakers. It is capable of driving a 30 Ohm load.

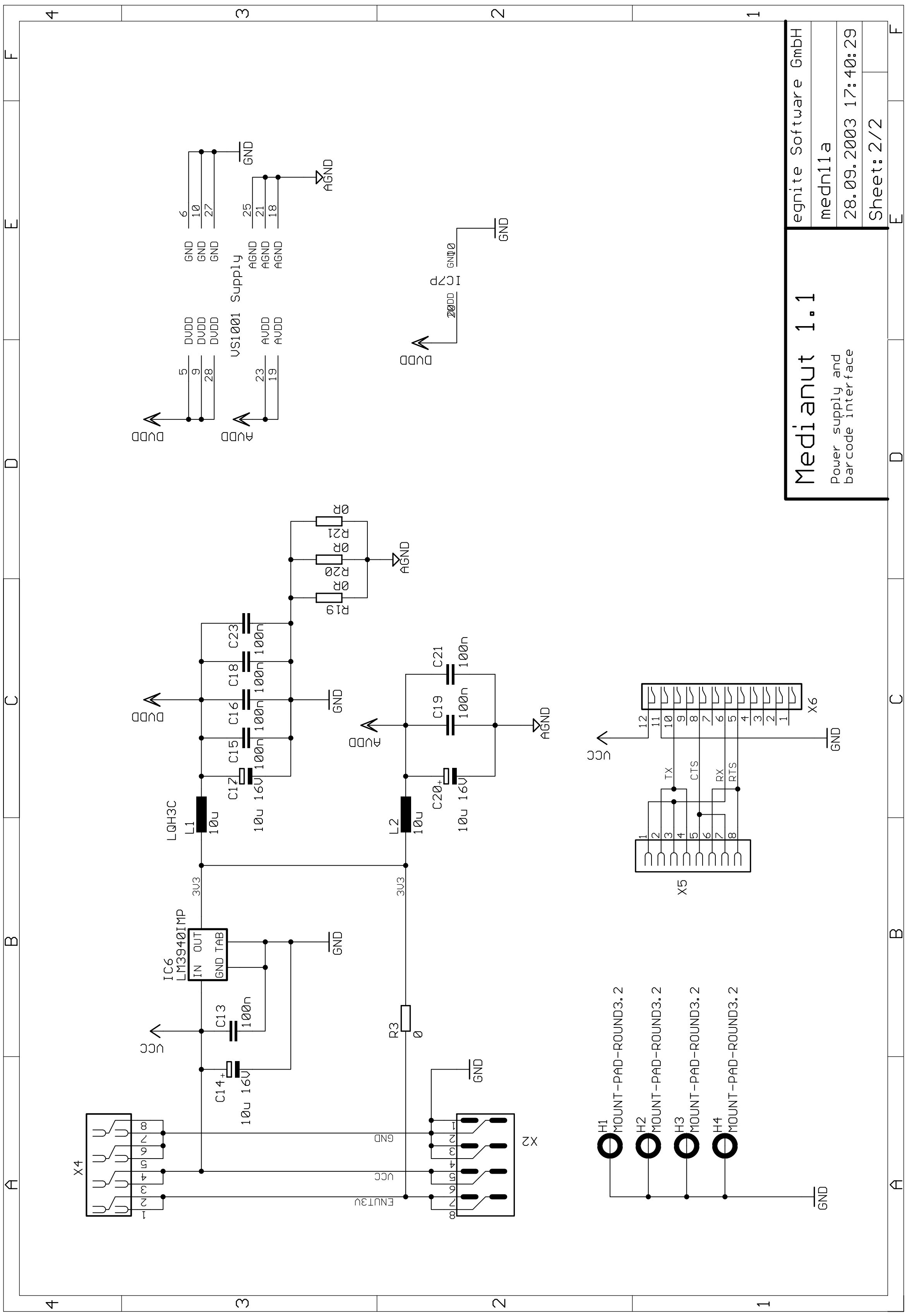
Please be carefull when using earphones, always remove them from your ears before attaching or detaching connectors, playing around with untested software or switching on and off the power supply. Even with the tiny amplifier of the Medianut you can severly damage your hearing. Tiny earplugs are more dangerous than larger headphones. Professionals prefer to use speakers while developing audio hardware and software.

Scanner Interface

This interface is used with egnite's record shop system. If you are an owner of a music shop chain, you may be attracted. Call us or send us an email for more interesting information. Otherwise simply ignore it, it's not there.

6 Schematics and Board Layout

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Sheet: 2/2
Medianut 1.1
Power supply and
barcode interface
VS1001 Supply
DVDD
AVDD
GND
AGND
IC7P
IC6
LM3940IMP
IN OUT
GND TAB
VCC
3V3
C13 100n
C14 10u 16V
R3 0
L1 LQH3C 10u
L2 10u
C17 10u 16V
C15 100n
C16 100n
C18 100n
C23 100n
C20 10u 16V
C19 100n
C21 100n
R19 0R
R20 0R
R21 0R
X2
X4
X5
X6
TX
CTS
RX
RTS
ENUT3V
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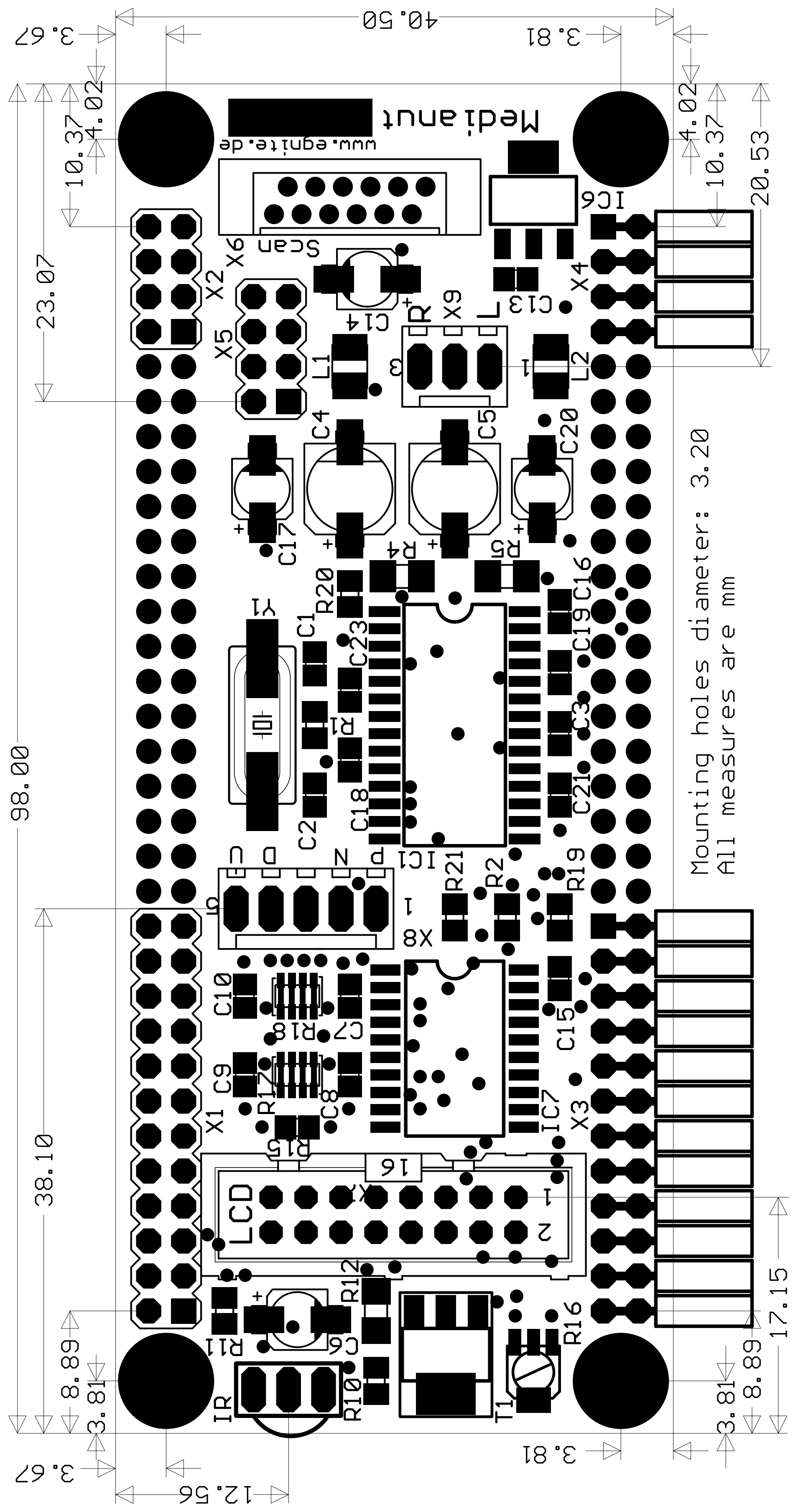
H2 MOUNT-PAD-ROUND3.2
H3 MOUNT-PAD-ROUND3.2
H4 MOUNT-PAD-ROUND3.2


Mounting holes diameter: 3.20
All measures are mm
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3.81
4.02
10.37
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23.07
98.00
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12.56
Scan
X1
X2
X3
X4
X5
X6
X7
X8
X9
IC1
IC6
IC7
Y1
L1
L2
T1
IR
LCD
C1
C2
C3
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C5
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