

Ethernut Version 3.0  
Hardware User`s Manual



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## About the Ethernut 3.0 Board

Low-cost Ethernet capability can be added to many embedded applications.

Since its introduction in the year 2000, Ethernut boards have been used to develop some of the most innovative products. Using the hardware, firmware, software and tools, developers have everything they need to develop leading networked devices rapidly and affordably. The board is well suited for application development in a wide range of applications. Some areas are:

- Networked sensors
- Remote monitoring equipment
- Alarm service providing
- Remote diagnose and service
- Industrial Ethernet applications
- Home and building control

### Ethernut Features

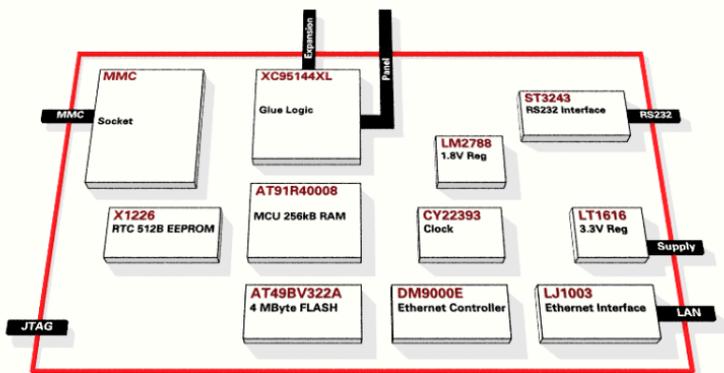
Ethernut 3.0 is a small (80 x 100 mm) board combining Atmel's AT91R40008 RISC microcontroller with Davicom's DM9000E Ethernet controller. The main features are:

- ARM7TDMI RISC microcontroller with up to 75 MIPS throughput
- Full duplex IEEE 802.3 compliant 10/100 Mbps Ethernet controller with on-board RJ-45 connector
- RS-232 at DB-9 connector with full handshake
- Multimedia Card Socket
- 4 MByte in-system programmable Flash ROM
- 256 kByte SRAM
- 512 Byte in-system programmable EEPROM
- 24 programmable digital I/O lines
- Real time clock with two alarms
- Three 16-bit timer/counters
- Watchdog timer for enhanced reliability
- LED indicators for power supply and Ethernet activity
- Single power supply DC 5-24V

## Block Diagram

The block diagram shows the main components.

Definitely the most important part is the AT91R40008 microcontroller. It's a quite complex chip and described in detail in Atmel's AT91R40008 data sheet. Almost all I/O ports are routed to the Ethernet expansion port, a 64-pin connector, which can be used to add custom hardware.



The microcontroller provides two UART channels, which are routed to the on-board RS-232 level shifters.

A Xilinx CPLD is used to implement the glue logic.

While Ethernet's software offers several bootloader capabilities over RS-232 or Ethernet, program code is initially uploaded through the JTAG interface. The connector layout conforms to Atmel's 10-pin AVR JTAG interface.



**WARNING:** Ethernet 3 uses the same JTAG connector layout as its predecessors Ethernet 1 and 2, which is not compatible with the standard ARM 14-pin or 20-pin connectors. A cable adapter will be required to attach standard ARM JTAG adapters.

## LED Indicators

The Ethernet 3.0 board is equipped with four LEDs. Two of them are integrated in the reset switch, a red LED to indicate power supply and a green LED, which is available for user applications.

Another two LEDs are integrated in the RJ45 Ethernet connector. The yellow LED indicates the network link status and is lit when the link status is OK. The green LED indicates receive and transmit activity from and to the network.

## Serial Ports

Ethernet provides an on-board DB-9 male connector for RS-232 serial communication. IC6 is used to convert the required voltage levels for RS-232 from the 3.3V power supply.

Any of the two serial interfaces of the microcontroller can be routed to the RS-232 connector via selection registers within the CPLD. In the default configuration the first interface (UART0) is routed to the RS-232 connector while the second interface (UART1) is not used.

## Ethernet Port

Ethernet provides an on-board modular RJ-45 connector with an integrated 100/10Base-T transformer/filter for its twisted pair Ethernet port. This port is connected to the Davicom DM9000E Ethernet controller. The interface supports the maximum cable length of 100 meters between the Ethernet board and a hub or switch.

## Expansion Port

Add-on boards can be added to the expansion port. These boards may contain simple I/O circuits driven by the Ethernet board, or may be equipped with their own CPU, using the Ethernet board as an Ethernet I/O processor only.

## Power Supply

The I/O logic of the Ethernet 3 board is driven by a 3.3V power supply, while the CPU core runs at 1.8V. The board provides its own voltage regulators (IC8 and IC9). It only requires an unregulated power supply of DC 5-24V with a minimum current of 200 mA.

Two different methods may be used to connect an external power supply.

**1** A standard 2.1 mm barrel connector. This input is protected by a fuse (F1), a fast transient voltage suppressor (D1) and a rectifier bridge (D4, D5, D6 and D7).

**2** The DC signal is routed to the Ethernet expansion connector to either supply add-on boards or to receive power supply from an add-on board. This input is unprotected.

As soon as power is attached to any of the inputs, the red LED in the reset switch will lit.

## Watchdog Timer

Software bugs, temporary hardware failures caused by electrical transients or interference and many other problems might cause the system to malfunction. The AT91R40008 microcontroller (IC1) provides an on-chip watchdog timer, which forces a system reset, if the application program fails to periodically update this timer.

## System Clock

Driven by a 25 MHz crystal, all high speed clock signals are generated by a programmable clock generator (IC5). The microcontroller clock is configured at 73.728 MHz, while the Ethernet Controller runs from a 25 MHz clock signal. Two additional clocks are available for the CPLD, but are not used in the standard configuration.

A second crystal (Y2) with 32.768 kHz drives the on-board RTC chip (IC7).



**WARNING:** Note, that changing any frequency will alter the Ethernet board's EMC characteristics and require re-testing.

## Static RAM

The AT91R40008 CPU provides 256 kBytes of high speed 32-bit on-chip SRAM, which can be used for code execution and data storage.

## Flash ROM

The AT91R40008 provides no on-chip flash memory. An external flash memory chip had been added to permanently store program code and read-only data. This memory is organized as 4 Mb x 8 bits and can be (re-)programmed by the CPU. To achieve this, a simple flash utility is programmed into the CPU RAM and started via the JTAG interface. This utility will then communicate via the JTAG adapter and burn the received flash image into the external memory chip.

## EEPROM

The Xicor X1286 Realtime Clock/Calendar chip has a integrated 32 kByte EEPROM, typically used for configuration data storage. This chip is accessed via a TWI (I2C) interface. However, as the CPU doesn't contain any TWI hardware, software bit-banging must be used.

## Configuration Jumpers

In opposite to its predecessors, almost all configuration settings are done in the CPLD (IC3). Only a single jumper area is left to configure the JTAG chain. For historical reasons this jumper is named JP5. Jumpers JP1 to JP4 do not exist.

## Upgrading from Previous Ethernet Revisions

Ethernut has undergone many changes since its initial release in the year 2000, but board dimensions and positions of main connectors remained unchanged.

Also, the software still supports all previous Ethernet Boards, even revision 1.1 with the ATmega103 microcontroller, which is no longer in production. However, there are a few things to consider.

The most important change to notice is the different CPU used on Ethernet 3. Thus you can't use programming adapters shipped with previous starter kits, because Ethernet 3.0 needs a specific JTAG adapter for an ARM CPU. SPI programming is not supported. Never plug your SPI adapter into Ethernet 3.0 programming socket.

Also note, that the ARM7TDMI used on Ethernet 3 has a different I/O port layout compared to the AVR CPUs used on previous boards. Care has been taken to keep the expansion port as compatible as possible. However, all expansion port pins, which are directly connected to the CPU must not be used for 5V logic. Only 3.3V logic is allowed at these pins, because the CPU is not 5V tolerant.

5V logic signals may be connected to expansion port pins, which are connected to the CPLD only. The CPLD is 5V tolerant.

- Changes from Ethernet 3.0 Rev-D to Rev-E:
- Fully RoHS conformant.
- RJ45 magnetics Taimag RJLD-043TC replaces Falco LJ1003.
- Double layer capacitor increased from 0.33F to 0.47F.
- CPU clock fed from PLL CLKB output for glitch free clock switching.
- Open drain drivers for IOWAIT outputs of the CPLD and the DM9000E.
- X1286 with 32k EEPROM replaces the X1226 with 512 Bytes EEPROM only.
- Yellow LED for link and green LED for activity conforms to Ethernet 1 and 2.
- Pull-down forces Ethernet Controller into 16-bit mode after power-up.

## Quick Start

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

### Prerequisites for Operation

The following items are necessary to run the Ethernet board:

- A standard PC equipped with Linux or Windows, an available serial COM port and a twisted pair Ethernet adapter card.
- Terminal emulation software, such as TeraTerm or Hyperterminal.
- TFTP server, such as TFTP32.
- An unregulated power supply matching your local mains. It should supply DC 5-24V, 200 mA minimum, on a standard 2.1 mm barrel connector.
- Two straight-through twisted pair cables together with 100 or 10 Base-T hub or switch or a twisted pair cross cable, if you don't got a hub or switch.

The following items are included in the Ethernet Starter Kit:

- A JTAG compatible programming adapter.
- A crossed serial communication cable with DB-9 female connector at both ends.

It is further assumed, that you got some basic knowledge about digital hardware and TCP/IP networking. This manual will not present any of these basics, but you can find excellent books or web resources about these topics.

### Precautions

Born out of an Open Source Project, the Ethernet board is a commercial product, from which you expect some kind of fail safe operation. But also keep in mind, that a bare electronic circuit is a fragile product, which demands careful handling. In the first place learn how to avoid problems caused by electrostatic discharge.

## Board Installation

**1** Remove the board from the antistatic bag. Visually inspect the board to verify that it was not damaged during shipment. Do not use the antistatic bag as a underlying pad for Ethernet, because it's electroconductive. Put the board on a wooden surface or simply on a piece of paper. Plastic surfaces may be harmful because of electrostatic discharge.



**WARNING:** As with all computer equipment, the Ethernet board may be severely damaged by electrostatic discharge (ESD). Be sure to take proper precautions before removing the Ethernet board from the antistatic bag. Never pass the board from one person's hand to another.

**2** Connect Ethernet's DB-9 RS232 port to an available COM port using the serial cable.

**3** Use one twisted pair cable to connect Ethernet's RJ-45 connector to the hub or switch and the other twisted pair cable to connect the hub or switch with the network adapter in the PC. If you are not using a hub or switch, then directly connect the Ethernet board with the PC's network adapter using a twisted pair cross cable.

**4** Connect the power supply to the barrel connector on the Ethernet board. The Ethernet board is equipped with its own rectifier bridge and voltage regulator. Therefore the polarity of the barrel connector isn't important.



**WARNING:** The power supply should not be plugged into an electrical outlet before connecting it to the Ethernet board.

**5** Apply power to the Ethernet board by connecting the power supply to an electrical outlet. When the board is powered up, the red power LED should go on.

**6** Start the terminal emulation program at 115200 baud, no parity, 8 data bits, and 1 stop bit. Disable hardware (RTS/CTS) and software (XON/XOFF) flow control.

### Baudrate

The baudrate of the Ethernet board is specified by the CPU clock (IC5, 73.720 MHz by default) and a baudrate divisor ranging from 0 to 65535.

The actual baudrate can be calculated by

$$\text{baudrate} = \text{CPU clock} / (16 * \text{divisor})$$

**7** Reset the Ethernut board by depressing and releasing the reset switch located near the MMC socket. Hold down the spacebar on the terminal emulation program and wait until the BootMon welcome message is displayed.

See the next chapter for a detailed description of the BootMon program.

## Using the Bootloader

Using the preloaded BootMon firmware to load Ethernet applications.

When using a terminal emulation program like described in the previous chapter, hold down the space bar on the PC keyboard and press and release the reset button on the Ethernet board. This is the tiny push button with the red LED at the board's edge near the MMC socket. After some seconds the following output should appear in the terminal emulation window:

```
BootMon 1.0.1
MAC address (000698300000):
```

Your preloaded version may be higher and the MAC address will differ.

The bootloader is resident, which means, that it is started each time you apply power to the board or press the reset button. However, it will normally work silently in the background, using any previously entered configuration. To change this configuration, a space character must be send to the serial port immediately after starting. Let's enter a new configuration now.

The MAC address should have been correctly set. Press enter to confirm this parameter.

A MAC address, also referred to as the hardware or Ethernet address is a unique 48 bit number assigned to every Ethernet node. The upper 24 bits are the manufacturer's ID, assigned by the IEEE Standards Office. The ID of Ethernet boards manufactured by egnite Software GmbH is 000698 hexadecimal. The lower 24 bits are the board's unique ID assigned by the manufacturer of the board. Boards produced by egnite do have a unique ID, which is written on the board.

BootMon will ask for the IP Address of the board.

```
IP address (0.0.0.0):
```

If your network provides a DHCP service, you can leave the IP address at all zeros. However, for a first test it is recommended to specify an individual address, which fits to your local network. For example, let's assume, that your PC got IP address 192.168.0.3, than 192.168.0.4 should work, provided that no other device in your network is using this address.

Enter the individual IP address and press enter. BootMon will prompt for the network mask.

```
Net mask (255.255.255.0):
```

You must use the same network mask as it is used with your PC. In general, all nodes within a local IP network must have the same network mask.

After entering a network mask, BootMon asks for a default route.

```
Default route (0.0.0.0):
```

This should be the IP address of your router, used to connect to the Internet. This information is only required, if the Ethernet board will be accessed from or will

access another node via the Internet. For now we can leave this entry at 0.0.0.0, which means, that no Internet gateway should be used.

Finally BootMon will ask for the TFTP Server IP and for the name of the image to load from this server.

```
TFTP IP (192.168.192.2):
TFTP Image (threads.bin):
```

The IP address should be the one of your PC. The name of the image is actually the Ethernet Application we will load into the board.

After pressing enter to confirm the TFTP image name, all parameters will be stored in non-volatile EEPROM memory and BootMon will immediately try to load the specified file from the specified TFTP server.

## TFTP Server

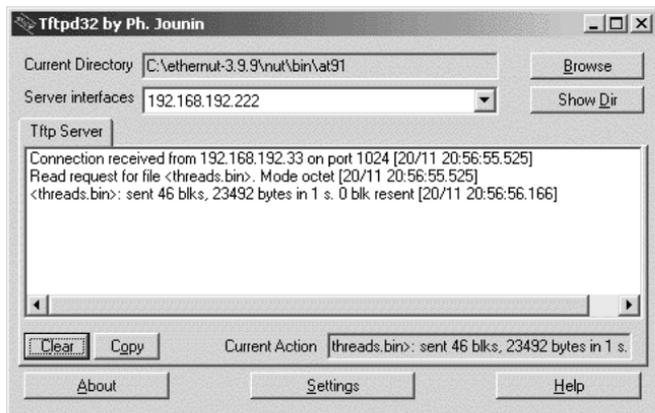
There are a number of TFTP servers available, many of them are free of charge.

For Windows, TFTP32 is a good choice. With Linux, a TFTP daemon is typically installed already, it just needs to be activated.

The following screenshot shows a sample configuration of TFTP32. The Base Directory point to the directory that contains the precompiled Nut/OS application binaries.



After pressing the reset button, BootMon will request the binary image from the TFTP server running on your PC. On TFTP32 the following should appear.



The sample contained in threads.bin demonstrates NUT/OS multithreading capabilities and outputs a series of Hs, Ms and Ls. You may want to check the source code of this sample now or try some of the other samples.



The following table lists all pins of JP5.

Pin	Signal	Connected to	Pin	Signal	Connected to
1	P16	CPU pin 70	2	XTMS	CPLD pin 65
3	TMS	J7 pin 5	4	TMS	J7 pin 5
5	ATMS	CPU pin 88	6	ATCK	CPU pin 91
7	TCK	J7 pin 1	8	TCK	J7 pin 1
9	XTCK	CPLD pin 67	10	P18	CPU pin 72
11	NC	Not connected	12	TDI	J7 pin 9
13	P23	CPU pin 83	14	XTDI	CPLD pin 63
15	TDO	J7 pin 3	16	ATDO	CPU pin 90
17	XTDO	CPLD pin 22	18	P19	CPU pin 73
19	ATDI	CPU pin 89	20	TDI	J7 pin 9

Here are some common JTAG configurations:



**CPU JTAG** Jumper JP5 routes the JTAG signals to the AT91R40008, if pins 3 and 5, 8 and 8, 15 and 16 as well as pins 19 and 20 are shortened. This is the default configuration and is used to upload software to the CPU or burn the FLASH Memory.



**CPLD JTAG** Routing the JTAG interface to the CPLD is provided by shortening pins 2 and 4, 7 and 9, 12 and 14 as well as pins 15 and 17. Note, that you need a special Xilinx adapter for programming the CPLD via JTAG.



**Internal JTAG** As an alternative, the Ethernet is able to program its own CPLD. The required jumper configuration is shown on the left. This configuration may be combined with the first one (CPU JTAG), in which case you can download the CPLD programming software to the CPU via JTAG. As soon as this software starts running, it will program the CPLD.

## Hardware Expansion

Ethernut and custom hardware.

Many applications will do just fine with nothing else than the Ethernut or external hardware may be connected to the RS-232 port. However, if more is required, the Ethernut expansion port is the first choice to add custom designed hardware.

### Expansion Port

Add-on boards can be added to the expansion port. This connector contains partial CPU data and address bus, memory read/write signals, digital I/O ports, reset signal and power supply. Nearly all microcontroller pins are available at the expansion port connector, providing an interface with several features like 2-wire interface (I2C) or counter inputs and outputs. It is strictly recommended to consult the AT19R40008 data sheet before attaching hardware to the expansion port.

Many signals are routed through the CPLD and may be redefined by re-programming this chip.

Although available at the connector, some signals are used internally by Ethernut and can't be used by external hardware. Carefully check the schematic.

The following table lists the expansion port's pin assignment.

Pin	Signal	Description	Pin	Signal	Description
1	VCC3	Regulated +3.3V	2	VCC3	Regulated +3.3V
3	NC	Not connected	4	NC	Not connected
5	GND	Signal ground	6	GND	Signal ground
7	GND	Signal ground	8	GND	Signal ground
9	MR\	Reset input	10	DC	Unregulated supply
11	NC	Not connected	12	NC	Not connected
13	RD\	Memory read signal	14	WR\	Memory write signal
15	D0	Data bus bit 0	16	D1	Data bus bit 1
17	D2	Data bus bit 2	18	D3	Data bus bit 3
19	D4	Data bus bit 4	20	D5	Data bus bit 5
21	D6	Data bus bit 6	22	D7	Data bus bit 7
23	A0	Address bus bit 0	24	A1	Address bus bit 1
25	A2	Address bus bit 2	26	A3	Address bus bit 3
27	A4	Address bus bit 4	28	A5	Address bus bit 5
29	A6	Address bus bit 6	30	A7	Address bus bit 7
31	A8	Address bus bit 8	32	A9	Address bus bit 9
33	A10	Address bus bit 10	34	A11	Address bus bit 11
35	A12	Address bus bit 12	36	A13	Address bus bit 13
37	A14	Address bus bit 14	38	A15	Address bus bit 15
39	P15	UART 0 Receive	40	P14	UART 0 Transceive
41	P13	UART 0 Clock	42	P8	Timer 2 I/O B
43	P9	External IRQ0	44	P27	Chip select 3
45	P11	External IRQ2	46	P12	Fast IRQ
47	P0	Timer 0 Clock	48	P1	Timer 0 I/O A
49	P2	Timer 0 I/O B	50	P3	Timer 1 Clock
51	P4	Timer 1 I/O A	52	P5	Timer 1 I/O B
53	P6	Timer 2 Clock	54	P7	Timer 2 I/O A
55	P17	GPIO	56	P16	GPIO
57	P22	UART 1 Receive	58	P21	UART 1 Transmit
59	P23	GPIO	60	P20	UART 1 Clock
61	P19	GPIO	62	P18	GPIO
63	NC	Not connected	64	NC	Not connected

**Important Note:** Pins 39 - 62 are not 5V tolerant and must not be connected to 5V logic without proper level translation. Pins 13 - 38 are 5V tolerant. For detailed specifications refer to the AT91R40008 and XC95144XL datasheets.

## Troubleshooting

Problem	Solution
<p>BootMon produces garbage output and the yellow LED at the RJ45 goes on after a few seconds.</p>	<p>BootMon was unable to detect a space characters at the required baudrate. The terminal emulator may use a wrong baudrate not send any characters because of handshake settings or other RS-232 communication issues.</p>
<p>The red LED does not go on when applying power.</p>	<p>The fuse may be blown. Remove any kind of attached hardware and remove all jumpers. Make sure the board is placed on a non conductive surface like a piece of paper. Replace the fuse (1A superfast) and supply the board via the barrel connector J2 only with not more than 24V DC. Best use a lab power supply with current control and carefully increase the voltage starting from 3V. The board should not draw more than 150 milliamps.</p>
<p>The yellow LED at the RJ45 connector does not go on after pressing the reset button.</p>	<p>The yellow LED will go on only if Ethernut is connected to an Ethernet network and the Ethernut software properly initialized the LAN controller hardware on the Ethernut. Load the board with BootMon image via JTAG. Replace the Ethernet cable and try the same connection with your PC to make sure that the network link is working.</p>

Problems	Solution
<p>Ethernut doesn't respond to pings. The yellow LED does not go on.</p>	<p>Configuring TCP/IP looks generally simple after one has understood the principle, but may still become confusing under some circumstances. For example, changing Ethernut's MAC address can disable a link, which had been running fine before the change. This happens, because the PC remembers the MAC/IP relations for some minutes.</p> <p>Check your configuration again. Make sure, that Ethernut and the PC are located in the same network, sharing the same IP mask and network IP address. If you don't know what all this means, check the WWW for some excellent TCP/IP tutorials.</p>
<p>My application is working fine when uploaded by TFTP. How to burn it into non-volatile Flash?</p>	<p>The Starterkit came with a programming adapter called Turtelizer. It works with the JTAG-O-MAT utility, which is available on the Starterkit CD and at <a href="http://www.ethernut.de">www.ethernut.de</a>.</p>
<p>After reprogramming the CPLD, my board stopped working.</p>	<p>You can change the contents, but not without risk. Anyway, Ethernut 3 had been designed with user programmable CPLD in mind. Just make sure, that you never create output pins, which may conflict with output or bidirectional pins of the CPU.</p> <p>To re-awake the board, combine the JTAG jumper settings "CPU JTAG" and "Internal JTAG" and upload the XSVF Executor into the RAM by using the Turtelizer. More details are available at <a href="http://www.ethernut.de">www.ethernut.de</a>.</p>

## Sick Ethernuts

### Is there still life in it?

Our warranty scheme is simple. All boards have been extensively tested before shipment and we feel responsible, that it continues to work reliable after passing it to you.

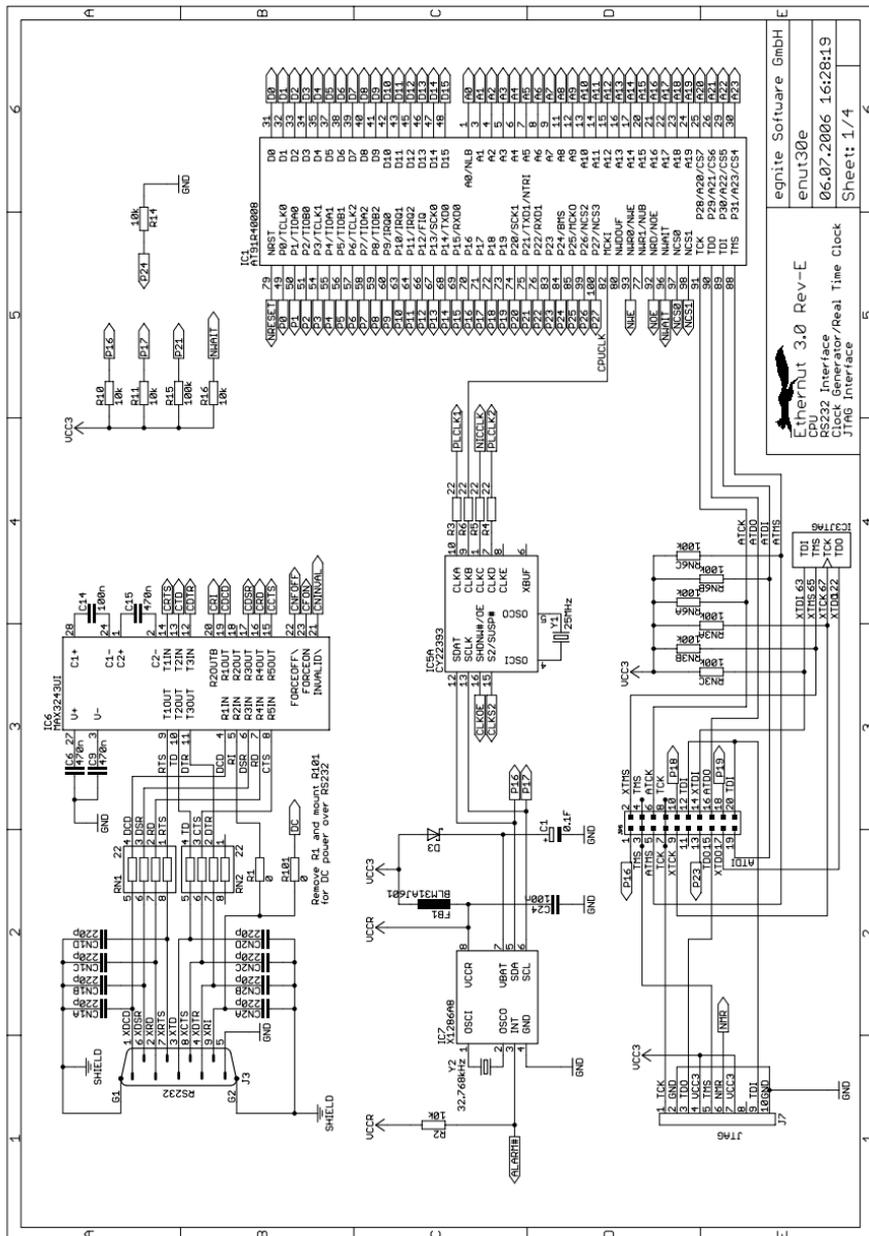
If the trouble shooting guide doesn't help or if it results in the conclusion, that your Ethernut is broken, you should send an email to [info@egnite.de](mailto:info@egnite.de), including the following information:

- Ethernut Revision, printed on the back side of the board.
- MAC address of your Ethernut, written on top of the board and on the invoice.
- BootMon output, if applicable. Or software revision you're using, noted on the first page of the API documentation.
- Description of your problem. You may keep it simple, we may request details later.

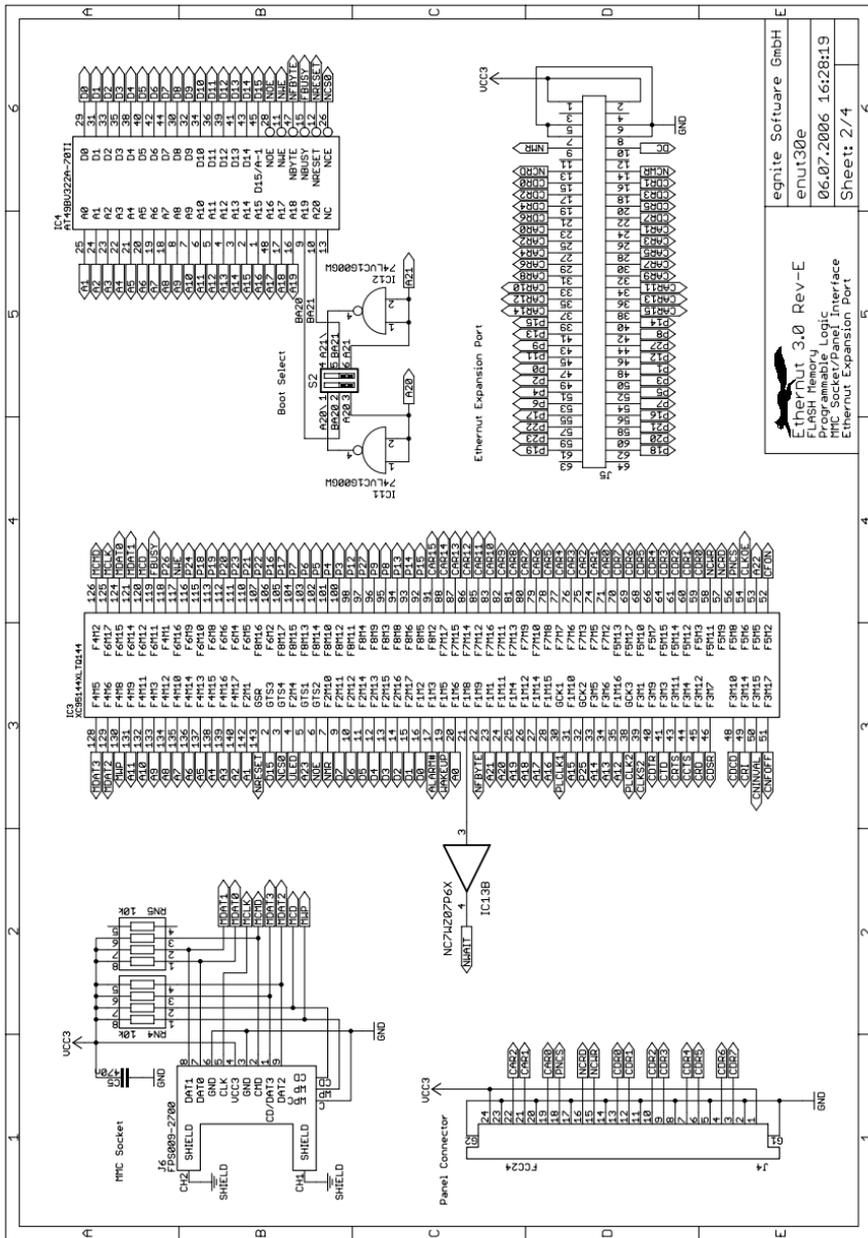
Please understand, that we are not able to provide any warranty, if you destroyed the board because of ignoring our ESD precautions advises or attaching badly designed hardware. In such cases we may ask at least for a refund of our shipping costs.

Anyway, whatever happened, we will do anything possible to revitalize your Ethernut. Or, if it finally passed away, let it rest in peace and send a replacement back to you at the least possible costs.

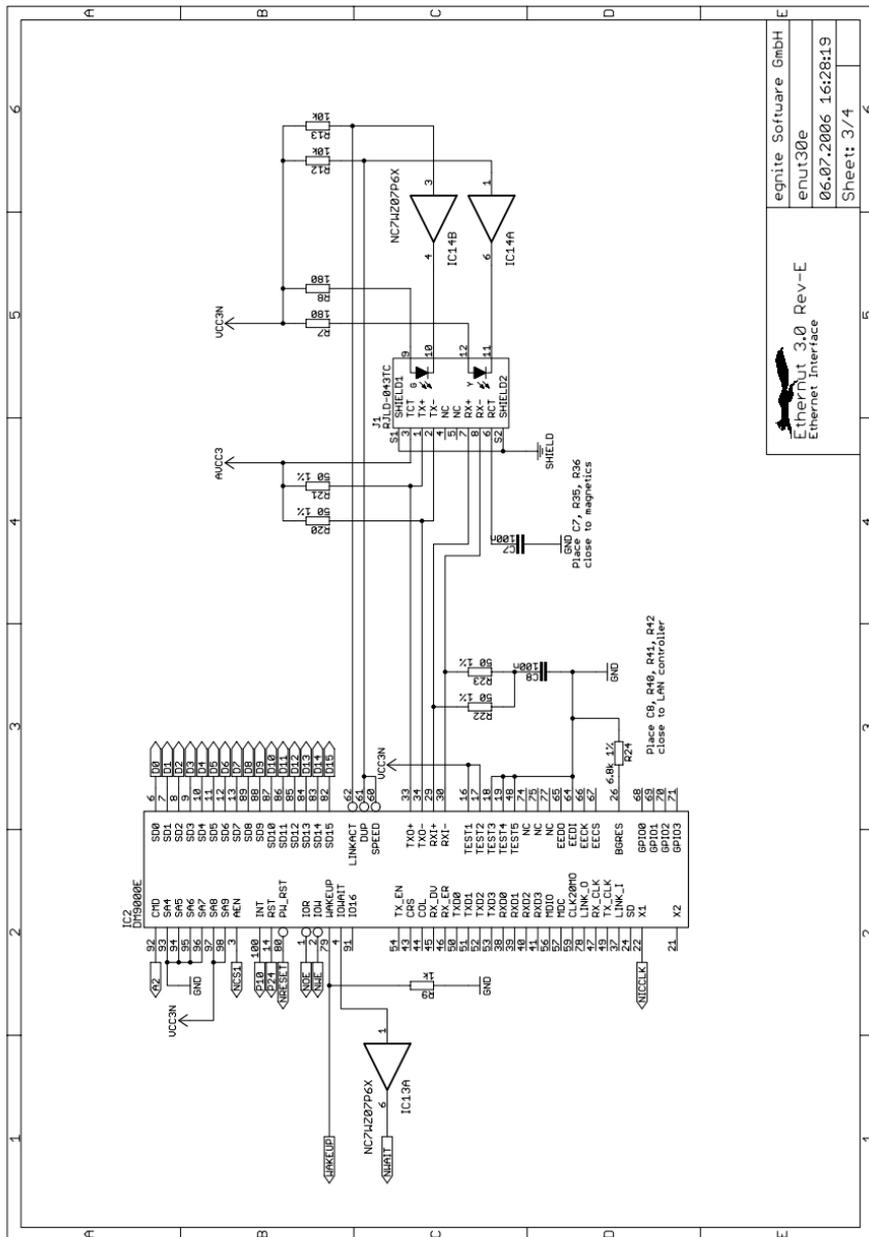





  
 egnite Software GmbH
   
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 Ethernet 3.0 Rev-E
   
 CPU S252 Interface
   
 CPU30E/Real Time Clock
   
 JTAG Interface
   
 Sheet: 1/4

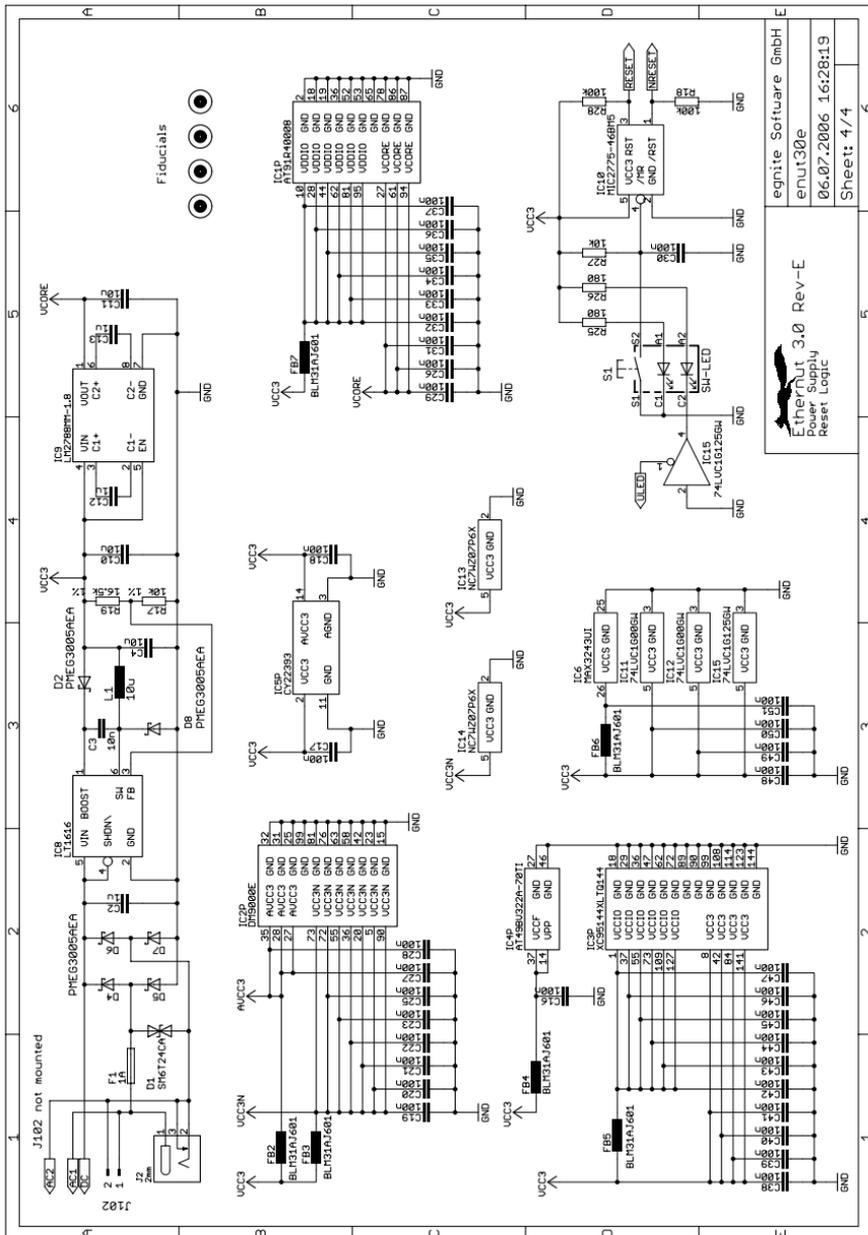


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 Ethernet 3.0 Rev-E  
 Programmable Logic  
 MHC Socket/Panel Interface  
 Ethernet Expansion Part  
 Sheet: 2/4



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**Ethernet 3.0 Rev-E**  
 Ethernet Interface



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 Sheet: 4/4



egnite Software GmbH  
Erinstr. 9  
44575 Castrop-Rauxel  
Germany

Phone +49 (0)23 05-44 12 56  
Fax +49 (0)23 05-44 14 87

Email [info@egnite.de](mailto:info@egnite.de)

<http://www.egnite.de>  
<http://www.ethernut.de>