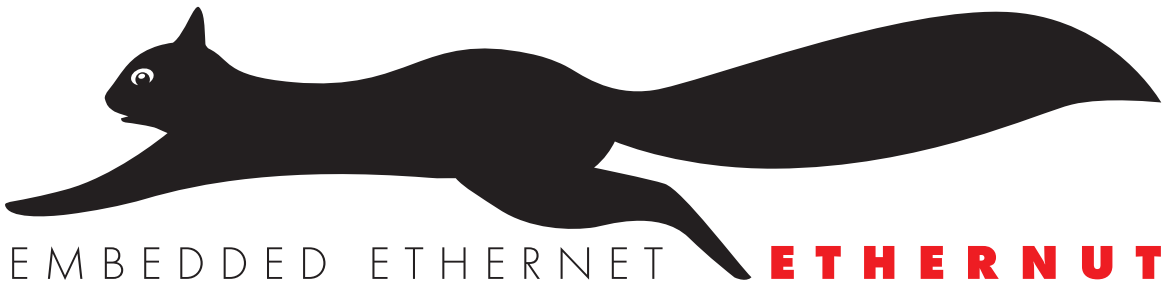
Volume 1
Hardware Manual



Version 1.3

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1 About the Ethernut Board

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

Ethernut is a small (80 x 100 mm) board combining Atmel's ATmega 103 RISC microcontroller with Realtek's 8019AS Ethernet controller. 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

The Ethernut board provides the following features:

- ATmega 103 RISC microcontroller with up to 6 MIPS throughput
- Full duplex IEEE 802.3 compliant Ethernet controller with on-board RJ- 45 connector
- RS-232 serial port with on-board DB-9 connector
- 128 Kbyte in-system programmable flash ROM
- 4 Kbyte in-system programmable EEPROM
- 32 Kbyte SRAM
- 22 programmable digital I/O lines
- 8-channel, 10-bit analog/digital converter
- Two 8-bit and one 16-bit timer/counter
- Watchdog timer and reset controller for enhanced reliability
- LED indicators for power supply, programming mode and Ethernet activity
- Single power supply DC 9-15V or AC 7-12V

2 Quick Start

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

Prerequisites for Operation

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

- A standard PC equipped with Linux or Windows 95/98/NT/2000, an available serial COM port and a twisted pair Ethernet adapter card.
- Terminal emulation software, such as Hyperterminal.
- An unregulated power supply matching your local mains. It should supply AC 7-12V or DC 9-15V, 100 mA minimum, on a standard 2.1 mm barrel connector.
- 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.

The following items are included in the Ethernut Development Kit:

- An STK-300 compatible programming adapter.
- A straight through serial communication cable with a DB-9 female on one end and a DB-9 male connector on the other. The available serial COM port on the PC might require a DB-25 connector, in which case a DB-9 to DB-25 serial connector adapter is additionally needed.

Board Installation

WARNING: As with all computer equipment, the Ethernut 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.

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

2 Connect Ethernut`s DB-9 RS232 port to an available COM port using the serial cable. Make sure, that jumper JP1 has been properly set. Jumper JP2 is not used.

Jumper Settings

There are two jumpers on the Ethernut board near the DB-9 connector. If you place the board in front of you with the LEDs on the lower left and the jumpers on the upper right corner, JP1 is the left one and JP2 the one nearer to the DB-9 connector on the right.

JP1 is used to switch the serial port from DCE to DTE. Using a straight through serial cable between the Ethernut board and a PC requires DCE setting, in which case the two upper pins of JP1 should be shortened by one jumper and the two lower pins by another (holding the board as specified above).
JP2 needs not to be equipped with any jumper.

3 Use one twisted pair cable to connect Ethernut'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 Ethernut board with the network adapter using a twisted pair cross cable.

~

WARNING: The power supply must not be plugged into an electrical outlet before connecting it to the Ethernut board.

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

5 Apply power to the Ethernut board by connecting the power supply to an electrical outlet. When the board is powered up, the red power LED (LED1) and the yellow Ethernet link LED (LED3) should go on.

Power Supply

The Ethernut board is equipped with its on rectifier bridge and voltage regulator. Therefore the power supply may be of either DC or AC type, regulated or unregulated. The polarity of the barrel connector isn't important either.

6 Start the terminal emulation program at 2400 baud or any higher rate up to 115200 baud, no parity, 8 data bits, and 1 stop bit. Disable hardware (RTS/CTS) and software (XON/XOFF) flow control.

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

Baudrate

The baudrate of the Ethernut board is specified by the CPU crystal (Q1, 3.6864 MHz by default) and a baudrate selector ranging from 0 to 255. The actual baudrate can be calculated by

baudrate = crystal frequency / (16 * (selector + 1))

Running at 3.6864 MHz, a selector value of 1 gives a baudrate of 115200 Baud:

115200 = 3686400 / (16 * (1 + 1))

The BaseMon program provides a simple automatic baudrate selection by changing the selector from zero to 71, while trying to receive a space character.

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

3 Testing the Board

Using the preloaded BaseMon firmware to test the Ethernut hardware.

When using a terminal emulation program like described in the previous chapter, hold down the spacebar on the PC keyboard after pressing the reset button on the Ethernut board. After some seconds the following output should appear in the terminal emulation window:

```
Ethernut BaseMon Version 1.0.0
Baudrate select = 0x01
External SRAM Test...0x1000-0x7FFF OK
NIC hardware reset...OK
NIC id detection...OK
Press any of the following keys:
E - Ethernet controller read/write loop
R - Ethernet controller hardware reset loop
S - SRAM read/write loop
X - Exit BaseMon
```

The baudrate selector may differ, depending on the CPU crystal (Q1) on the Ethernut board and the baudrate used with the terminal emulation program.
If any of the above tests fails, you may try one of the keys shown in the BaseMon menu to enter a specific test loop.
If after a few minutes the Ethernut board doesn't receive a space character, it will skip the BaseMon program and initialize the Nut/OS operating system as well as the Nut/Net TCP/IP stack and finally enter a sample HTTP daemon application.

Ethernet Controller Read/Write Loop

When pressing E on the BaseMon menu, the Ethernut board will enter an endless loop, trying to locate an Ethernet controller in the address range from 8000 hex to FFE0 hex. After performing a software reset on the controller, its internal ID is checked. If a valid ID of 5070 hex can be found, the following line is displayed:

```
NIC 8300 reset...OK id=0x5070 OK
```

The loop keeps running until a key is pressed in the terminal emulation program and may be used to check the board's address and data bus signals with an oscilloscope or logic analyzer.

Ethernet Controller Hardware Reset Loop

When pressing R on the BaseMon menu, the Ethernut board toggles bit 4 on port E in an endless loop. This port bit is tied via an inverter gate to the

Ethernet controller's hardware reset line. The interval is about one second on a 3.6864 MHz CPU clock. The green LED (LED4) should flash in the same interval.

SRAM Read/Write Loop

When pressing S on the BaseMon menu, the Ethernut board enters an endless loop, doing a walking bit test of the external SRAM in the address range from 1000 hex to 82FF hex. On the Ethernut board this test will fail at address 8000 hex, displaying

```
0x8000  0x01  0xF6
```

The loop keeps running until a key is pressed in the terminal emulation program and may be used to check the board's address and data bus signals with an oscilloscope or logic analyzer.

Exit BaseMon

Pressing X on the BaseMon menu will quit the BaseMon program, initialize the Nut/OS operating system and Nut/Net TCP/IP stack and finally enter a sample HTTP daemon application. However, before that is done, BaseMon queries its IP address and network mask:

```
IP address (192.168.192.100):
Net mask     (255.255.255.0):
```

You may simply press enter, to confirm the defaults shown in brackets, or enter other values in their decimal dotted form.

Network configuration is discussed in more detail in the next chapter.

4 Network Configuration

This chapter shows different methods to configure Ethernut`s network parameters.

In order to communicate over a TCP/IP network, the Ethernut board needs a unique IP address. It is important, that this address is not used by any other node on the network.

DHCP/BOOTP Method

The Ethernut board ships with a blank EEPROM. If a DHCP server exists on the network, the Ethernut board will automatically request its IP address, the IP address of the standard gateway, and the IP address mask of the local network. If no DHCP server could be located, the Ethernut board switches to the ARP method.

ARP Method

If the Ethernut's EEPROM contains no configuration data and no DHCP server is available on the network, then the ARP method can be used to set the board's IP address. In this mode the Ethernut board set its address from the first ICMP packet it receives.

To set the Ethernut's IP address by the ARP method, an ARP entry can be manually created on the PC and then a ping packet is sent from the PC to the Ethernut board.

Enter the following command to manually create an ARP entry for an Ethernut board with a MAC address of 00:06:98:00:00:00 and an IP address of 192.168.171.5 on a LINUX command line shell:

```
arp -s 192.168.171.5 00:06:98:00:00:00
```

On a Windows DOS prompt this command is slightly different:

```
arp -s 192.168.171.5 00-06-98-00-00-00
```

The next command to enter is the same on both systems:

```
ping 192.168.171.5
```

The first ping packet that arrives at the Ethernut board with the MAC address of 00:06:98:00:00:00 sets the IP address of that board to 192.168.171.5. Note, that the ARP method will not configure a default gateway and will fix the network mask to 255.255.255.0.

MAC address

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 Ethernut 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.

Reset to Factory Default

The ARP method will be used on blank EEPROMs only. After having set it once, the configuration will be stored in the EEPROM and used in the next system start. To enable the ARP method again, you must use your ISP Software to clear the EEPROM contents. Refer to the Ethernut Software Manual for further information about ISP Software.

Manual Configuration

The preloaded BaseMon firmware may be used to manually configure the boards IP address and network mask.

Testing Network Operation

You can now check, that the Ethernut board is properly hooked up to the network by running ping from your PC. On a DOS prompt or command line shell, type:

```
ping 192.168.171.5
```

Instead of the above IP address use the one you configured previously. If you receive a response without timing out, the Ethernut board is ready to try the HTTP daemon.

Use any Webbrowser to query the following URL:

```
http://192.168.171.5/index.html
```

Again, instead of the above IP address use the one previously configured.

5 Functional Description

This chapter explains the main functions of the Ethernut board.

Power Supply

The complete logic of the Ethernut board is driven by a single 5V power supply. Because the board provides its own on-board rectifier bridge (B1) and voltage regulator (IC8), it only requires an unregulated power supply of AC 7-12V or DC 9-15V with a minimum current of 100 mA.

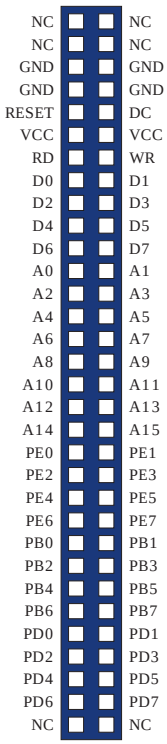
Three different methods may be used to connect an external power supply.
1 A standard 2.1 mm barrel connector.
2 An optional screw terminal, which is not mounted in the standard version.
3 Using pins 4, 5 and pins 7, 8 of the Ethernet connector. In this case pins 1 and 3 and pins 2 and 4 of jumper JP3 must be shortened.

The unregulated power supply as well as a regulated 5V supply is available at the expansion port connector. If additional components draw more than 150 mA from the regulated 5V power supply, a heat sink will be required on the on-board regulator.

Expansion Port

External devices can be added to the expansion port. These devices may be simple I/O circuits driven by the Ethernut board, or may be equipped with their own processor, using the Ethernut board as an Ethernet I/O processor only.

The expansion port contains CPU data and address bus, memory read/write signals, digital I/O ports, reset signal and power supply.

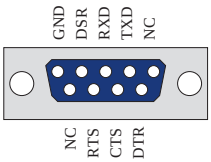


Pins	Signal	Function
1...4	NC	Not connected.
5...8	GND	Signal ground.
9	RESET	Low active reset signal. This open collector input must be held low for at least 50 ns to reset the system. Automatically pulled low for 150 ms, if supply voltage drops below 4.5 Volts.
10	DC	Unregulated supply voltage, depends on the board`s supply.
11...12	VCC	+5 Volts regulated supply, app. 400 mA.
13	RD	Low active read strobe.
14	WR	Low active write strobe.
15...22	D[0...7]	8-bit data bus.
23...38	A[0...15]	16-bit address bus.
39...46	PE[0...7]	8-bit bi-directional digital I/O Port E.
47...54	PB[0...7]	8-bit bi-directional digital I/O Port B.
55...62	PD[0...7]	8-bit bi-directional digital I/O Port D.
63...64	NC	Not connected.

Serial Port

Ethernut provides an on-board DB-9 connector for its RS-232 serial communication port. This port is connected to the ATmega 103 on-chip UART via a single-chip RS-232 driver/receiver interface circuit (IC6), which converts the required voltage levels from the 5V power supply.

Two jumpers are provided to switch the DB-9 connector between DCE and DTE mode and two solder jumpers must be shortened to enable hardware handshake.

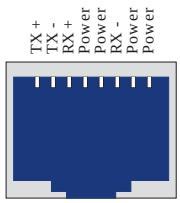


Pins	Signal	Function
2	TXD	Transmit data, if jumper JP1 pin 2 and 4 shortend.
3	RXD	Receive data, if jumper JP1 pin 1 and 3 shortend.
4	DSR	Data set ready, not connected.
5	GND	Signal ground.
6	DTR	Data terminal ready, not connected.
7	CTS	Clear to send. Used for hardware handshake, if jumper JP2 pin 2 and 4 and solder jumper JP6 shortened.
8	RTS	Ready to send. Used for hardware handshake, if jumper JP2 pin 1 and 3 and solder jumper JP7 shortened.

Ethernet Port

Ethernut provides an on-board modular RJ-45 connector for its twisted pair Ethernet port. This port is connected to the Realtek 8019AS Ethernet controller via a 10Base-T transformer/filter. The interface supports the maximum cable length of 100 meters between the Ethernet board and a hub.

Pins	Signal	Function
1 + 2	TX	Differential transmit output pair.
3 + 6	RX	Differential receive input pair.
4 + 5	Power	Power supply.
7 + 8	GND	Power supply.



In-System Programming Port

WARNING: Do not plug in or remove the programming adapter while power is supplied to the Ethernut board. You may damage the Ethernut board or the parallel port on the PC.

This port allows serial (re-)programming of the ATmega 103 non-volatile Flash ROM and EEPROM without physical removal of the microcontroller from the system.

A multiplexer (IC7) switches the microcontroller pins during programming, which are used by the serial port during normal operation. An on-board LED (LED2) indicates programming activity.

Pins	Signal	Function
1	MOSI	Slave serial data input.
2	VCC	Regulated +5 Volts programming cable supply.
3	PROG	Programming mode, must be held low during programming.
5	RST	Reset signal, must be held low during programming.
7	SCK	Slave input for serial clock.
9	MISO	Slave serial data output.
4, 6, 8, 10	GND	Signal ground.

LED Indicators

The Ethernut board is equipped with four LEDs.

One red LED (LED1) is directly connected to the power supply. It is lit when power is applied to the board.

A second red LED (LED2) is lit during in-system programming.

A yellow and a green LED (LED3 and LED4 resp.) are used to indicate activity on the Ethernet port. The yellow LED indicates the 10BASE-T link status and should be lit, if the link status is OK. The green LED indicates receive and transmit activity from and to the network.

System Reset

System reset is controlled by a push button and a voltage supply supervisor (IC9). This device protects the EEPROM from corruption by generating a reset signal, when power supply from the on-board regulator (IC8) falls below 4.75 volts.

Watchdog Timer

Software bugs, temporary hardware failures caused by electrical transients or interference and many other problems might cause the system to malfunction. The ATmega 103 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

~ WARNING: Note, that changing any crystal will alter the Ethernut board's EMC characteristics and require re-testing.

The ATmega 103 microcontroller clock is generated by a 3.6864 MHz crystal (Q1), which may be replaced by a crystal of up to 6 MHz. An additional 32.768 kHz crystal (Q2) drives an on-chip asynchronous timer, which is typically used for a software realtime clock. The Ethernet controller is driven by a seperate 20-MHz crystal (Q3).

Flash ROM

The ATmega 103 provides 128 kBytes of on-chip, non-volatile flash memory space, which is used for program code and read-only data storage. This memory is organized as 64K x 16 bits and can be (re-)programmed through in-system programming.

Static RAM

The Ethernut board provides 32 kByte SRAM (IC4), which is used as read/write data storage. However, the lower 4 kBytes are overlayed by the ATmega 103 internal register and SRAM space.

The required address latch is provided by a 74HC573 (IC3).

EEPROM

The ATmega 103 provides 4 kBytes of on-chip, non-volatile, electrically erasable memory, typically used for configuration data storage. This memory provides read/write access under program control as well as through in-system programming.

Note, that EEPROM write access is much slower (about 2.5 ms) than writing to SRAM.

6 Troubleshooting

This chapter will help you in case of problems.

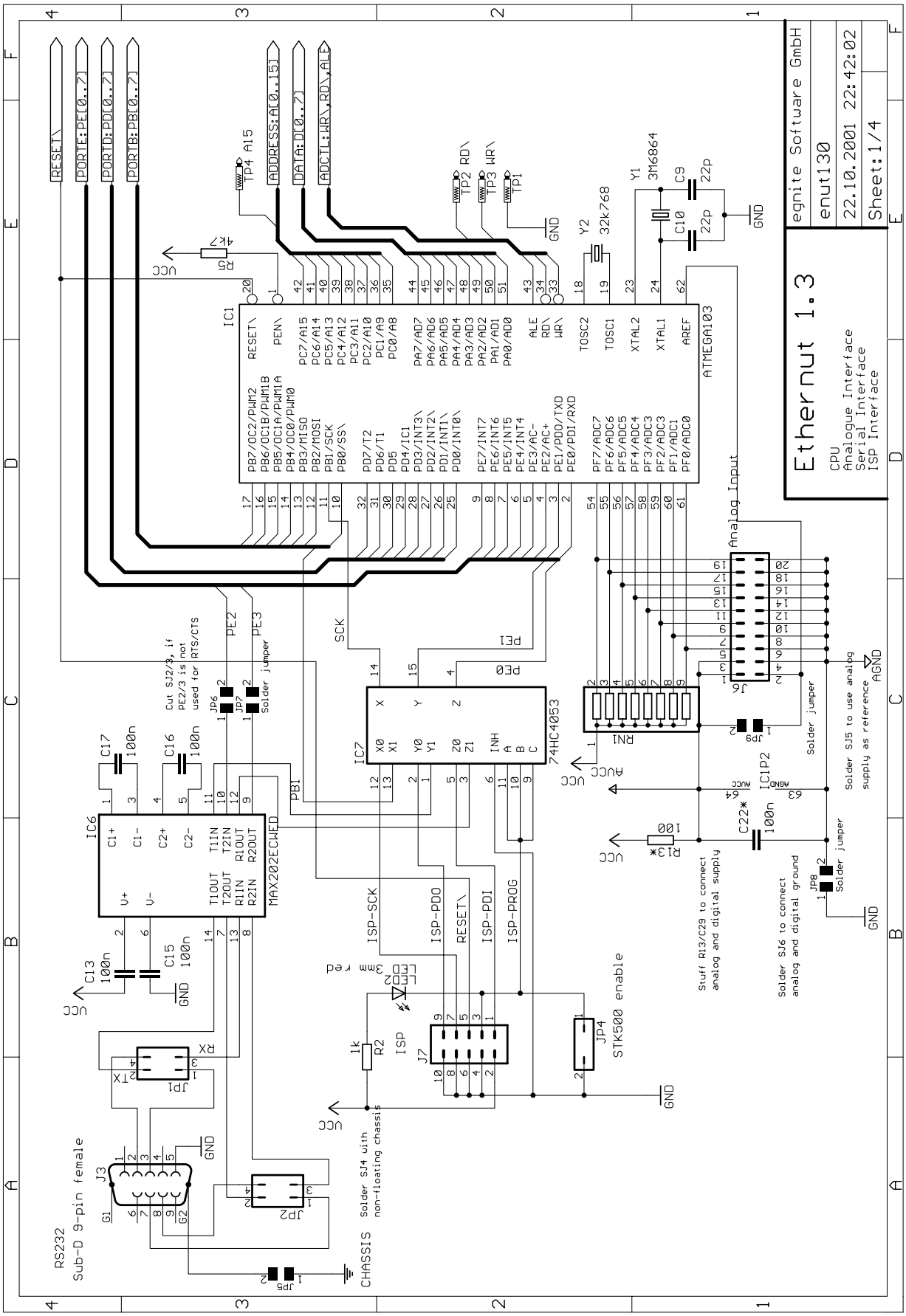
Problem	Solution
The red power LED is not on.	Connect the DC power cable. Check that the power supply is of DC type 9-15V or AC type 7-12V min. 100 mA.
Nothing happens when pushing the RESET button.	Sometimes it is difficult to make a good connection when pushing the small RESET button. Try removing the power supply from the AC electrical outlet and disconnecting and reconnecting the power supply.
The PC does not show BaseMon software prompt.	Check the COM port connection with the Ethernut board. Make sure that the same COM port is selected in the terminal emulation software. Verify the power, check the cables, etc. Try using a different baudrate and make sure, that the terminal emulation repeatingly transmits space characters while the spacebar is held down. If not sure, try another program. Make sure, that any flow control is switched off and jumper JP1 is properly set.
The terminal emulation software displays unreadable characters.	Check the word length, number of stop bits and parity setting of the terminal emulation software. It should be set to 8 data bits, no parity and 1 stop bit.
The AVR device cannot be programmed.	Check that the notch on the Ethernut socket matches the notch on the programming device. The memory lock bits may be cleared. Completely erase the memory before programming.
AVRISP does not detect the advanced ATmega device.	Disable the signature check in the option menu of the AVRISP.
There is a problem you cannot resolve.	Contact your dealer for assistance.

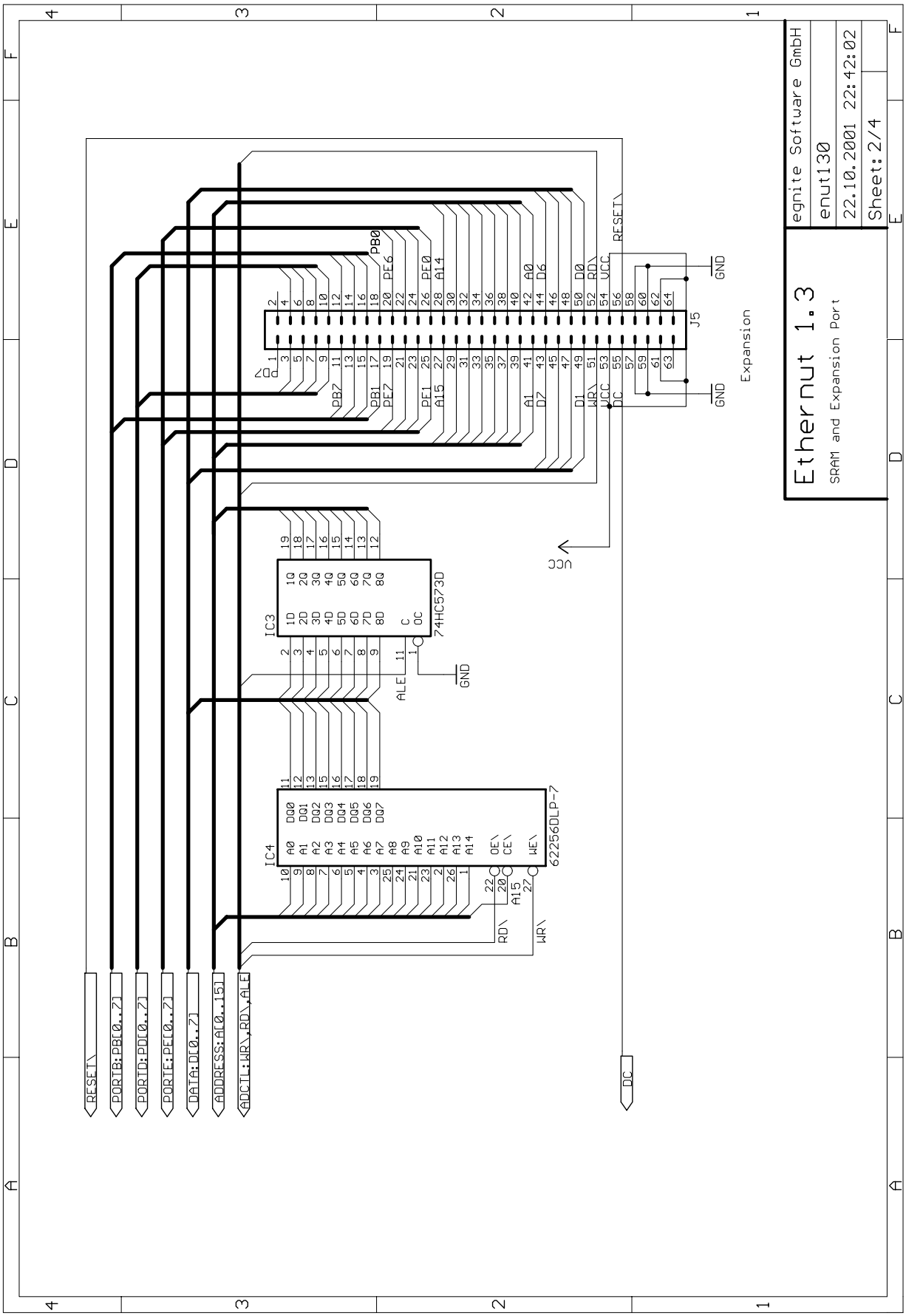
7 Part List

Number	Part
ACDC	2.1 mm barrel connector
ANALOG	2 x 10 pinhead connector
B1	DIL rectifier bridge
C1-C2, C11-C18, C21	100 nF capacitor 0805
C3-C4	33 pF capacitor 0805
C5-C6	10 nF capacitor 0805
C7-C8	10 nF ceramic capacitor 1kV
C9-C10	22 pF capacitor 0805
C19-C20	22 uF electrolyt capacitor 25V
ETHERNET	RJ-45 shielded
EXPANSION	2 x 28 pinhead connector
IC1	ATmega 103 microcontroller TQFP64
IC2	RTL8019AS Ethernet controller QFP100
IC3	74HC573 address latch SO20
IC4	62256 32k x 8, 70 ns SRAM SO28
IC5	74HC04 inverter SO14
IC6	MAX202ECSE RS232 driver SO16
IC7	74HC4053 multiplexer SO16
IC8	7805CV linear voltage regulator TO220H
IC9	DS1811-R-10 reset controller SOT23
ISP	2 x 5 pinhead connector
JP1-JP2	Jumper
LED1-LED2	3 mm low power LED red
LED3	3 mm low power LED yellow
LED4	3 mm low power LED green
Q1	3.6864 MHz crystal HC18U
Q2	32.768 kHz crystal TC26
Q3	20 MHz crystal HC18U
R1-R4	1 kOhm resistor 0805
R5, R7-R8, R12	4.7 kOhm resistor 0805
R6	200 Ohm resistor, 0.25W
R9-R10	270 Ohm resistor 0805
R11	27 kOhm resistor 0805
RESET	Omron B3F-10 key

RS232	DSub-9 female connector
TR1	20F001N Ethernet transformer/filter

8 Schematics




Ethernut 1.3
SRAM and Expansion Port
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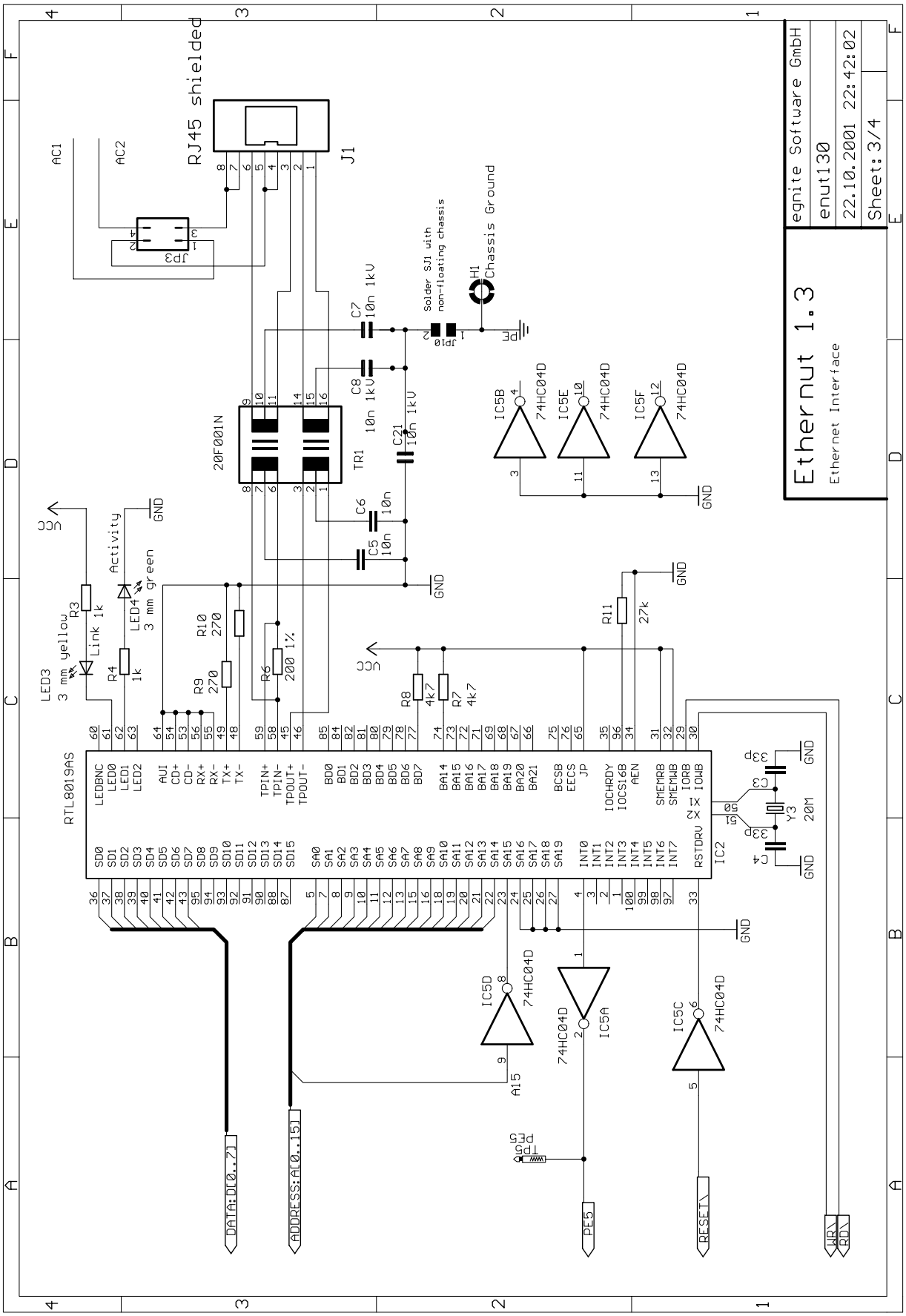
Expansion
J5
IC3
74HC573D
IC4
62256DLP-7
RESET\
PORTB:PB[0..7]
PORTD:PD[0..7]
PORTE:PE[0..7]
DATA:DL[0..7]
ADDRESS:AL[0..15]
ADCTL:WR\,RD\,ALE
ALE
RD\
WR\
GND
VCC
DC


Ethernut 1.3
Ethernet Interface
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enut130
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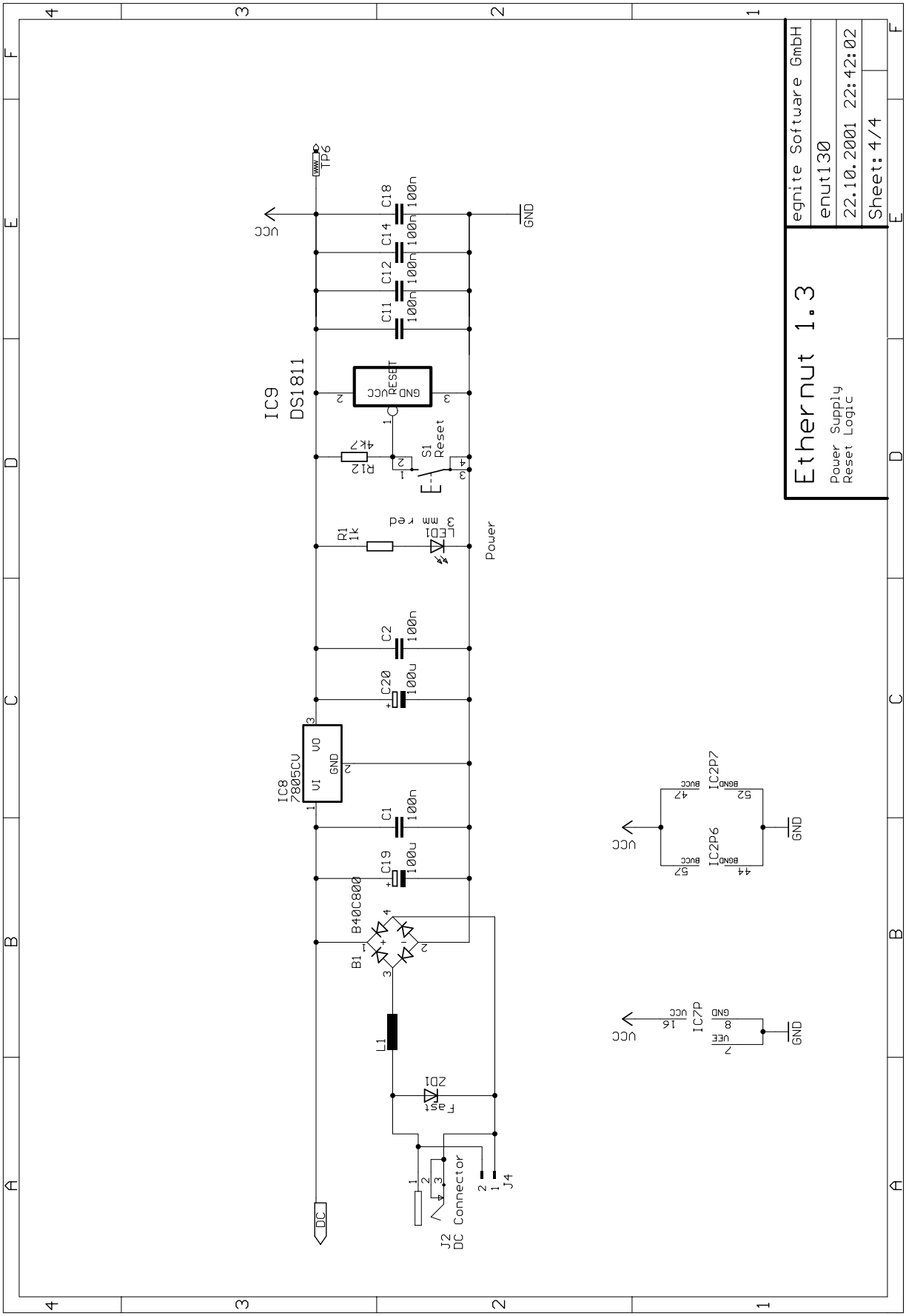
Sheet:3/4
RJ45 shielded
J1
AC1
AC2
JP3
H1
Chassis Ground
Solder SJ1 with non-floating chassis
JP10
C7 10n 1kV
C8 10n 1kV
C21 10n 1kV
TR1
20F001N
C6 10n
C5 10n
R3 Link 1k
LED3 3 mm yellow
R4 1k
LED4 3 mm green
Activity
R10 270
R9 270
R6 200 1%
R8 4k7
R7 4k7
R11 27k
IC5B 74HC04D
IC5E 74HC04D
IC5F 74HC04D
IC5D 74HC04D
IC5A 74HC04D
IC5C 74HC04D
RTL8019AS
IC2
Y3 20M
C3 33p
C4 33p
RSTDRV
PE5
A15
DATA:D[0..7]
ADDRESS:A[0..15]
RESET
WR
RD
GND
VCC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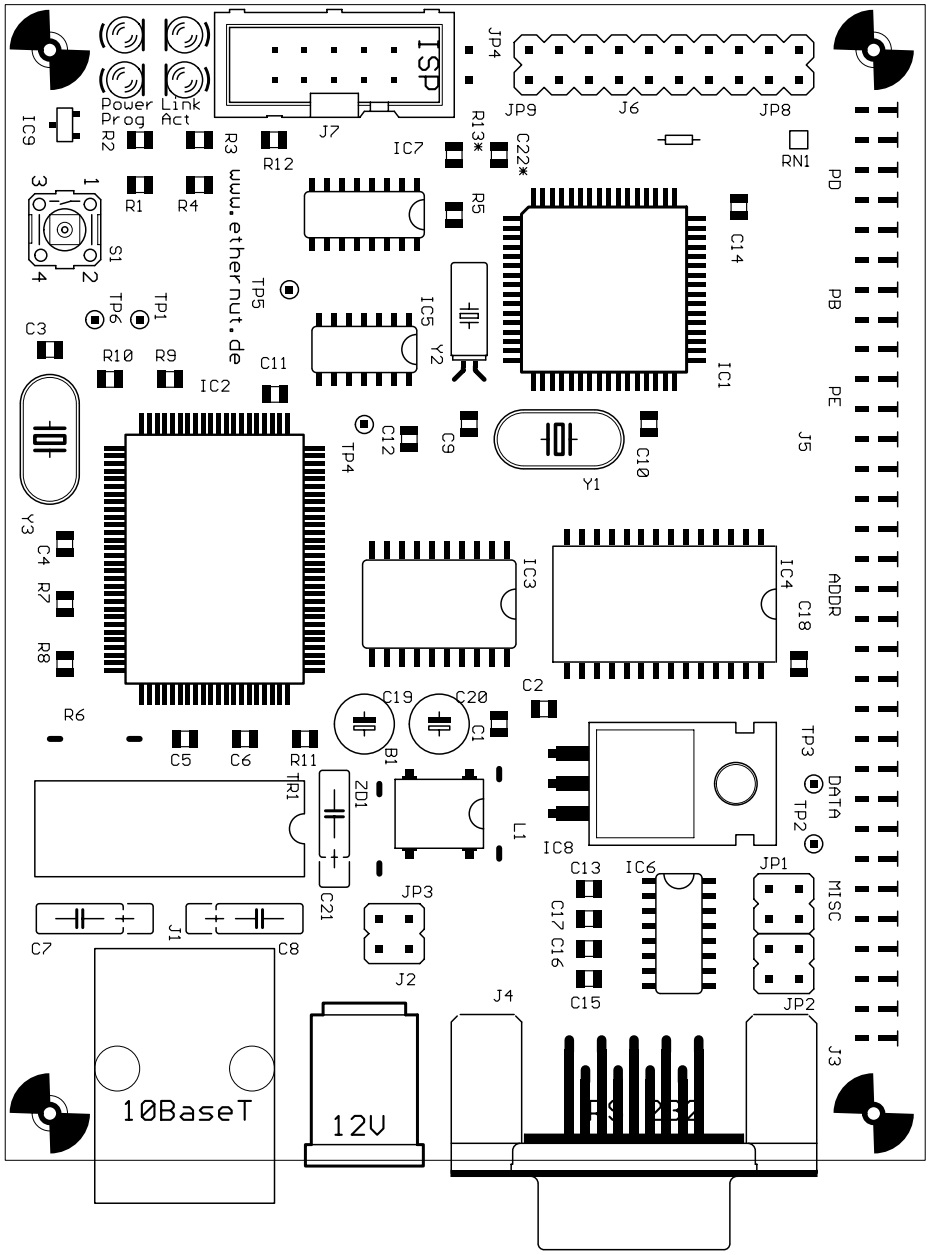
Ethernut 1.3
Power Supply
Reset Logic
TP6
VCC
GND
C18 100n
C14 100n
C12 100n
C11 100n
IC9
DS1811
GND RESET VCC
S1
Reset
R12 4K7
R1 1k
LED red
Power
C2 100n
C20 100u
IC8
7805CV
VI VO GND
C1 100n
C19 100u
B1
B40C800
L1
ZD1
Fast
DC
J2
DC Connector
J4
IC2P7
IC2P6
BGND BVCC
IC7P
VEE VCC GND

9 Bord Layout

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