XNUT-105
Hardware manual

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XNUT-105: Hardware manual

Document revision history

2005-06-08, 1.0	Initial Release for hardware release J367-S3-PB
2007-01-18, 1.1	Updated incorrect pin-out diagram for CAN connector J5
2008-08-18, 1.2	Updated incorrect pin-out for RS-232 connector J7 & J9. Added DSR/DTR signals. Corrected RS-485 load and max. node number. Updated company name and address. Editorial Changes.

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About this manual

This manual explains the installation and the hardware aspects of a *XNUT*-105 module.

Document Conventions

Throughout this manual we use the following symbols and typefaces to make you aware of safety or other important considerations:

	Indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury.
	Indicates a potentially hazardous situation that, if not avoided, could result in damage to equipment.
	Indicates information that is critical for successful application and understanding of the product.
	Provides other helpful user information that does not fall in above categories.
	Provides supplemental user information.
Acronym	This typeface is used to introduce acronyms or product names.
`Command`	This typeface is used to represent commands, prompts, input fields and filenames. In the context of programming it is used for functions, variable names, constants or class names.
`Placeholder`	This typeface is used to represent replacable text. Replaceable text is a placeholder for data you have to provide, like file-names or command line arguments.
`User input`	This typeface is used to represent data entered by the user or buttons.
`Screen output`	Screen output or program listing

Chapter 1. Introduction

The *XNUT*-105 single board computer features Ethernet connectivity, a CAN interface and several serial port configurations at a low cost while at the same time offering features required in an industrial environment. *XNUT*-105 is perfectly suited for customized protocol conversions and to integrate any serial device or CAN device into an Ethernet or TCP/IP based network.

Figure 1.1: XNUT-105 mounted on DIN rail

Possible areas of application are:

- Protocol converter
- Industrial Ethernet
- Fieldbus gateways
- Industrial automation
- PLC interconnection
- Serial device servers
- Building automation
- Distributed control systems
- Alarm monitoring
- Data logger
- Networked sensors
- Data concentrators
- Remote control & monitoring
- Embedded web servers

Features

The *XNUT*-105 module provides the following key features:

- Reliable design suitable for Industrial Automation applications
- Cost effective and flexible solution
- Industrial form factor
- Programmable in C
- Nut/OS Real-Time Operating System with TCP/IP stack
- GNU gcc compiler toolchain
- Convenient program upload via Ethernet TFTP bootloader for fast development cycle
- Ethernet port with RJ-45 connector
- Up to two RS-232 ports with SUB-D connectors
- Up to two RS-485 or one RS-422 port with 3.81 mm pluggable terminal header
- CAN interface
- DIN rail mountable enclosure
- 10-30 V DC low power switch mode power supply
- Atmel AT90CAN128 RISC CPU
- Realtek RTL8019AS Ethernet controller
- 128 KiB in-system programmable Flash ROM
- 32 KiB static RAM
- Two 8-bit and two 16-bit timer/counter
- Dual USART
- CAN 2.0A & 2.0B controller with 15 message objects and time stamping
- Status LEDs for power and Ethernet link as well as two bi-color user-defined LED's
- Watchdog and brown-out detection
- JTAG in-circuit programming & debugging port
- Ethernut 1.3 hardware compatible

Chapter 2. Getting started

Use the following steps to install your *XNUT*-105 module.

Safety precautions

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Only qualified workers should install this equipment. Such work should be performed only after reading this entire set of instructions.
- NEVER work alone.
- Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power. Assume that all circuits are live until they have been completely de-energized, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.
- Apply appropriate personal protective equipment and follow safe electrical practices.
- Turn off all power supplying the equipment in which the *XNUT*-105 is to be installed before installing and wiring the *XNUT*-105.
- Always use a properly rated voltage sensing device to confirm that power is off.
- Beware of potential hazards, wear personal protective equipment, and carefully inspect the work area for tools and objects that may have been left inside the equipment.
- The successful operation of this equipment depends upon proper handling, installation, and operation. Neglecting fundamental installation requirements may lead to personal injury as well as damage to electrical equipment or other property.

Failure to follow these instructions will result in death or serious injury!

Regulatory notes

1. The *XNUT*-105 module is suitable for use in non-hazardous locations only.
2. The *XNUT*-105 module is not authorized for use in life support devices or systems.
3. Wiring and installation must be in accordance with applicable electrical codes in accordance with the authority having jurisdiction.
4. The *XNUT*-105 is designed for installation into an electrical switchboard or cubical as part of a fixed installation.

Unpacking and handling

1. Please read this manual carefully before opening the module or fitting it into your system.

2. Keep all original packaging material for future storage or warranty shipments of the module.

3. Prevent electrostatic discharge (ESD) before you handle the open module:

- Touch a grounded object to drain static potential
- Wear an approved wrist-strap grounding device
- Do not touch connector pins
- Do not touch circuit components inside the module
- Not observing these precautions could result in damage to the device.

4. Do not exceed the specified temperatures. Please note that the optionally fitted RTC battery has temperature restrictions.

5. If the product is fitted with the optional RTC battery, do not place the board on conductive surfaces or anti-static plastic or sponge, which can cause shorts and lead to battery or board trace damage.

Before connecting anything

1. Before installing or removing the module or any connector, ensure that the system power and external supplies have been turned off.

2. Check the system supply voltage with a multimeter for correct voltage range and polarity.

3. Connect the power supply cable and switch on the system power. Check if the Power LED is lit.

4. Turn off system power.

5. Connect all I/O cables.

6. Once you are certain that all connections have been made properly, restore the power.

Mounting rules

The enclosure provides protection against solid objects according to IP 20 / NEMA Type 1 protection rating. When mounting the enclosure observe the following rules:

- Avoid splash water and water drops
- Avoid aggressive gas, steam or liquids
- Avoid dusty environments

- Make sure there is sufficient air ventilation and clearance to other devices mounted next to the module
- Do not exceed the specified operational temperatures.
- Mount inside a sealed electrical switchboard or cubicle
- Observe applicable local regulations like EN60204 / VDE0113

Location of connectors

The power, CAN and RS-485/RS-422 connectors are placed on the top side of the module. The RS-232 and Ethernet connectors are placed on the bottom side of the module as shown in the following illustration:

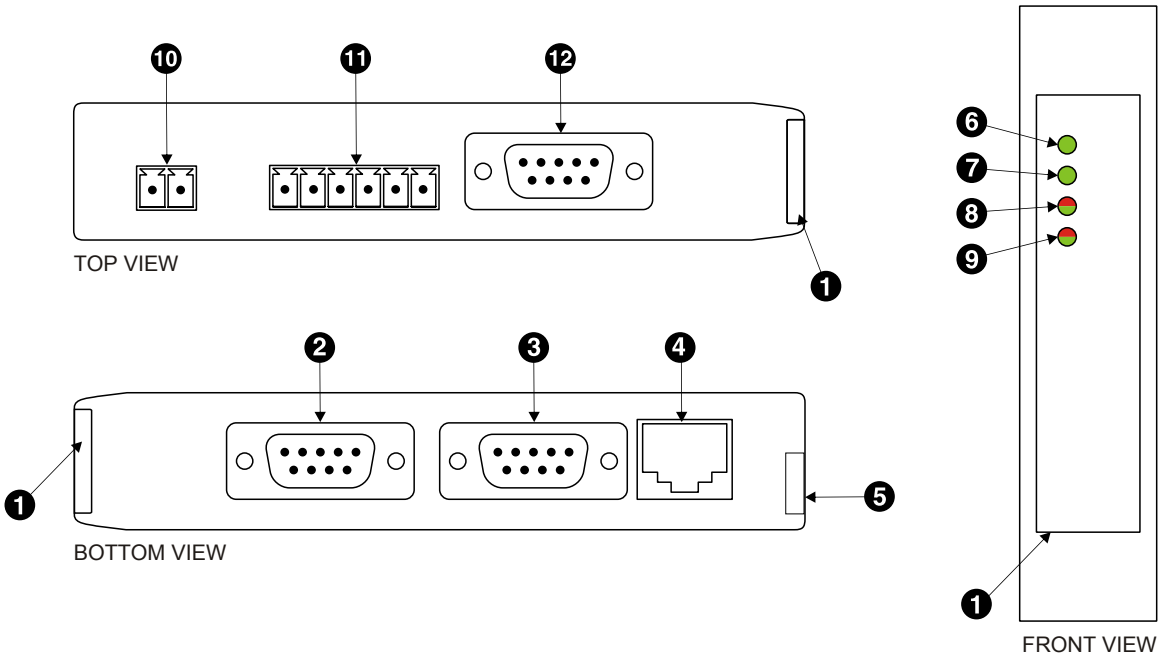


Figure 2.1: Location of connectors

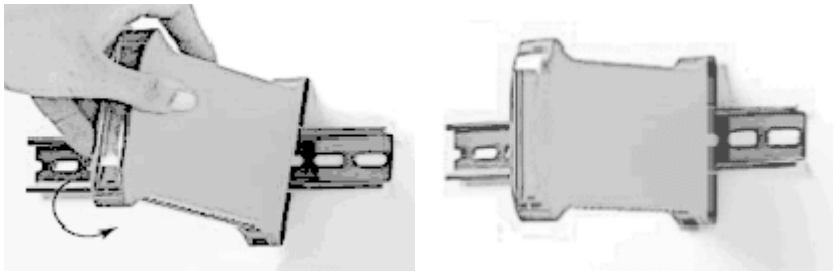
❶ Clear front cover
❷ SER0 RS-232 connector (J9)
❸ SER1 RS-232 connector (J7)
❹ Ethernet connector (J2)
❺ DIN rail clip
❻ Power LED (LED1)
❼ Ethernet link LED (LED2)
❽ Status 1 LED (LED3)
❾ Status 2 LED (LED4)
❿ Power terminal block socket (J3)
⓫ RS-485/RS-422 terminal block socket (J6)
⓬ CAN connector (J5)

Chapter 3. The Enclosure

The *XNUT*-105 module is designed to be mounted on a 35 mm DIN rail according to DIN/EN 50022. The enclosure features a 35 mm profile at the back which snaps into the DIN rail. No tools are required for mounting. Please observe the rules outlined in the section called “Mounting rules”.

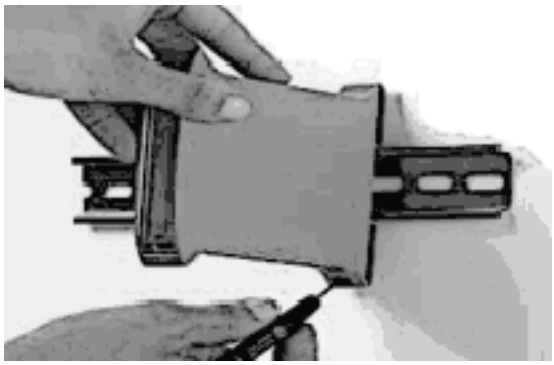
Clipping the XNUT on the DIN rail

To mount the *XNUT*-105 on a DIN rail, slot the top part of the *XNUT*-105 into the upper guide of the rail and lower the enclosure until the bottom of the red hook clicks into place.



Removing from the DIN rail

Use a screw driver as a lever by inserting it in the small slot of the red hook and push the red hook downwards to unlock the *XNUT*-105 enclosure from the DIN rail. Then remove the *XNUT*-105 from the rail by raising the bottom front edge of the enclosure.

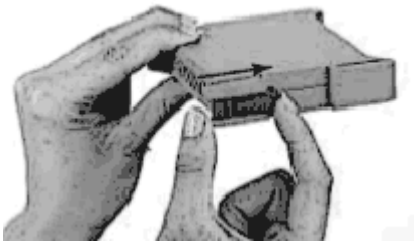


Opening the enclosure

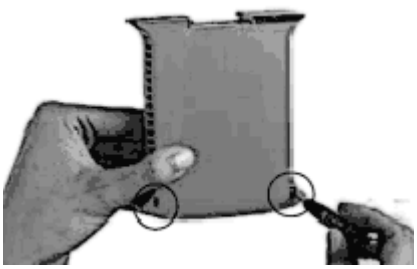
1. Before opening the enclosure, ensure that the system power and external supplies have been turned off. Then unplug all connectors.

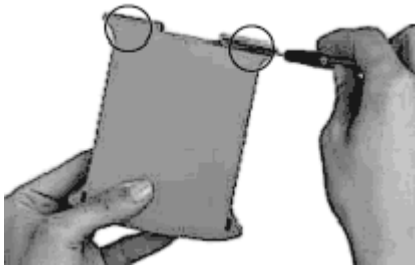
2. Follow the electrostatic discharge (ESD) precautions as described in the section called “Unpacking and handling”.

3. Remove the red DIN rail hook by pushing it backwards following the direction of the arrow:

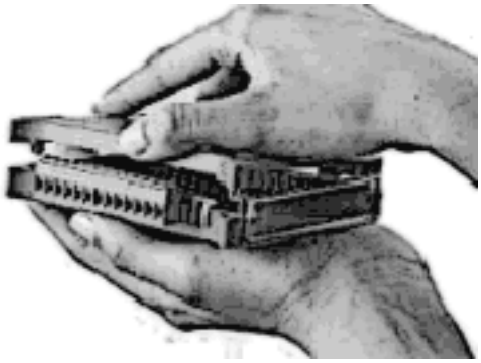


4. Unhook the top shell from the base by releasing the plastic clips in each corner with a small screwdriver.





5. Remove the top shell.



Care must be taken when opening the enclosure to avoid breaking the plastic clips holding the top and base shell of the enclosure together. The enclosure opens with ease, do not use force!

Chapter 4. Connecting your peripherals

The *XNUT*-105 single board computer is a connectivity device designed for protocol conversion and to serve as an industrial gateway. The peripherals which can be connected are any device with either RS-232, RS-485, RS-422 and CAN interface or 10BASE-T Ethernet port.

Connector	*Function*
J1	JTAG
J2	Ethernet
J3	Power supply
J5	CAN
J6	RS-485/RS-422
J7	RS-232 (SER1)
J8	Optional daughter board
J9	RS-232 (SER0)

Table 4.1: Connector designators

Before connecting any cable please follow the rules in the section called “Safety precautions” and the section called “Before connecting anything”.

Power supply connector J3

The unit can be powered be either a regulated or an unregulated DC power supply with a voltage between 10 and 30 V DC.

Before connecting power please follow the rules in the section called “Safety precautions” and the section called “Before connecting anything”.

Power is supplied via a 3.81 mm 2-pin pluggable terminal block (Phoenix Contact *Mini Combicon* type MC1,5/2-ST-3.81) located at the top side of the mounted module (refer to Figure 2.1, “Location of connectors”). The following table and picture shows the power terminal socket pinout:

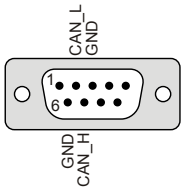
Pin	*Signal*	*Function*
1	V+	Positive voltage supply (10 - 30 V DC)
2	V-	Negative voltage supply, ground

Table 4.2: J3 Power supply connector pinout

Make sure that the polarity of the supply voltage is correct before connecting any device to the serial and CAN ports! A wrong polarity can cause high currents on the ground plane between the V- power supply pin and the CAN port and serial port GND pins, which can cause damage to the device.

CAN connector J5

The J5 CAN connector is a male 9-pin D-sub type located at the top side of the mounted module (refer to Figure 2.1, “Location of connectors”). It has industry standard CiA DS-102 pinout as shown in the following table and picture:



Pin	Signal	Function
1	NC	
2	CANL	CAN_L bus line
3	GND	CAN ground
4	NC	
5	NC	
6	GND	Optional CAN ground
7	CANH	CAN_H bus line
8	NC	
9	NC	
	FG	*Connector frame/shell is internally connected to ground*

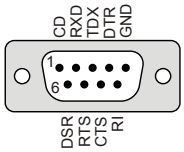
Table 4.3: J5 CAN connector pinout

- The bus must be terminated at both ends with its characteristic impedance, typically a 120 Ohm resistor.
- The cable must be a twisted pair (for CAN_H/CAN_L) and a third wire (for the ground).
- Maximum number of CAN nodes is 64
- Maximum CAN cable length is 250 m (820 ft).
- Stub connections off the main line should be avoided if possible or at least be kept as short as possible.
- The cable must be shielded and the shield must be connected to a protective ground at a single point to assure a high degree of electromagnetic compatibility and surge protection.
- The shield must *not* be connected to the GND pins or the connector shell.

RS-232 connector J9 (SER0)

J9's RXD and TXD signals are logically connected to USART0 of the AVR CPU.

The J9 RS-232 port connector is a male 9-pin D-sub type located at the bottom side of the mounted module (refer to Figure 2.1, “Location of connectors”). It has industry standard EIA-574 data terminal equipment (DTE) pinout as shown in the following table and picture:



Pin	Signal	Function	Direction
1	DCD	Data carrier detect	in
2	RXD	Receive data	in
3	TXD	Transmit data	out
4	DTR	Data terminal ready [a]	out
5	GND	Signal ground	
6	DSR	Data set ready [a]	in
7	RTS	Request to send	out
8	CTS	Clear to send	in
9	RI	Ring indicator	in
	FG	*Connector frame/shell is internally connected to ground*	

[a]DSR and DTR only available for devices with serial number 224 upwards (since PCB Revision C).

Table 4.4: J9 RS-232 connector pinout

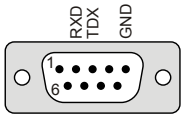
- Maximum cable length is 15 m (50 ft) or a length equal to a line capacitance of 2500 pF, both at the maximum standard bit rate of 20 kbps. If operating at higher bit rates the maximum cable length drops to 3 m (10 ft) at a bit rate of 57.6 kbps.
- The RS-232 cable must be shielded and the shield must be connected to a protective ground at a single point to assure a high degree of electromagnetic compatibility and surge protection.
- The shield must *not* be connected to the GND pin or the connector shell.

To connect the *XNUT*-105 to a PC (Personal Computer) or any other device with data terminal equipment (DTE) pinout you need a null-modem or cross-over cable.

RS-232 connector J7 (SER1)

J7's RXD and TXD signals are logically connected to USART1 of the AVR CPU.

The J7 RS-232 port connector is a male 9-pin D-sub type located at the bottom side of the mounted module. It has industry standard EIA-574 data terminal equipment (DTE) pinout as shown in the following table and picture:



Pin	Signal	Function	Direction
1	NC		
2	RXD	Receive data	in
3	TXD	Transmit data	out
4	NC		
5	GND	Signal ground	
6	NC		
7	NC		
8	NC		
9	NC		
	FG	*Connector frame/shell is internally connected to ground*	

Table 4.5: J7 RS-232 connector pinout

- Maximum cable length is 15 m (50 ft) or a length equal to a line capacitance of 2500 pF, both at the maximum standard bit rate of 20 kbps. If operating at higher bit rates the maximum cable length drops to 3 m (10 ft) at a bit rate of 57.6 kbps.
- The cable must be shielded and the shield must be connected to a protective ground at a single point to assure a high degree of electromagnetic compatibility and surge protection.
- The shield must *not* be connected to the GND pin or the connector shell.

To connect the *XNUT*-105 to a PC (Personal Computer) or any other device with data terminal equipment (DTE) pinout you need a null-modem or cross-over cable.

RS-485/422 Connector J6

J6's RX/TX0 signal pair is logically connected to USART0 of the AVR CPU, J6's RX/TX1 signal pair is logically connected to USART1 of the AVR CPU.

J6 is a combined RS-485 and RS-422 port. In order to operate as RS-422 port, both serial ports are combined and USART0 is used for sending and USART1 is used for receiving.

The RS-485 and RS-422 signals are located at the 3.81 mm 6-pin pluggable terminal block (Phoenix Contact *Mini Combicon* type MC1,5/2-ST-3.81) on the top side of the mounted module (refer to Figure 2.1, “Location of connectors”). The following table and picture shows the pinout:

2 x RS-485

1 x RS-422

Pin	Signal	RS-485 function	RS-422 function	AVR I/O pin
1	GND	Signal ground	Signal ground	
2	RX/TX0+	B+	TX+	PE0 & PE1
3	RX/TX0-	A-	TX-	PE0 & PE1
4	GND	Signal ground	Signal ground	
5	RX/TX1+	B+	RX+	PD2 & PD3
6	RX/TX1-	A-	RX-	PD2 & PD3

Table 4.6: J6 RS-485/422 connector pinout

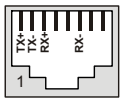
- The cables must be terminated at both ends with its characteristic impedance, typically a 120 Ohm resistor.
- In case of RS-485, the bus lines are to be biased (polarized) at one point, typically at the master connection.
- The cable must be twisted pairs for send and receive and an additional wire (for the common).
- In case of RS-485, maximum number of nodes without repeater is 32.
- Maximum cable length to 1200 m (4000 ft).
- Stub connections off the main line should be avoided if possible or at least be kept as short as possible.

- To assure a high degree of electromagnetic compatibility and surge protection, the RS-485/422 cable must be shielded and the shield must be connected to a protective ground at a single point.
- The shield must *not* be connected to the GND pin.

Ethernet Connector J2

J2 is a 10BASE-T Ethernet RJ-45 receptacle that accepts an Ethernet cable.

The following table describes the 10BASE-T Ethernet RJ-45 connector pinout:



Pin	Signal	Function
1	TX+	Non-inverting transmit signal
2	TX-	Inverting transmit signal
3	RX+	Non-inverting receive signal
4		*Internal termination network*
5		*Internal termination network*
6	RX-	Inverting receive signal
7		*Internal termination network*
8		*Internal termination network*
	FG	*Connector frame/shell is internally connected to ground*

Table 4.7: J2 Ethernet connector pinout

- We recommend to use Category 5 shielded twisted pair network cable.
- Maximum cable length is 100 m (3000 ft).
- The network cable must be shielded and the shield must be connected to a protective ground at a single point to assure a high degree of electromagnetic compatibility and surge protection.
- The shield must *not* be connected to the connector frame.

Chapter 5. Connecting a JTAG programmer

There are several ways of programming the *XNUT*-105 single board computer. Probably the most convenient method is remote programming using the Ethernet boot loader, as this does not require additional programming equipment or opening the enclosure.

However there are situations where a JTAG programmer connection is mandatory. This could be for the initial programming of the device or when source level debugging is necessary.

The *XNUT*-105 module provides a 10-pin JTAG port (J1) which is pin-compatible with Atmel's STK501 JTAG interface. This allows direct connection of Atmel's JTAGICE mkII on-chip programmer/debugger. There are also several vendors of compatible JTAG programming equipment supporting Atmel's 10-pin JTAG interface. To access J1, the enclosure has to be opened. Refer to the section called “Opening the enclosure” how to open the enclosure.

The following pictures illustrate how the JTAGICE mkII is connected to the *XNUT*-105 module. The enclosure has been opened.

Figure 5.1: JTAGICE mkII connected to XNUT-105 circuit board

Follow the electrostatic discharge (ESD) precautions as described in the section called “Unpacking and handling” when working with an open enclosure.

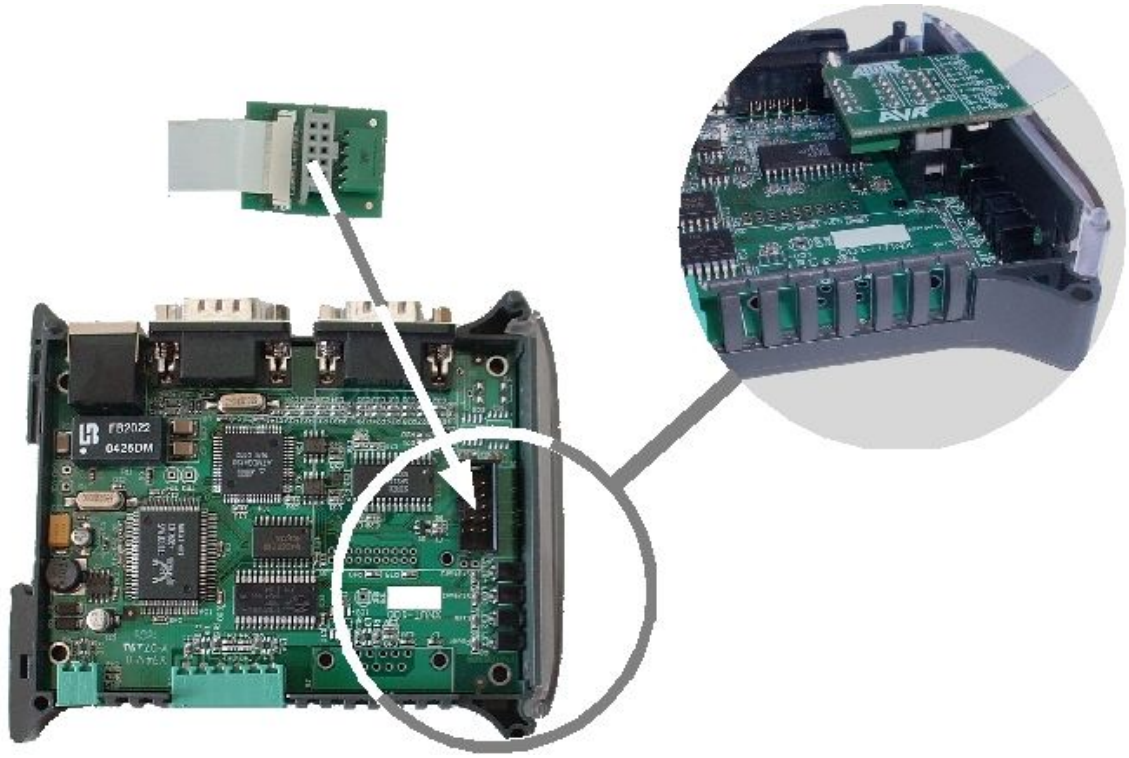


Figure 5.2: Connection of the JTAGICE mkII probe to J1

Do no plug-in or remove the JTAG programming adapter or touch any electronic parts inside the module while power is supplied to the module or to the programmer. Always switch off programmer first and then the module.

Do not connect an ISP programming adapter to the JTAG port! The JTAG interface is not compatible with the in system programming interface (ISP) used on several other AVR boards. Unfortunately Atmel used the same connector for both programming interfaces. Connecting an ISP programming adapter to the JTAG interface will short +5V to GND and damage the device!

JTAG connector J1

J1 is a 10-pin 2.54 mm dual-row IDC header with the following pin-out:

Pin	Signal	Function	AVR I/O pin
1	TCK	Test clock	PF4
2	GND	Logic supply ground	
3	TDO	Test data output	PF6
4	VCC	+5 V logic supply voltage. Max. 100 mA may be drawn.	
5	TMS	Test mode select	PF5
6	RESET	Reset signal	RESET
7	Vsupply	Optional +5 V supply voltage from JP1 to power programmer from target board. Max. 100 mA may be drawn.	
8	NC		
9	TDI	Test data input	PF7
10	GND	Logic supply ground	

Table 5.1: JTAG connector pinout (J1)

Most JTAG programmer like the JTAGICE mkII provide their own power supply. The JTAG interface has provision to supply a JTAG programmer from the target board. For this function jumper JP1 needs to be fitted and closed. JP1 connects +5V to pin 7 of the JTAG interface. Care must be taken not to overload the module's power supply, max. 100 mA may be drawn on pin 7.

Chapter 6. Functional description

This chapter describes the various function blocks of the *XNUT*-105 device.

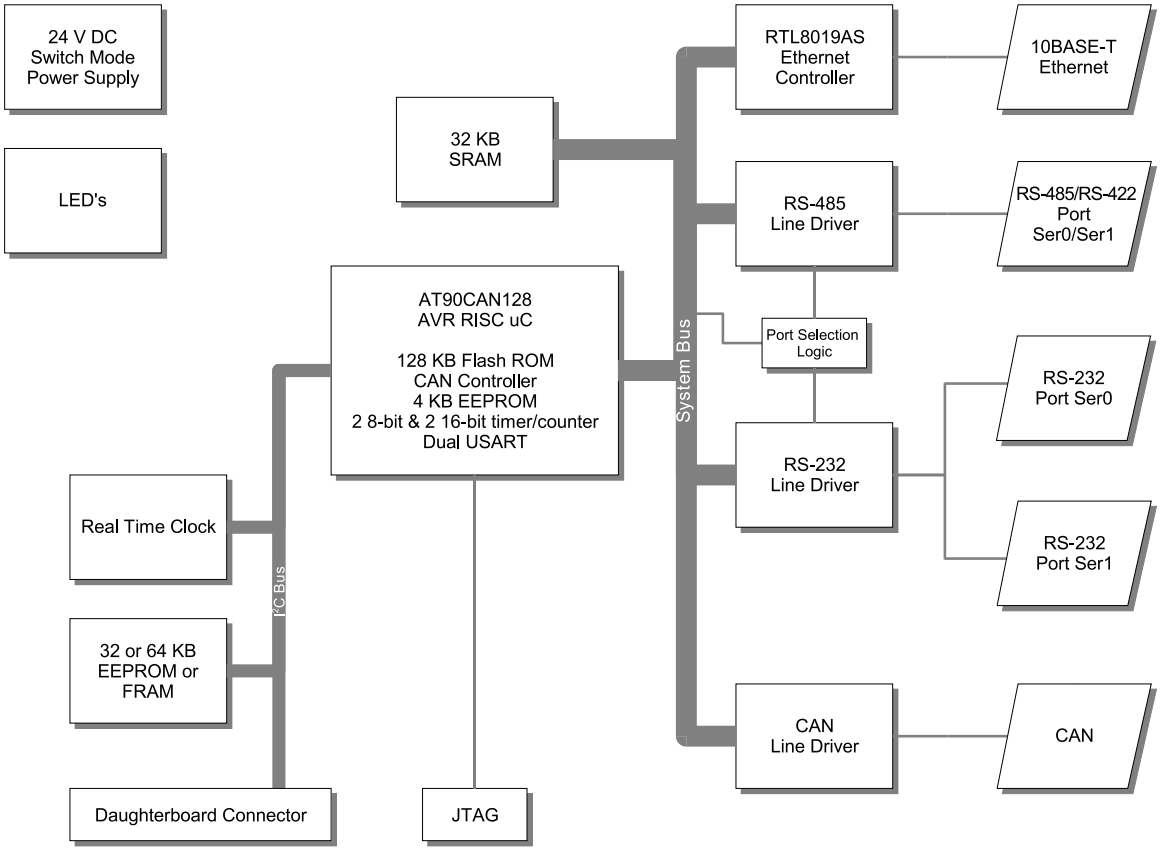


Figure 6.1: XNUT-105 Block Diagram

Power supply

The unit is powered with either a regulated or an unregulated 10 to 30 V DC power supply connected to J3. The typical power consumption of the *XNUT*-105 single board computer is 750 mW which corresponds to 30 mA at 24 V DC input voltage.

The power supply has a basic polarity mis-wiring protection and thermal shutdown as well as current limit protection.

The unit is equipped with a high efficiency switch mode power supply operating at 260 kHz which generates the +5 V supply voltage for the internal logic. The use of switch mode power supply technology allows the unit to operate at a wide input voltage range and have at the same time a low heat dissipation and low power consumption.

Processor core

The *XNUT*-105 single board computer is powered by an AVR AT90CAN128 RISC micro-controller CPU (IC4) from Atmel. The CPU is running at 12.0 MHz clock frequency

which yields 12 MIPS processing speed. The low clock frequency contributes to the excellent EMC characteristics of the module. The AVR is a Harvard architecture CPU design with separate memory spaces for data and code.

The CPU provides 128 KiBytes of in-system-programmable flash program memory, 4 KiBytes internal SRAM, an external memory interface, 4 KiBytes internal EEPROM, brown-out detection, watchdog timer, two serial ports, an I2C compatible TWI interface, several timers and I/O ports. Most I/O ports are used by the board design to accommodate serial port control lines. Refer to Table 6.6, “Allocation of AVR I/O pins” for allocation of I/O pins.

For a detailed description of the CPU refer to the datasheet [AT90CAN128].

Watchdog timer and brown-out detection

The *XNUT*-105 is equipped with a watchdog timer provided by the AVR CPU which once it is enabled, requires periodic reloading by the application software. If the application fails to reload the watchdog timer, the system performs a reset. The watchdog timer can be either enabled by software or an AVR fuse bit.

The AVR CPU provides a brown-out detection circuit which monitors the +5V logic supply voltage and resets the system if the supply voltage is below a threshold. For the *XNUT*-105 module the detection threshold should be set to 4.0 V. The brown-out detection can be enabled by an AVR fuse bit.

It is recommended to enable watchdog timer and brown-out detection for any real-world software application. Both functions increase the system's availability, should it fail due to software bugs or electrical problems.

System clock

The systems clock is generated by a 12.0 MHz clock crystal (Y2). This clock frequency is the best compromise between running the processor at maximum speed while keeping the baud rate error to a minimum for the commonly used baud rates from 300 to 115200 bps.

Memory

The AVR CPU core provides already 128 KiBytes of flash program memory and 4 KiBytes internal EEPROM. It also provides 4 KiBytes internal SRAM. As 4 KiBytes of RAM is insufficient for most real world applications involving dynamic memory management, communication buffer allocation and Ethernet connectivity, the *XNUT*-105 provides an extra 32 KiBytes memory chip. The additional memory provides sufficient space for communication buffers and a TCP/IP stack running several socket connections concurrently.

The table below shows the layout of the data memory space of the *XNUT*-105:

Address	Size	Used by
0x0000 - 0x00FF	256 Bytes	AVR register space
0x0100 - 0x10FF	4 KiBytes	Internal RAM
0x1100 - 0x7FFF	27.75 KiBytes	External RAM
0x8000 - 0xFFFF	32 KiBytes	RTL8019AS register window

Table 6.1: Memory map

The internal RAM and the external RAM form one continuous address space available for applications.

LEDs

Figure 6.2: XNUT-105 front panel

Four LEDs located at the front panel indicate the status of the *XNUT*-105 module. LED1 (Power) indicates with green color the unit is powered up, LED2 (Link) indicates with green color the presence of an Ethernet link.

The two remaining LEDs, LED3 and LED4 are bi-color with green and red and their function is user-defined.

LED3 and LED4 are typically used to indicate fault states or sate information of the application software. For example in DeviceNet applications, LED3 can be used to indicate Module status and LED4 can be used to indicate Network Status.

LED3 and LED4 are controlled by the AVR I/O pins PF0 to PF3. The following logic table may be used to change the color of LED3 and LED4:

LED	Color	PF2	PF3	PF0	PF1
LED3 Status1	off	0	0		
LED3 Status1	green	1	0		
LED3 Status1	red	0	1		
LED4 Status2	off			0	0
LED4 Status2	green			1	0
LED4 Status2	red			0	1

Table 6.2: LED colors

CAN

The *Controller Area Network* (CAN) is a serial communications protocol which efficiently supports distributed real-time control with a very high level of security.

The *XNUT*-105 offers a CAN 2.0A & CAN 2.0B compliant CAN controller which is part of the AT90CAN128 CPU.

The CAN interface conforms to ISO 11898. It transmits and receives data up to 1 Mbit/s. It offers protection against high-voltage transients and against damage due to short-circuit conditions (positive or negative battery voltage) as well as an automatic thermal shutdown.

The nomenclature of the CAN interface knows two logic states: bus dominant and bus recessive. The bus state is defined by the difference voltage between CAN_H and CAN_L. The CAN interface will transmit a dominant state when CANTX is low and a recessive state when CANTX is high.

Serial ports

The *XNUT*-105 single board computer features two serial ports designated as SER0 and SER1.

These two serial ports can be configured by software to operate either in RS-232, RS-485 or RS-422 mode. In case of RS-422 operation, the RS-485 drivers of both serial ports are combined and only one serial port is available in this mode.

The following AVR I/O pins are used as control lines:

AVR I/O pin	*Direction*	*Signal*	*Function*
PB0	OUT	RX0SWITCH	SER0 mode switch, 1 = RS232 mode
PB1	OUT	TX0EN	SER0 RS-485 transmitter enable, 0 = disabled
PB2	OUT	RX1SWITCH	SER1 mode switch, 1 = RS232 mode
PB3	OUT	TX1EN	SER1 RS-485 transmitter enable, 0 = disabled
PB4	OUT	RTS0	SER0 request to send
PB5	OUT	DTR0	SER0 data terminal ready [a]
PB6	INP	CD0	SER0 carrier detect
PB7	INP	RI0	SER0 ring indicator
PD2	INP	RXD1	SER1 receive data
PD3	IO	TXD1/SQW	SER1 transmit data [b]
PD4	OUT	RS232EN	RS-232 driver enable, 0 = enable
PE0	INP	RXD0	SER0 receive data
PE1	OUT	TXD0	SER0 transmit data
PE4	INP	DSR0	SER0 data set ready [a]
PE6	INP	CTS0	SER0 clear to send

[a] DSR and DTR only available for devices with serial number 224 upwards (since PCB Revision C).

[b] This pin has an alternate function and can serve as an SQW interrupt from the RTC

Table 6.3: Allocation of AVR I/O pins as serial control lines

RS-232 interfaces

The *XNUT*-105 offers two RS-232 ports on J9 and J7. Both ports have ESD protection and EMI filters on the signal lines. The connector frame is internally connected to the power supply ground.

SER0 in RS-232 mode

To operate USART0 in RS-232 mode the following control signals have to be set:

- RS232EN (PD4) = 0
- RX0SWITCH (PB0) = 1

SER1 in RS-232 mode

To operate USART1 in RS-232 mode port the following control signals have to be set:

- RS232EN (PD4) = 0
- RX1SWITCH (PB2) = 1

RS-485/RS-422 interface

The *XNUT*-105 offers two RS-485 interfaces or alternatively one RS-422 interface on port J6.

The RS-485/422 interface have ESD protection and EMI filters on the signal lines.

RS-485 is a half-duplex bus and uses one differential pair of signal lines for sending and receiving. Only one node is allowed to drive it's transmitter at any given point in time. This requires switching the transmitter on and off by software, typically switching it on before data is sent and switching it off after the laster character has left the USART.

SER0 in RS-485 mode

To operate SER0 in RS-485 mode port the following control signals have to be set:

- RX0SWITCH (PB0) = 0
- Set TX0EN (PB1) to 1 to enable the transmitter or to 0 to switch off the transmitter.

SER1 in RS-485 mode

To operate SER1 in RS-485 mode port the following control signals have to be set:

- RX1SWITCH (PB2) = 0
- Set TX1EN (PB3) to 1 to enable the transmitter or to 0 to switch off the transmitter.

If both serial ports are operating in RS-485 mode, the RS-232 transceiver chip can be switched off by setting the RS232EN (PD4) control signal to 1.

RS-422 mode

To operate in RS-422 mode both serial ports are combined and SER0 is used for transmission and SER1 is used for receiption. To operate in this mode, the following control signals have to be set:

- RX0SWITCH (PB0) = 0
- RX1SWITCH (PB2) = 0
- TX0EN (PB1) = 1
- TX1EN (PB3) = 0
- RS232EN (PD4) = 1 (The RS-232 transceiver chip can be switched off)

Ethernet interface

The *XNUT*-105 is equipped with a 10BASE-T Ethernet port (J2) which operates in 10 Mbit/s half-duplex mode. Because of it's half-duplex mode it is compatible with classic Ethernet hubs as well with modern Ethernet switches. The Ethernet port features a termination circuit to reduce EMI susceptibility.

The Ethernet controller used is a RealTek RTL8019AS network interface controller (IC6) which is NE2000 compatible and well supported by most network protocol stack software.

The network controller is hardwired for the following hardware resources:

Resource	*Value / mode*	*AVR I/O pin*
Address range within AVR data space	0x8300 - 0x831F	
I/O Base	0x300	
Interrupt	Rising edge	PE5 / INT5
Reset signal	Active high	PD7
I/O channel ready	Active high	PE7
Address Mode	8-bit mode	
Link mode	Half-duplex	
Link-test	Auto-detect	

Table 6.4: NIC configuration

For registration and identification on an Ethernet network a unique 48-bit number called MAC address is required. The *XNUT*-105 is currently using a locally administered MAC address which consists of 4 fixed bytes and 2 bytes made up of the *XNUT*-105 serial number in hex notation as per following formula:

```
72-03-48-4D-xx-xx
```

"Locally administered" means that it is the operator of the equipment's responsibility to make sure that the MAC address is unique within the network (compared to a universally administered MAC address where the IEEE organization guarantees uniqueness of the address). Refer to: http://standards.ieee.org/regauth/groupmac/tutorial.html

It is important to make sure that each node on your network has a unique MAC address.

Optional real time clock

The *XNUT*-105 single board computer can optionally be fitted with battery buffered real time clock (RTC).

The real time can be used to implement data logging or time stamping functions.

The real time clock is realized with a Dallas/Maxim DS1307 chip (IC5) which is connected to the I2C bus. The I2C address of the RTC device is 0xD0. A 32.768 kHz quartz crystal (Y3) provides the clock source.

For more details refer to the datasheet [DS1307].

The maximum I2C clock frequency allowed with the DS1307 chip fitted is 100 kHz.

The real time clock is buffered with a lithium battery and will back up the DS1307 for more than 10 years in the absence of power at +25 °C. The real time clock can handle the time up to the year 2100. The approximate timekeeping accuracy is 10 min/year (20 ppm) at +25 °C.

Optional external EEPROM

The *XNUT*-105 single board computer can optionally be equipped with 64 KiBytes of external EEPROM.

The external EEPROM can be used to store web pages or recipe data and similar device configuration information which otherwise would not fit into the AVR's internal 4 KiBytes EEPROM space.

The external serial EEPROM is realized with a Microchip 24LC512 serial EEPROM chip (IC2) which is connected to the I2C bus. The I2C address for the device is 0xA0. The 24LC512 can be operated at either 100 kHz or 400 kHz I2C clock frequency depending if the DS1307 chip (IC5) is fitted as well which then limits the I2C clock frequency to 100 kHz. The device has 1,000,000 erase/write cycles and a data retention > 200 years.

For more details refer to the datasheet [24LC512].

Optional daughter board connector

The *XNUT*-105 has provision for a daughter board connector (J8) to accommodate small expansion boards like I/O modules or a galvanically isolated serial port. The internal +5V supply voltage, the I2C bus, logic level signals of USART0 or 8 AVR I/O ports are available on the *XNUT*-105 daughter board interface. The daughter board interface is a 20 pin double row 2 mm IDC header with the following pinout:

Pin	Signal	Function	AVR I/O pin
1	NC		
2	VCC	+5V logic supply voltage	
3	NC		
4	VCC	+5V logic supply voltage	
5	OC0	General purpose I/O	PB4
6	SCL/INT0	I2C clock or general purpose I/O with interrupt	PD0
7	SDA/INT1	I2C data or general purpose I/O with interrupt	PD1
8	AIN0	General purpose I/O	PE2
9	AIN1	General purpose I/O	PE3
10	GND	Logic supply ground	
11	RXD0	Received data, +5V logic-level [a]	PE0
12	TXD0	Transmitted data, +5V logic-level	PE1
13	GND	Logic supply ground	
14	NC		
15	NC		
16	GND	Logic supply ground	
17	NC		
18	GND	Logic supply ground	
19	T3/INT6	General purpose I/O with interrupt [b]	PE6
20	NC		

[a] If connected remove resistor R40
[b] If connected remove resistor R39

Table 6.5: Daughter board connector pinout (J8)

J8 is mounted only on special order and on units equipped with daughter boards.

I/O pin allocation

The following table documents how the AVR I/O pins are used:

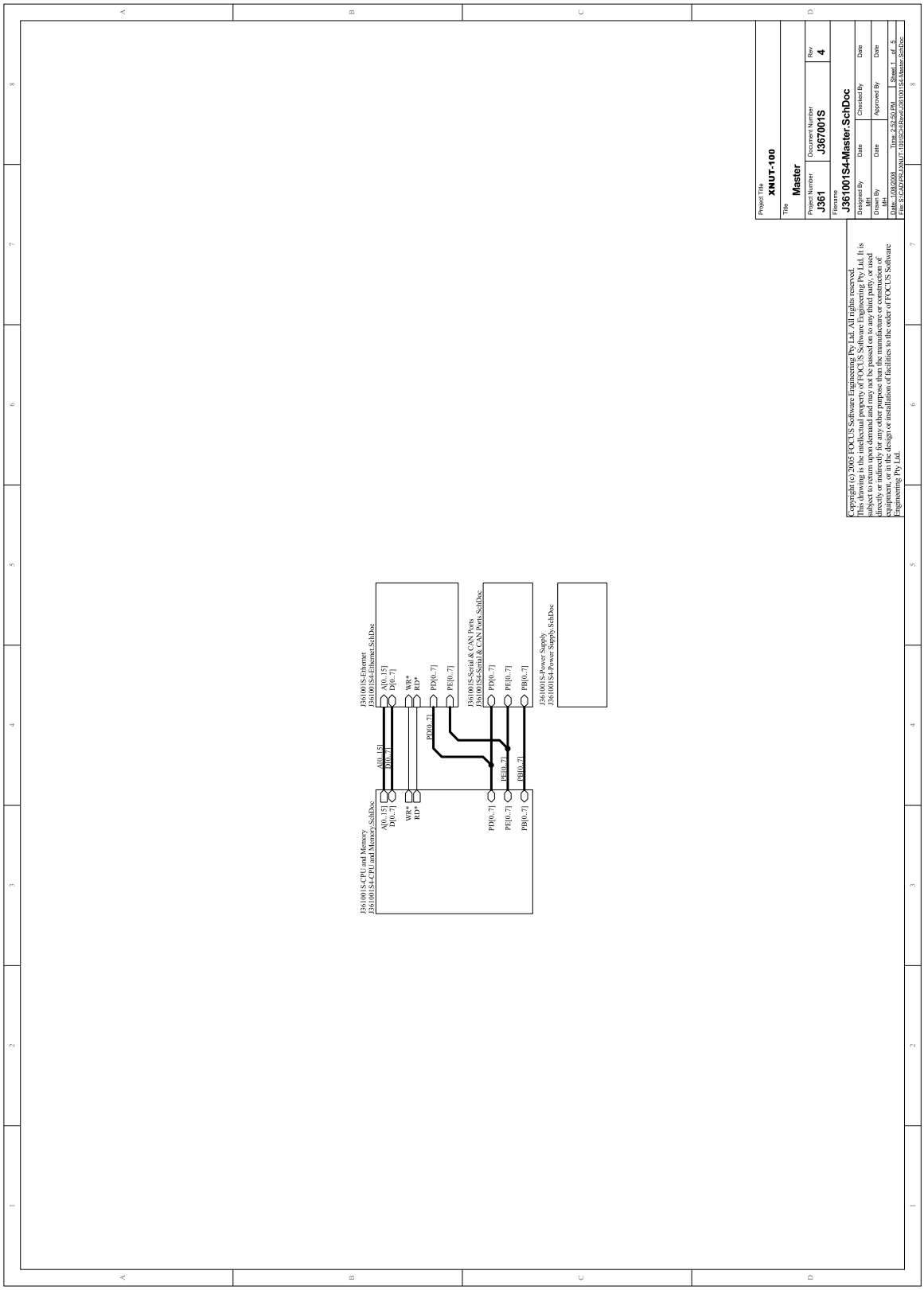
AVR I/O pin	Direction	Port Value	Signal	Function
Port A				
PA0-7	OUT	1		Multiplexed address and data lines
Port B				
PB0	OUT	1	RX0SWITCH	SER0 mode switch, 1 = RS232 mode
PB1	OUT	0	TX0EN	SER0 RS-485 transmitter enable, 0 = disabled
PB2	OUT	1	RX1SWITCH	SER1 mode switch, 1 = RS232 mode
PB3	OUT	0	TX1EN	SER1 RS-485 transmitter enable, 0 = disabled
PB4	OUT	1	RTS0	SER0 request to send
PB5	OUT	1	DTR0	SER0 data terminal ready [a]
PB6	INP	1	CD0	SER0 carrier detect (enable internal pull-up)
PB7	INP	1	RI0	SER0 ring indicator (enable internal pull-up)
Port C				
PC0-7	OUT [b]	x	PA0-PA7	Address lines A8-A15
Port D				
PD0	IO [b]	0	SCL	I2C clock (pulled up externally)

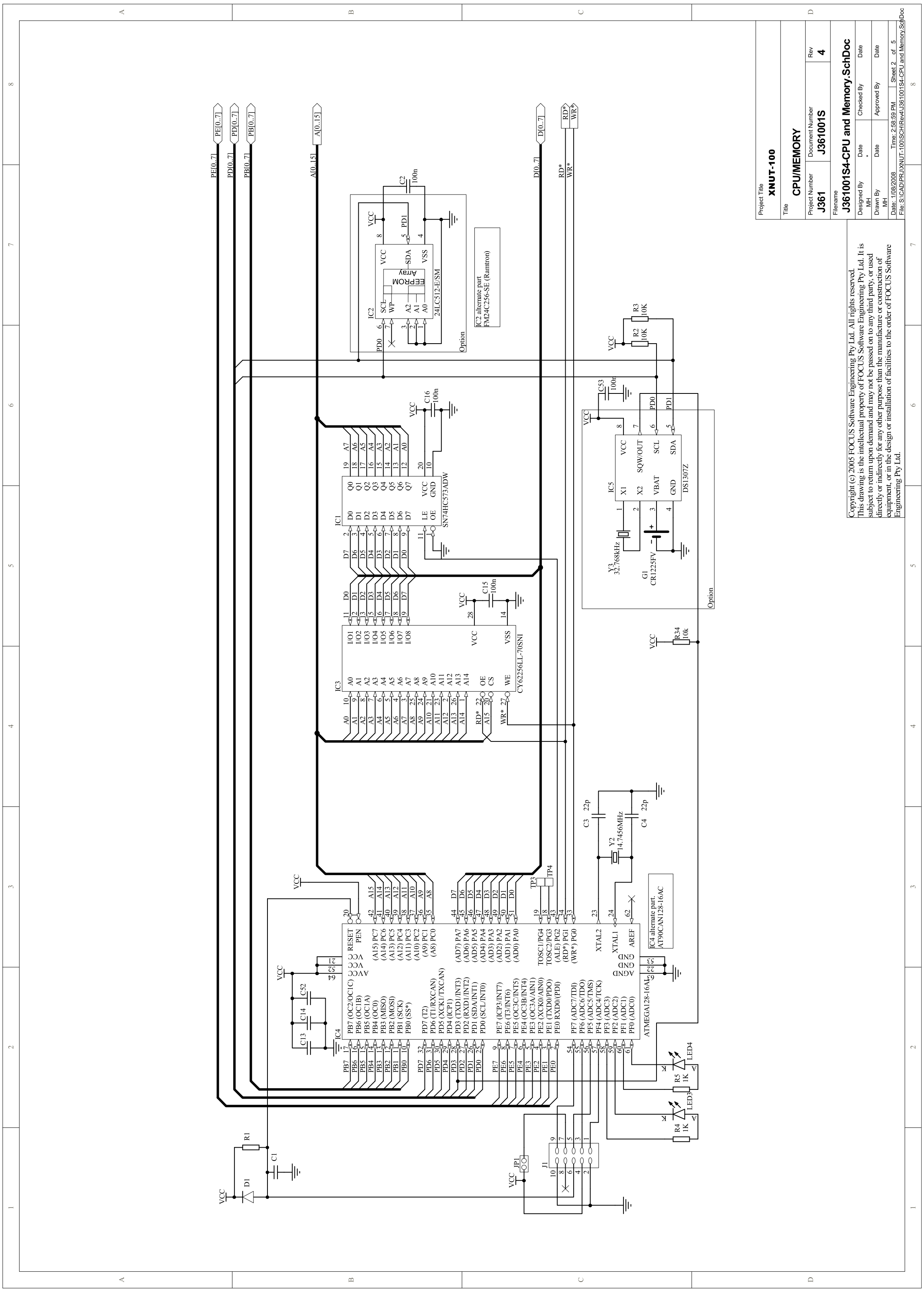
AVR I/O pin	Direction	Port Value	Signal	Function
PD1	IO [b]	0	SDA	I2C data (pulled up externally)
PD2	INP [b]	1	RXD1	SER1 receive data (enable internal pull-up)
PD3	IO [b]	1	TXD1/SQW	SER1 transmit data (enable internal pull-up) [c]
PD4	OUT	0	RS232EN	RS-232 driver enable, 0 = enable
PD5	OUT [b]	1	TXCAN	CAN transmit data
PD6	INP [b]	1	RXCAN	CAN receive data (enable internal pull-up)
PD7	OUT	0	NICRST	NIC reset signal
Port E				
PE0	INP [b]	1	RXD0	SER0 receive data (enable internal pull-up)
PE1	OUT [b]	1	TXD0	SER0 transmit data
PE2	IO	1	Daughter board GPIO	(not connected, enable internal pull-up)
PE3	IO	1	Daughter board GPIO	(not connected, enable internal pull-up)
PE4	INP	1	DSR0	Data set ready [a]
PE5	INP	1	NICINT	NIC interrupt (enable internal pull-up)
PE6	INP	1	CTS0	SER0 clear to send (enable internal pull-up)
PE7	INP	1	NICIOCHRDY	NIC "I/O" channel ready (enable internal pull-up)
Port F				
PF0	OUT	0	LED4 cathode	STATUS2 LED
PF1	OUT	0	LED4 anode	STATUS2 LED
PF2	OUT	0	LED3 cathode	STATUS1 LED
PF3	OUT	0	LED3 anode	STATUS1 LED
PF4	IO [b]	1	JTAG TCK	Test clock (enable internal pull-up)
PF5	IO [b]	1	JTAG TMS	Test mode select (enable internal pull-up)
PF6	IO [b]	1	JTAG TDO	Test data output (enable internal pull-up)
PF7	IO [b]	1	JTAG TDI	Test data input (enable internal pull-up)
Port G				
PG0	OUT [b]	1	"/WR"	Write signal
PG1	OUT [b]	1	"/RD"	Read signal
PG2	OUT [b]	1	ALE	Address latch enable
PG3	IO	1	TP4	Test point (enable internal pull-up)
PG4	IO	1	TP3	Test point (enable internal pull-up)

[a] DSR and DTR only available for devices with serial number 224 upwards (since PCB Revision C).
[b] Pin configuration is overridden by the AVR's alternate pin function.
[c] This pin has an alternate function and can serve as an SQW interrupt from the RTC.

Table 6.6: Allocation of AVR I/O pins

Chapter 7. Schematics

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CPU/MEMORY
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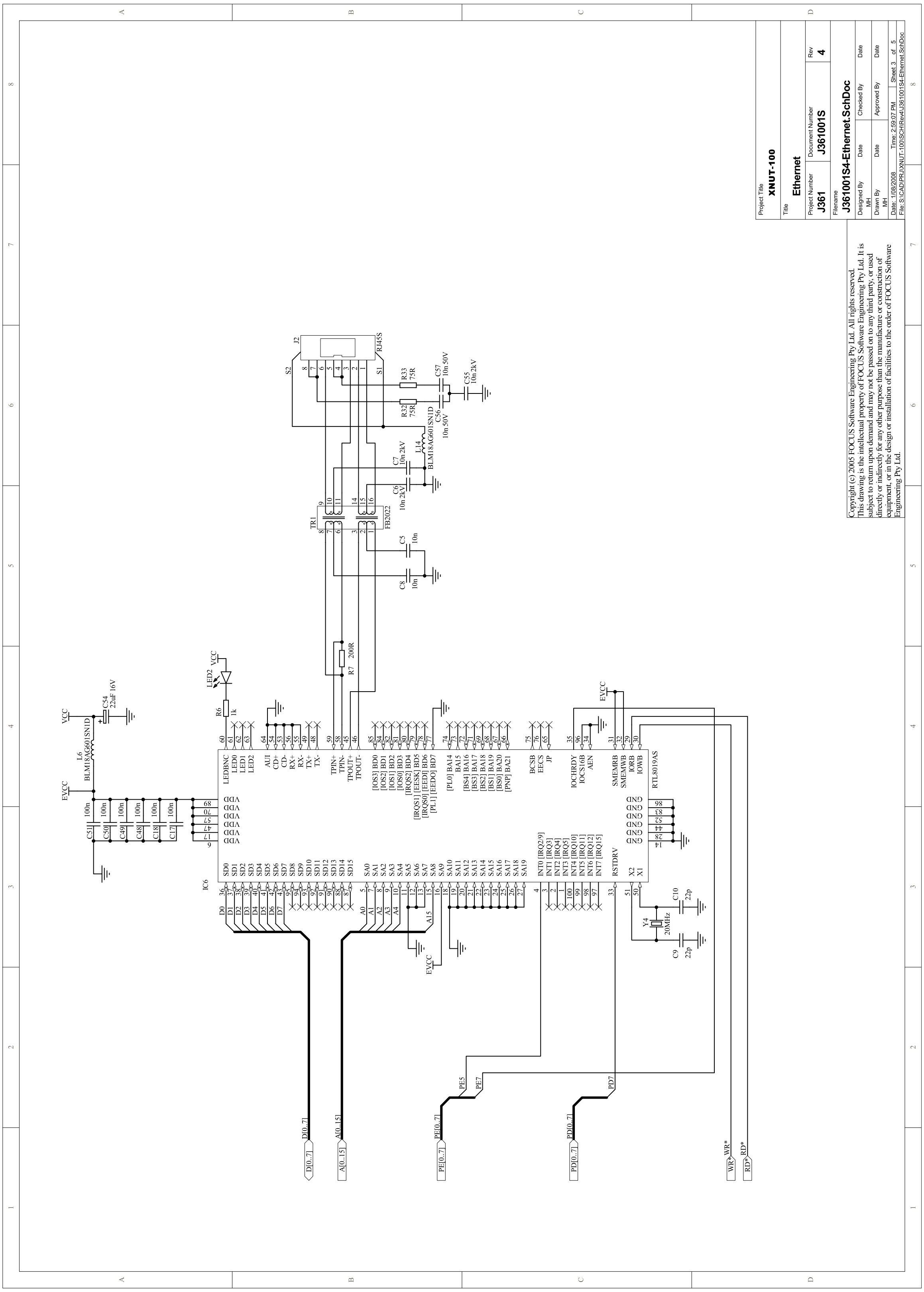
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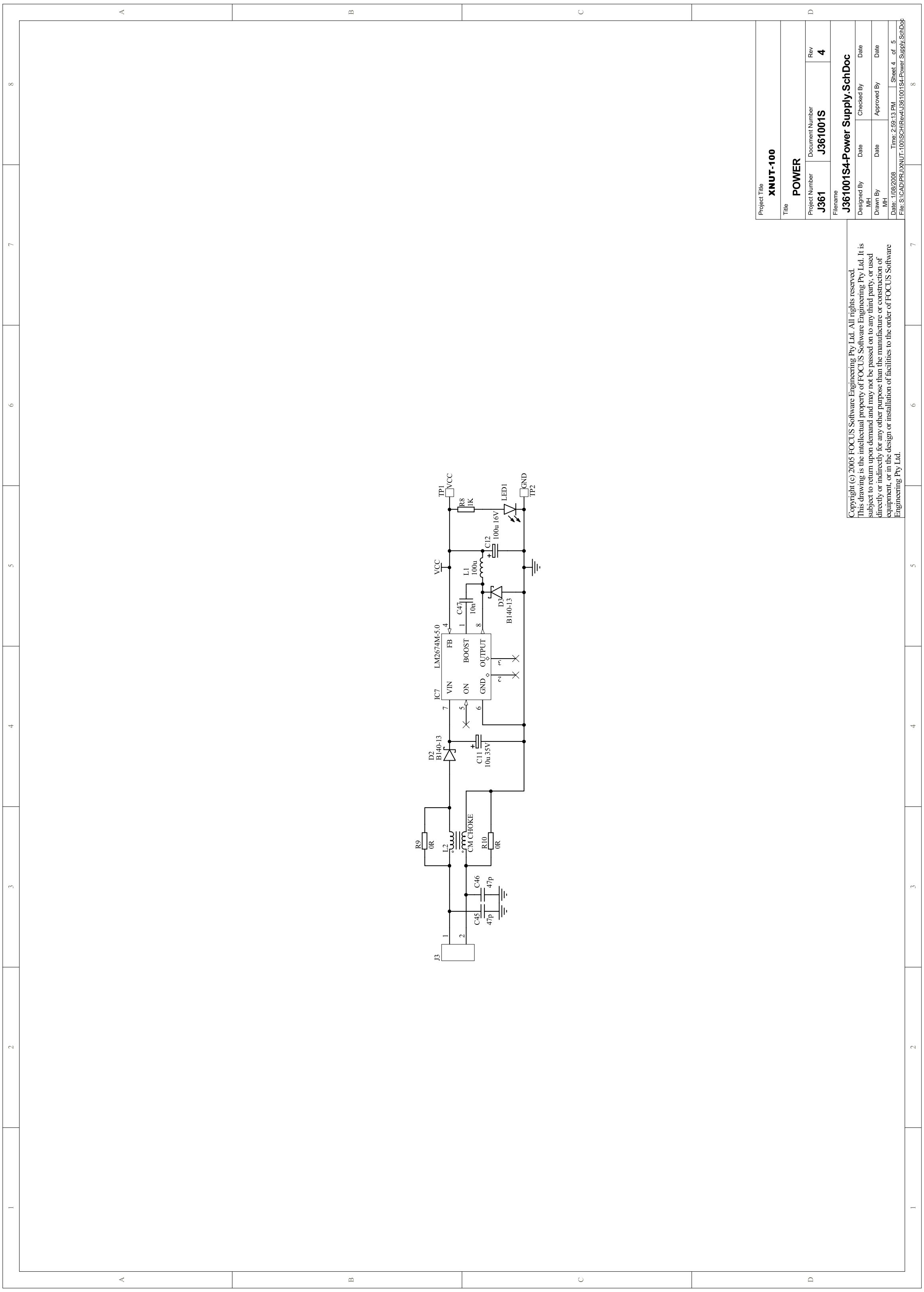
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Project Number
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Copyright (c) 2005 FOCUS Software Engineering Pty Ltd. All rights reserved.
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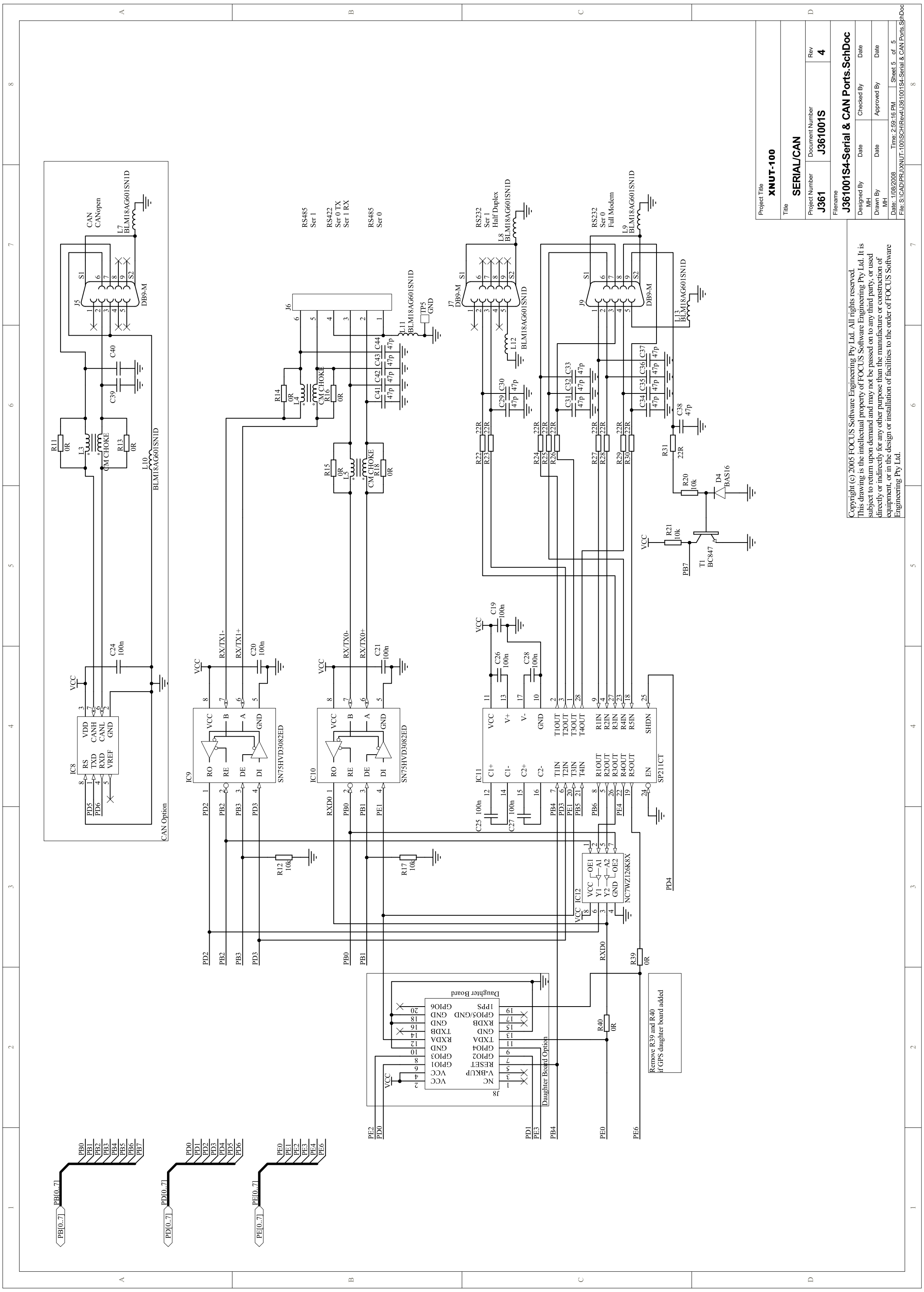
CM CHOKE
B140-13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J361001S4-Serial & CAN Ports.SchDoc
Copyright (c) 2005 FOCUS Software Engineering Pty Ltd. All rights reserved.
CAN Option
Daughter Board Option
Remove R39 and R40 if GPS daughter board added

Chapter 8. Drawings

Enclosure

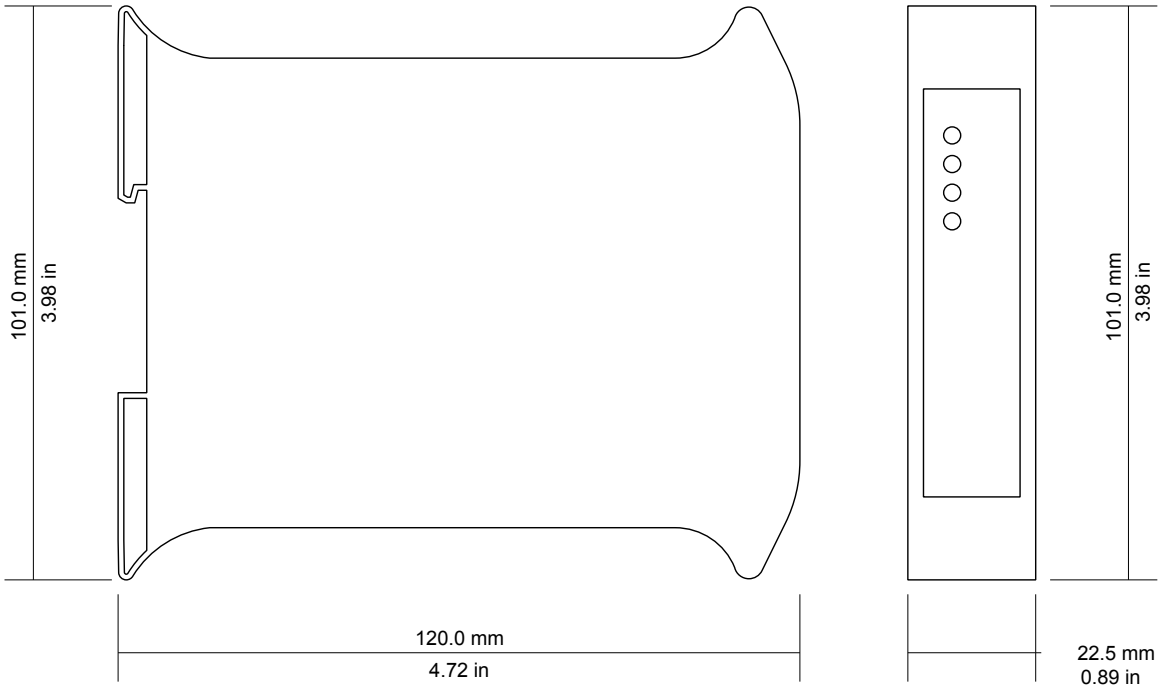

Figure 8.1: Enclosure dimensions

Assembly drawing

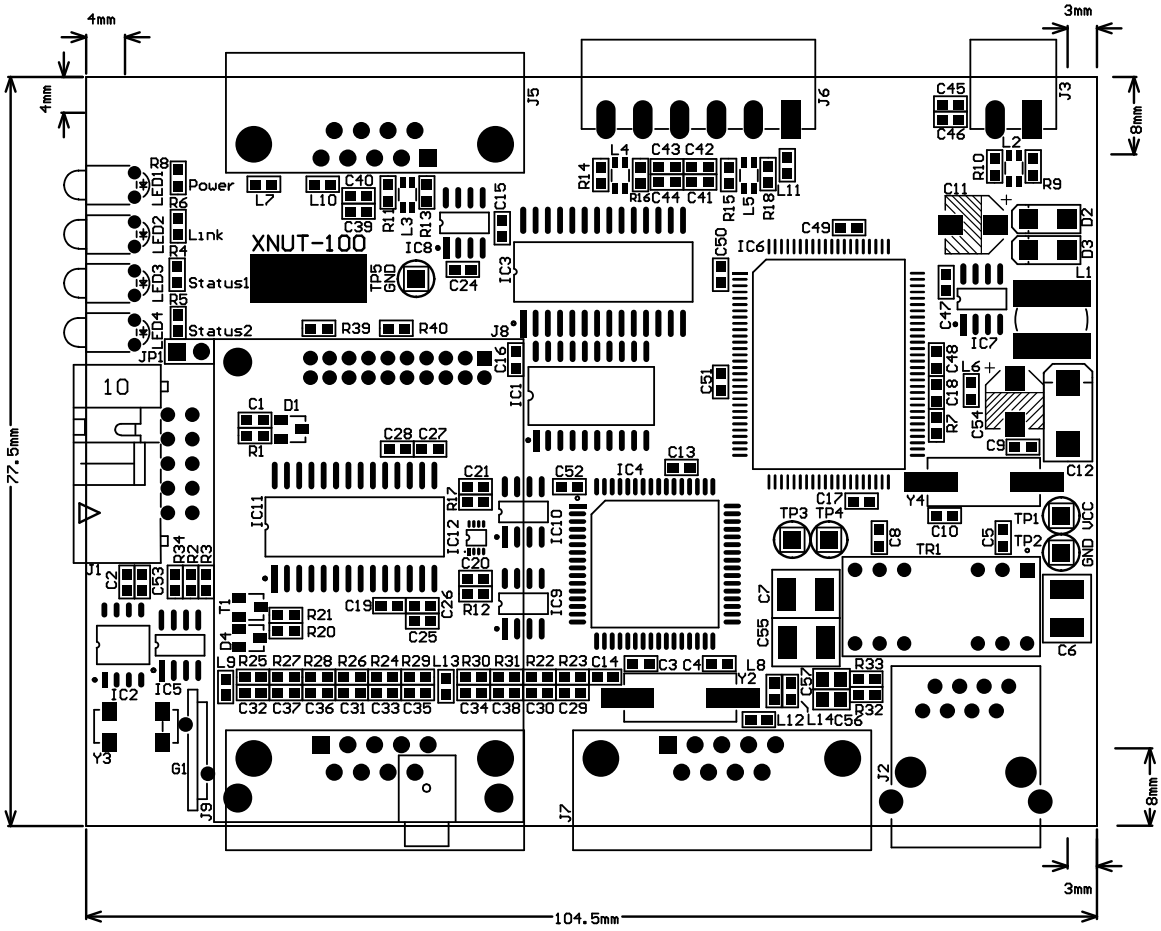

Figure 8.2: Assembly drawing

Chapter 9. Specifications

Supported development tools

- Nut/OS RTOS and embedded TCP/IP stack
- *XNUT* Library for on-board hardware support
- WinAVR gcc compiler and C run-time library
- Ethernet TFTP bootloader
- Optional AVRStudio IDE & source level debugger
- Optional SPDuo low-cost JTAG programmer
- Optional AVR JTAGICE mkII in-circuit JTAG programmer/debugger

Connectivity

- Ethernet port (IEEE 802.3i 10BASE-T) with 8-pin RJ-45 socket
- CAN interface (ISO 11898) with DE9M connector, CiA DS-102 pin-out
- Two serial ports, software configurable as:
  - 1 EIA-232-F DE9M port with EIA-574 DTE pinout and RD, TD, RTS, CTS, DSR, DTR[1], DCD, RI signals
  - 1 EIA-232-F DE9M port with EIA-574 DTE pinout and RXD, TXD signals
  - 2 EIA-485-A 2-wire ports with A-,B+ signals
  - 1 EIA-422-B port with RD+, RD-, TD+, TD- signals

CPU

- Atmel AT90CAN128 RISC micro controller with Harvard architecture
- 12 MIPS processing speed
- Full CAN controller
- Programmable watchdog timer
- Brown-out detection
- Realtek RTL8019AS network interface controller
- Two 8-bit & two 16-bit timer/counter
- Optional battery buffered real time clock (RTC)
- LED indicators for power, Ethernet link and two bi-color status
- JTAG programming interface (IEEE 1149.1) with 10-pin header

Memory

- 128 KiB program memory
- 32 KiB static RAM for data
- 4 KiB EEPROM
- optional 64 KiB EEPROM

Protection

- 10 kV ESD protection on RS-232/RS-485/422 ports
- 6 kV ESD protection on CAN port
- 1.5 kV galv. isolation on Ethernet

Power requirements

- 10-30 V DC, 750 mW
- 30 mA typical @ 24 V DC

Environment

- 0 to 60 °C (32 to 140 °F) operating temperature
- -25 to 85 °C (-13 to 185 °F) storage temperature, max. 70 °C if RTC is fitted
- 10 to 95% humidity, non-condensing
- Free from corrosive gas, minimal dust

Form factor / enclosure

- 35 mm DIN rail mountable enclosure, self-extinguishing PC/ABS blend (UL 94-V0)
- IP 20 / NEMA Type 1 protection rating
- 101 x 22.5 x 120 mm (3.98 x 0.886 x 4.72 in) w/ enclosure
- 0.13 kg (0.287 lbs)

References

[AT90CAN128] Atmel Corporation, "8-bit AVR Microcontroller with 128K Bytes of ISP Flash and CAN Controller — AT90CAN32 AT90CAN64 AT90CAN128", revision G, 3/08, http://www.atmel.com/dyn/resources/prod_documents/doc7679.pdf

[DS1307] Maxim/Dallas Semiconductor, "DS1307 64 x 8, Serial, I2C Real-Time Clock", 2005, http://pdfserv.maxim-ic.com/en/ds/DS1307.pdf

[24LC512] Microchip Technology Inc., "24AA512/24LC512/24FC512 — 512K I2C™ CMOS Serial EEPROM", October 2004, http://ww1.microchip.com/downloads/en/DeviceDoc/21754E.pdf

Glossary

10BASE-T
: 10 Mbit/s twisted pair Ethernet standard. Standardized in IEEE 802.3i

AVR
: 8-bit RISC microcontroller family by Atmel

CAN
: Controller area network. Standardized in ISO 11898.

CiA DS-102
: Standard for the pinout of CAN connectors

DCE
: Data communications equipment. DTE and DCE devices have different pinouts for RS-232 connectors. A Modem for example is a DCE.

DIN rail
: 35 mm wide mounting bracket standardized in DIN/EN 50022.

DTE
: Data terminal equipment. DTE and DCE devices have different pinouts for RS-232 connectors. A PC for example is a DTE.

EEPROM
: Electrically Erasable Programmable Read-Only Memory. Type of non-volatile memory.

EIA-232
: Standard for serial transmission of data between two devices, also known as RS-232 and V.24.

EIA-422
: ANSI/TIA/EIA-422 standard for serial transmission of data between two devices, also known as RS-422 and V.11.

EIA-485
: ANSI/TIA/EIA-485 standard for serial transmission of data between multiple devices, also known as RS-485.

EIA-574
: Standard for the pinout of serial D-sub connectors.

EMI
: Electromagnetic interference

ESD
: Electrostatic discharge. ESD can damage electronic equipment.

Harvard architecture
: Computer architecture with physically separate storage for instructions and data.

I2C
: Multi-master serial computer bus. Also known as two wire interface (TWI).

IDC
: Insulation displacement cable. Typically of flat ribbon type.

IEEE
: Institute of Electrical and Electronics Engineers

IP
: Ingress Protection Rating standardized in IEC 60529. Standard for various grades of electrical enclosures.

ISO
: International Standards Organisation

ISP
: In system programming

JTAG
: Joint Test Action Group. Standard for circuit testing.

JTAG programmer
: A device using the standardized JTAG interface to load software into flash memory.

JTAGICE mkII
: JTAG programmer by Atmel. Used to load software onto the device.

KiB, KiByte
: 1024 bytes. The SI standard recommends the usage of the binary unit prefix *Ki* for 1024.

MAC address
: Every piece of Ethernet hardware has a unique number assigned to it called it's MAC address. MAC addresses are administered and assigned by the IEEE organization.

NEMA
: National Electrical Manufacturers Association. NEMA defines standards for various grades of electrical enclosures.

Node
: A communications device on the network

PC/ABS
: Polycarbonate-ABS. Widely used thermoplastic material.

PLC
: Programmable Logic Controller

RISC
: Reduced Instruction Set Code (CPU)

RS-232
: See *EIA-232*.

RS-422
: See *EIA-422*.

RS-485
: See *EIA-485*.

RTC
: Real time clock

RTOS
: Real-Time operating system

SPDuo
: Low-cost JTAG programmer by Embedded Creations. Used to load software onto the device.

UL 94
: Plastics flammability standard released by Underwriters Laboratories of the USA.

USART
: Universal Synchronous Asynchronous Receiver/Transmitter. A USART is similar to a UART but in addition support synchronous transmission.

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