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1. Introduction

M-501 is an ARM9-based Linux ready System on Module. The M-501 is equipped with an ATMEL AT91RM9200 SoC and features:

- ARM920T ARM Thumb Processor with 200MIPS at 180MHz, Memory Management Unit
- 16-KByte Data Cache and 16-KByte Instruction Cache
- 64MB SDRAM, 16MB Flash
- One 10/100Mbps Ethernet with MACPHY and transformer
- Two USB 2.0 full speed (12Mbps) Host Ports
- Multimedia Card Interface for SD memory card
- Four UARTs with hardware and software flow control
- Two-wire Interface (I2C) for Real Time Clock
- 32 Programmable Digital I/O Port
- 8-bit external local bus interface

Linux 2.6 OS is pre-installed in the flash disk of M-501 and many powerful utility programs are also included. M-501 is ready to drop in your design to save your time in software porting and hardware debug.

Artila uses M-501 to design Matrix-510/520. Please refer to Matrix-510/520 user guide and if you are interested in those design, please contact Artila.
2. Layout

**Front View**
- Mounting Hole (M2)
- Ø 2mm (M2)
- PHY
- LAN Transformer
- ARM9
- FLASH
- SDRAM

**Rear View**
- CN3
  - 2mm 2x25 pins header
- CN1
  - 2mm 2x14 pins header
- CN2
  - 2mm 2x25 pins header

**Function Block Diagram**
- RJ45 Connect
- Power +3.3VDC
- SD Socket
- SPI Connect
- SD Interface
- SPI Interface
- UARTx4 (TTL)
- I2C (TWI)
- RS-232 Line Driver
- RTC
- USB Host Interface
- USB 2.0 Host Connect
- External Devices
- 8-bit Local Bus
- EEPROM
3. Hardware Specifications

CPU / Memory
- SoC: ATMEL AT91RM9200
- CPU: ARM920T ARM Thumb Processor with Memory Management Unit (MMU)
- Clock: 180MHz
- SDRAM: 64MB
- Flash: 16MB Intel StrataFlash or Equivalent

Network
- Ethernet: 10/100Mbps with MAC/PHY and Transformer
- PHY: DAVCOM DM9161
- Transformer: 1.5 KV isolation
- Signal: ETX0+, ETX0-, ERX0+, ERX-

USB Port
- Host: USB 2.0 full speed (12Mbps) Host x2
- Signal: UDataA+, UDataA-, UDataB+, UDataB-

UART
- Four Universal Asynchronous Receiver and Transmitter
- Data Bits: 5 to 9 bits
- Parity: None, Even, Odd, Mark, Space
- Stop: 1, 1.5, 2 bits
- Baud Rate: Up to 921.6 Kbps
- Flow Control: RTS/CTS, XON/XOFF, None
- Multi-drop Mode with address generation and detection (COM1 only)
- RS-485 Driver Control Signal (COM1: RTS0)
- Signal Level: CMOS/3.3V compatible
- COM1: TXD0, RXD0, RTS0, CTS0 (RS485 Control: RTS0) (Software configurable RS-232/422/485)
- COM2: TXD1, RXD1, RTS1, CTS1, DCD1, DTR1, DSR1 (RS-232 with full modem control)
- COM3: TXD2, RXD2, RTS2, CTS2 (RS-232 with hardware flow control)
- COM4: TXD3, RXD3, RTS3, CTS3 (RS-232 with hardware flow control)

I2C Bus (Inter-IC Bus)
- Compatible with standard two-wire serial memory interface
- Supported Devices: (Driver built-in)
  - Real Time Clock: Ricoh (RS5C372)
  - EEPROM: ATMEL AT24C16 and compatible
- Signal: TWD, TWDK
I2S (Internal IC Sound)
- Transmitter: **TSCK, TWS, TSD**
- Receiver: **RSCK, RWS, RSD**

SPI (Serial Peripheral Interface)
- Two chip Selects with external decoder
- Three wires signals: MISO, MOSI and SPCK clock
- Signal: **MISO, MOSI, SPCK, CS1, CS2**

Multimedia Card Interface
- Compatible with SD memory card Specification 1.0
- Signal: **MCCDA, MCCK, MCDA0, MCDA1, MCDA2, MCDA3**

Watchdog Timer:
- CPU built-in WDT and used by Linux Kernel

Programmable DIO
- 32 General Purpose IOs and can be programmable as digital input or output
- Support interrupt function for digital inputs
- Signal Level: CMOS/3.3V Compatible
- Input:
  - Low level: -0.3V min / +0.8V max
  - High level: +2V min / +3.9V max
- Output:
  - Low level: +0.4V max @ 0mA / +0.2V min @ 8mA
  - High level: +3.1V max @ 0mA / +2.9V min @ 8mA
- Signal: **PIO0 to PIO31**

**Note**
- **PIO24 to PIO31** are reserved for RS-232/422/485 interface selection for serial ports 1 to 4. Please contact Artila if you want to use PIO24 to PIO31.

External Bus Interface
- 8-bit data bus
  - Signal: **D0~D7**
- 8-bit address bus
  - Signal: **A0~A7**
- 4 Chip Selection
  - Signal: **NCS3~NCS6**
- Signal Level: CMOS/3.3V
Predefine Pins
- Reset Button (CN2, pin#35, \textit{RST\#1}), input
- Buzzer (CN2, pin#37, \textit{BUZR}), output
- System ready LED (CN2, pin#38, \textit{RDY\_LED}), output
- LAN activity LED (CN3, pin#11, \textit{ACT\_LED}), output

Undefined Digital IO Pins (reserved)
- CN1: pin#23, #24, #25, #26
- CN3: pin#23, #24

Debug Port:
- Serial Console: Tx/Rx
  Signal: \textit{Tx} share with \textit{RTS2}
  \textit{Rx} share with \textit{CTS2}
- JTAG: For low level debug
  Signal: \textit{NTRST, TDI, TMS, TCK, TDO}

Power
- Input: 3.0 to 3.6VDC (3.3V nominal)
- Consumption: 2.5W
4. Software Specifications

4.1 General

- OS: Linux 2.6.14
- Boot Loader: U-Boot 1.1.2
- File System: JFFS2, EXT2/EXT3, VFAT/FAT, NFS

4.2 Protocol Stacks

- IPV4, ICMP, ARP, DHCP, NTP, TCP, UDP, FTP, Telnet, HTTP, PPP, PPPoE, CHAP, PAP, SMTP, SNMP V1/V3, SSL, SSH 1/2

4.3 Utilities

- Bash: Shell Command
- Tinylogin: Login and user manager utility
- Telnet: Telnet client program
- Busybox: Linux utility collection
- FTP: FTP client program

4.4 Daemon

- pppd: Dial In/out over serial port and PPPoE
- snmpd: SNMP agent program
- telnetd: Telnet server program
- inetd: TCP server program
- ftpd: FTP server program
- boa: Web server program
- sshd: secured shell server
- iptables: Firewall service manager
- armd: Artila manager daemon

4.5 Toolchain for Windows / Linux

- GCC: C/C++ PC cross compiler
- GLIBC: POSIX Library

4.6 Standard Device Drivers

- ttyS0: serial console port (AT91RM9200 debug port)
- ttyS1~ttyS4: serial ports (AT91RM9200 UART0~UART3)
- gpio: General Purpose I/O
- mmc: SD/MMC:
- rtc: Real Time Clock
- sda: USB flash memory disk
- ttyACM: USB Modem
- ttyUSB: USB RS-232 adaptor
- spi: spi bus

4.7 Default Setting
- Default IP Address: 192.168.2.127
- Netmask: 255.255.255.0
- ssh Login: root
- Password: root
- Telnet Login: guest
- Password: guest
- Terminal type: VT100

4.8 Network Configuration
To configure the IP address, Netmask and Gateway setting, please modify `/disk/etc/rc` as following:

```
# Static IP
ifconfig eth0 192.168.2.127 netmask 255.255.255.0
```

For DHCP setting:
```
# DHCP
dhcpcd eth0 &
```

4.9 Wireless LAN Configuration
M-501 supports wireless LAN by using USB WLAN adaptor which uses Ralink RT2571 controller. Please refer to the website: [http://ralink.rapla.net](http://ralink.rapla.net) for the supporting list of the USB WLAN adaptor. To configure the wireless LAN setting, please use command:

```
ifconfig wlan0 up
iwconfig wlan0 essid XXXX key YYYYYYYY mode MMMM
```

For infrastructure mode XXXX is the access point name and YYYYYYYY is the encryption key and MMMM should be managed.

For Ad-Hoc mode mode XXXX is the M-501 device name and YYYYYYYY is the encryption key MMMM should be ad-hoc.

To configure the IP address use command:
```
dhcpcd wlan0 & or ifconfig wlan0 192.168.2.127 netmask 255.255.255.0
```
4.10 Install GNU Toolchain
Find a PC with Linux 2.6.X Kernel installed and login as a root user then copy the
arm-linux-3.3.2.tar.gz to root directory \ of PC. Under \ directory type following command to install the
M-501 Toolchain.

```
#tar zxvf arm-linux-3.3.2.tar.gz
```

4.11 I/O Devices Control
M-501 uses standard I/O device control to access following devices:
- Ethernet: eth0
- Serial Ports: ttyS1, ttyS2, ttyS3, ttyS4
- Serial Console Port: ttyS0
- Real time clock: rtc
- USB Flash Disk: sda, sda1, sdb, sdb1
- SD memory Card: mmc0
- USB WLAN dongle: wlan0
- USB Serial Cable: ttyUSB0, ttyUSB1
- SPI bus: spi0, spi1

**Note**
Remember to include the “matrix500.h” header file in your program. Please refer to the example program included in the M-501 SDK CD to demo the RS-232/422/485 mode configuration of serial port 1 configuration.

4.12 File System
Matrix-500 uses jffs2 file system for the built-in flash memory disk. The directory are:
- /disk
- /home
- /etc

Write data to these directories are saved to flash memory and will not be erased after power off.

4.13 Mount External Disk
To mount the USB Flash Disk and SD memory card, use following commands after the disk are installed properly.

To mount USB disk

```
mount /mnt/sda or mount /mnt/sda1 or mount /mnt/sdb or mount /mnt/sdb1
```

To find out the device name of the USB disk, you can use

```
dmesg | grep sd
```
And to mount SD memory card

```bash
mount /mnt/mmc
```

### 4.14 Web Page Directory

The web pages are placed at `/home/httpd` and the `boa.conf` contains the boa web server settings. The home page name should be `index.html`.

### 4.15 Welcome Message

The welcome message “Artila” can be modified by editing the `/etc/motd` file.

### 4.16 Manager Utility Software

The Manager Utility software, `manager.jar` is a java program and is used to discovered the Matrix-500 in the network if the IP address is forgotten. It can be run at any OS where java run time is available. To install the java run time platform at your computer, please visit [http://java.sun.com](http://java.sun.com) and download the Java 2 Standard Edition (J2SE). Once the Matrix-500 is found, you can click the Telnet Console to configure the Matrix-500.

### 4.17 Upload file to M-501

To upload the file to M-501, you can use FTP command in command line or Web Browser such as Microsoft Internet Explorer. Type `ftp://192.168.2.127` and under the file menu, click log on option to login M-501. After login, you can see the files system of M-501.

### 4.18 Compile and upload the C program

Use following command of the GNU cross compiler to compile the C program:

```bash
#arm-linux-gcc –o hello hello.c
```

Then upload the `hello` to M-501. Remember to change the mode of the file. After upload to M-501 by `chmod +x hello`
5. Mechanical Dimension
## 6. Pin Assignment and Definition

<table>
<thead>
<tr>
<th>Function</th>
<th>CPU</th>
<th>SoM</th>
<th>SoM</th>
<th>CPU</th>
<th>Function</th>
</tr>
</thead>
<tbody>
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<td>A0</td>
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<td>2</td>
<td>D0</td>
<td>(Data Bus)</td>
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<td>18</td>
<td>NOE NRD</td>
<td>(Read Enable)</td>
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**CN1**
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<td></td>
</tr>
<tr>
<td>(GPIO) PC0</td>
<td>33</td>
<td>34</td>
<td>PIO9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(GPIO) PC2</td>
<td>35</td>
<td>36</td>
<td>PIO11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(GPIO) PC5</td>
<td>37</td>
<td>38</td>
<td>PIO13</td>
<td></td>
<td></td>
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<tr>
<td>(GPIO) PB28</td>
<td>39</td>
<td>40</td>
<td>PIO15</td>
<td></td>
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<tr>
<td>(GPIO) PD24</td>
<td>41</td>
<td>42</td>
<td>PIO2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(COM1) TXD1</td>
<td>43</td>
<td>44</td>
<td>RXD1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(COM1) CTS1</td>
<td>45</td>
<td>46</td>
<td>RTS1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(COM2) DTR2</td>
<td>47</td>
<td>48</td>
<td>TXD2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(COM2) RXD2</td>
<td>49</td>
<td>50</td>
<td>DCD2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. M-501 Evaluation Board Layout

- USB 2.0 Host
- LAN 1
- Reset Button
- GPIO 0~15
- Power +9~40VDC

- DIP Switches
- Power LED
- Ready LED
- LAN Link/Act
- GPIO 16~31
- CN8

- LED COM1~4

- COM1 RS-232
- RS-422
- RS-485

- COM2 RS-232
  With RTS
  With CTS

- COM3 RS-232
  With RTS
  With CTS

- COM4 RS-232
  With RTS
  With CTS
8. Enable Serial Console Port

**Step 1:** M-501 serial console port (ttyS0) shares three data pins with serial port P3 (RS-232 port ttyS3).

- `ttyS0. Tx` <=> `ttyS3. RTS`
- `ttyS0. Rx` <=> `ttyS3. CTS`
- `ttyS0. GND` <=> `ttyS3. GND`

Connect the Console cable to Port 3 and the serial port of your computer.

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>RS-232</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>TXD</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
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<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>RXD</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

**Step 2:** Once the serial console (ttyS0) are connected correctly to your PC, you need to use a terminal software such as hyper terminal of Microsoft and the serial port setting as 115200, N, 8, 1 and no flow control. Terminal type is VT100.

**Step 3:** Power on M-501 then you will see the message from your terminal software as follow:

Once “Starting Matrix 500” appears, please keep typing “@” to trigger the serial load program. Then you will see the Artila loader menu appear. If you miss the trigger procedure, please reset the M-501 and repeat step 3 again.
**Step 4:** Now you can type “A” to enable the serial console function. Once you see the console is enabled as follow, press “q” to return to main menu of console. Then please type “R” to reboot the system.

![Serial Console Enable](image1)

**Step 5:** Once you complete system debug, please remember to disable the serial console using the Toggle Console item by typing “A”.

![Serial Console Disable](image2)
9. Pin Assignment of Connectors

9.1 LAN1 and LAN2

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ETx+</td>
</tr>
<tr>
<td>2</td>
<td>ETx-</td>
</tr>
<tr>
<td>3</td>
<td>ERx+</td>
</tr>
<tr>
<td>6</td>
<td>ERx-</td>
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</table>

9.2 GPIO Port 0~15 and GPIO Port 16

<table>
<thead>
<tr>
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<th>Signal</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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</tr>
<tr>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>+3.3V</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
</tr>
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<td>4</td>
<td>15</td>
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<tr>
<td>5</td>
<td>GND</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>DIO10</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>11</td>
<td>DIO8</td>
</tr>
<tr>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>14</td>
<td>DIO6</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
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<tr>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>DIO0</td>
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9.3 COM Port

<table>
<thead>
<tr>
<th>Pin</th>
<th>RS-232</th>
<th>RS-422</th>
<th>RS-485</th>
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<tbody>
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<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>RTS</td>
<td>TXD+</td>
<td>Data+</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>4</td>
<td>TXD</td>
<td>TXD-</td>
<td>Data-</td>
</tr>
<tr>
<td>5</td>
<td>RND</td>
<td>RXD+</td>
<td>---</td>
</tr>
<tr>
<td>6</td>
<td>RND</td>
<td>RXD-</td>
<td>---</td>
</tr>
<tr>
<td>7</td>
<td>CTS</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>8</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

9.4 JP2 Serial Console Port

1. TxD
2. RxD
3. VCC3
4. GND

9.5 JP1 of M-501 Boot Mode Selection Jumper

1. 1-2: Internal ROM
2. 2-3: External Flash (Default)
9.6 CN4 JTAG Connector

![JTAG Connector Diagram]

9.7 CN8 Local Bus Connector

1. 1x14 Pin Header Pitch 2.54mm
2. CN8 directly connect to CN1 of M-501

<table>
<thead>
<tr>
<th>A0</th>
<th>1</th>
<th>2</th>
<th>D0</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>3</td>
<td>4</td>
<td>D1</td>
</tr>
<tr>
<td>A2</td>
<td>5</td>
<td>6</td>
<td>D2</td>
</tr>
<tr>
<td>A3</td>
<td>7</td>
<td>8</td>
<td>D3</td>
</tr>
<tr>
<td>A4</td>
<td>9</td>
<td>10</td>
<td>D4</td>
</tr>
<tr>
<td>A5</td>
<td>11</td>
<td>12</td>
<td>D5</td>
</tr>
<tr>
<td>A6</td>
<td>13</td>
<td>14</td>
<td>D6</td>
</tr>
<tr>
<td>A7</td>
<td>15</td>
<td>16</td>
<td>D7</td>
</tr>
<tr>
<td>NWE_NWR0</td>
<td>17</td>
<td>18</td>
<td>PC10/NCS4</td>
</tr>
<tr>
<td>NCS3</td>
<td>19</td>
<td>20</td>
<td>PC12/NCS6</td>
</tr>
<tr>
<td>PC11/NCS5</td>
<td>21</td>
<td>22</td>
<td>PA24</td>
</tr>
<tr>
<td>PA21</td>
<td>23</td>
<td>24</td>
<td>PB18</td>
</tr>
<tr>
<td>PB7</td>
<td>25</td>
<td>26</td>
<td>GND</td>
</tr>
<tr>
<td>VCC3</td>
<td>27</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>

9.8 CN7 (SPI) Pin Assignment

1. MISO (Master In Slave Out)
2. MOSI (Master Out Slave In)
3. SPCK (SPI Serial Clock)
4. NPCS0 (SPI Chip Select 0)
5. NPCS1 (SPI Chip Select 1)