

**TS-7200 User's Manual**





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This revision of the TS-7200 manual is dated  
June, 2005

All modifications from previous versions are listed in Appendix B.

A PDF version of this manual is included on the CD that shipped with your unit(s).  
The PDF version includes many active links that may be useful to you.

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## 1 Product Overview

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### 1.1 About This Manual

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This manual is intended to provide the user with an overview of the board's features, benefits, specifications, and set up procedures. It also contains important safety information.

### 1.2 Introduction

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The model TS-7200 is a compact, full-featured Single Board Computer (SBC) based on the Cirrus EP9302 ARM9 CPU. The EP9302 features an advanced 200 MHz ARM920T processor design with a memory management unit (MMU) that allows support for high-level operating systems such as Linux, Windows CE, and other embedded operating systems. The ARM920T's 32-bit architecture, with a five-stage pipeline, delivers very impressive performance at very low power.

The EP9302 CPU has a 16 KB instruction cache and a 16 KB data cache to provide zero-cycle latency to the current program and data, or they can be locked to guarantee no-latency access to critical sections of instructions and data. For applications with instruction-memory size restrictions, the ARM920T's compressed Thumb instruction set can be used to provide higher code density and lower Flash storage requirements.

The TS-7200 CPU integer performance at 200 MHz is about twice as fast as the Technologic Systems 133MHz 586-based products, but costs half as much!

## 1.3 Features and Benefits Summary

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### The TS-7200 comes standard with these features:

- 200 MHz ARM9 CPU with MMU
- 32MB RAM
- 8MB on-board Flash (Boots to Linux)
- True IDE Compact Flash socket (for additional Flash memory)
- 10/100 Megabit Ethernet port
- 2 USB compliant Full Speed host (OHCI) ports -- (12 Mb/s max)
- 2 COM ports (up to 230 Kbaud)
- Watchdog Timer
- PC/104 expansion bus
- SPI bus interface
- 20 Digital I/O lines
- Alphanumeric LCD and matrix keypad interface
- Single +5VDC supply @ 450 mA
- Small size -- 3.8 x 4.5 inches (9.7 x 11.5 cm)

### These optional features are also available:

- 8-channel 12-bit analog-to-digital converter
- Battery-backed Real-Time Clock (TS-5620)
- RS-485 support on COM2 with automatic TX enable
- Temperature sensor
- Additional COM ports

### TS-7200 power supply:

The TS-7200 requires **regulated** 5VDC at 450 mA @ 200 MHz(maximum). It is possible to lower this power significantly by lowering the CPU clock rate or by powering-down the Ethernet PHY chip. For example, by shutting down the Ethernet PHY chip and scaling down the CPU clock rate to 20 MHz, one can obtain power consumptions less than 150 mA.

A quick release screw-down terminal block for the 5V power and power GND connections is provided for easy connection to an external power supply.



Note:  
Supply voltages over 6 VDC may damage the TS-7200.

Be sure to use a **regulated** 5 VDC power supply, preferably with current limiting to 1 to 3 Amps. A current limited supply is very forgiving of common errors during development. A PC power supply that may be capable of supplying 20 Amps or more is not recommended -- it is possible to do irreversible damage to the TS-7200 if the polarity on the power leads is reversed.

When power is first supplied to the TS-7200, the board mounted LEDs are immediately turned on under hardware control. Once the processor begins execution, the LEDs are turned off. The RED led is briefly turned on while the processor looks for the TS-BOOTROM stored in the first sector of Flash. If the processor does not find the TS-BOOTROM, it will turn off the red LED and continuously blink the green LED. If the LEDs do not turn on at all, the most likely problem is the power supply. Check that the +5V and GND connections are not reversed. A diode protects the board against

damage in such a situation.

Once the processor has found the TS-BOOTROM, the green LED is turned on just before jumping to it. The TS-BOOTROM briefly turns off the green, and turns on the RED, while running the SDRAM initialization and test routines, but otherwise remains green until RedBoot is called and starts its own initialization. If a problem was detected with the hardware in the TS-BOOTROM, the LEDs blink alternately red, then green, at a very fast rate. The red LED is on during RedBoot initialization, and once complete, the green LED is lit and remains on from that point forward.

## 1.4 Related Products

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Technologic Systems offers an enclosure for the TS-7200. Several daughter boards are also available that can add functionality via the PC/104 bus. Since the PC/104 bus is an industry standard, an almost unlimited number of third-party products can be added via the PC/104 expansion bus.

## 2 Memory

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### 2.1 SDRAM

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The TS-7200 uses a 256 Megabit SDRAM chip to provide 32 Megabytes (MB) of high-speed RAM. By using the latest SDRAM technology (a 512 Megabit chip), it is possible to have 64 MB of RAM on the TS-7200. This option will be available in the near future when this technology becomes cost-effective.

The TS-7200 SDRAM chip is soldered directly to the board. By not using socketed memory, the TS-7200 is much more reliable in high-vibration environments.

The TS-7200 RAM is not contiguous in the physical memory map of the EP9302. But the MMU is programmed to remap the blocks of RAM to appear as a contiguous block of memory at the very beginning of the virtual memory map. In the case of a 256 Megabit SDRAM chip (32 MB), it is located at 0 through 32 MB in the virtual memory map.

### 2.2 Flash

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The TS-7200 uses an Intel 3.3V StrataFlash chip for its on-board Flash resource. For the standard 8 Megabyte chip, this is composed of 64 uniform sectors with 128 Kbytes per sector. The first sector is reserved for the TS-BOOTROM code. The TS-BOOTROM code initializes various internal configuration registers for proper operation for the TS-7200 design and initializes and tests the SDRAM. The next 48 sectors (6 Mb) are used for the JFFS2 file system. This is a journaling file system that uses wear leveling at the file system level to maximize Flash lifetime. It is also extremely tolerant of power failures during file write sequences. The last 1920Kb are reserved for the RedBoot ROM monitor, RedBoot FIS (Flash Image System) and RedBoot FCONFIG (Flash config). The default Linux kernel, vmlinux, is pre-loaded in the FIS and the default boot script and Ethernet MAC address are contained in the FCONFIG. You may also use the RedBoot FIS to store and load Flash images that contain eCos applications or other OS/RTOS bootloaders.

The physical address of the Flash chip is 0x6000\_0000 through 0x607F\_FFFF for the 8 MB chip. It is possible to use larger sizes of the Intel Strata Flash than the standard 8MB chip. The TS-7200 is designed to accommodate both 16 MB and 32 MB chips. Please call Technologic Systems to discuss lead times and current costs for these options.

The entire Flash chip can be write-protected by removing Jumper #3. When JP3 is not installed the Flash chip becomes a **read-only** resource.

The designer should be aware that Flash technology does have a wear-out mechanism that should be considered in all designs. The Intel Strata Flash memory is guaranteed capable of a minimum of 100,000 write/erase cycles. This means that if you completely erase and rewrite the entire Flash drive 10 times a day, it would take over 27 years before any problems would occur. Reading the Flash produces no wear at all.



## 2.3 Battery Backed SRAM

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There is a daughter board available for the TS-7xxx products (TS-NVRAM) that will allow adding 32K bytes or 128 Kbytes or 512K bytes of battery-backed SRAM. Battery backed SRAM provides non-volatile memory with very fast write times and unlimited write cycles, unlike Flash memory. This can be very important if the data is constantly being updated several times per minute, since Flash devices can wear-out after a few million write cycles. It also eliminates the latency that Flash memory has during write cycles, since Flash technology write cycles are about 10-100 times slower than read cycles.

The TS-NVRAM daughter card is located at the PC/104 memory space base address of 0x11AA\_0000. This resource is a byte-wide memory device using a lithium battery that is guaranteed to last a minimum of 10 years with or without power applied.

## 2.4 Compact Flash Cards

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If the 6MB or 14MB Flash file system on the TS-7200 is insufficient for your application, additional non-volatile storage can be added with a Compact Flash (CF) card. CF cards can supply additional storage that behaves much as a hard drive does with sizes ranging from 32MB to 1GB. These products are inherently more rugged than a hard drive since they are completely solid-state with no moving parts.

The Compact Flash card has the added advantage of being removable media. A SanDisk USB Compact Flash reader/writer (which is included in the TS-7200 Developer's Kit) is recommended for the host PC for file transfers. This results in the ability to quickly move files from a host PC to the TS-7200 using a Compact Flash card as the removable media. While a USB Compact Flash reader allows for hot swapping of the Compact Flash card on the host PC, the Compact Flash interface on the TS-7200 is **not** hot swappable, the TS-7200 must be rebooted after removing or installing a Compact Flash card.

The format of the CF card must be in EXT2 format for proper operation with Linux as a root filesystem.



**Note:**

The TS-7200 always needs to be powered-off before swapping CF cards.

## 2.5 USB Flash Drives

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Additional non-volatile storage can be added with a USB Flash drive. USB Flash drives can supply additional storage that behaves very much like a CF card except that a CF card can be the root drive whereas a USB drive can not be the root file system.

The USB Flash drive has the advantage over a CF card in that the USB drive can be hot swapped.

After booting into the demonstration TSLinux Operating System hosted on the on-board Flash, one can 'boot' into the Debian OS hosted on a thumb-drive with two scripts found on the demonstration TSLinux Operating System. First, invoke `/usr/bin/loadUSBModules.sh`, then run the script `/usr/bin/loadUSB.sh` to chroot into the Debian OS on the thumb-drive to take full advantage of such things as the Debian arm-toolchain.

For those who simply wish to load in the correct device drivers to access the USB thumb-drive when booted into the demonstrative TSLinux OS, simply invoke the `/usr/bin/loadUSBModules.sh` script.



**Note:**

Drivers are available in the TS-Linux distribution to support USB Flash Drives.

## 3 Serial Ports

The TS-7200 has two asynchronous serial ports (COM1 and COM2) provide a means to communicate with external serial devices. Each is independently configured as a 16C550- type COM port that is functionally similar to a standard PC COM port. These ports have 16-byte FIFOs in both the receive and the transmit UART channels.

Both COM ports can support all standard baud rates up through 230.4Kbaud. Both COM ports may be configured to use a DMA channel (useful when very high baud rates are being used).

Either UART can generate:

- four individually-maskable interrupts from the receive, transmit, and modem status logic blocks
- a single, combined interrupt that is asserted if any of the individual interrupts are asserted and unmasked

COM1 can also support HDLC protocol -- [Download the EP9301 User Guide](#) for more details.

COM2 can optionally support RS-485 half or full duplex levels.

### 3.1 COM1

The base address of COM1 appears in the physical address space at **0x808C\_0000**.

COM1 has RS-232 support for the following signals:

- TXD
- RXD
- RTS
- CTS
- DTR
- DSR
- DCD

This full complement of RS-232 signals (all except Ring Detect) allows COM1 to interface to almost any serial RS-232 device.

The COM1 RS-232 port uses a DB-9 male connector on the TS-7200. See Table 3.1 for a list of COM1 pin-outs.

**Table 3.1 COM1 DB9 Pin-Outs**

DB9 Pin	Signal	Description
1	DCD	Data Carrier Detect
2	RXD	Receive Data
3	TXD	Transmit Data
4	DTR	Data Terminal Ready
5	GND	Ground
6	DSR	Data Set Ready
7	RTS	Request to Send
8	CTS	Clear to Send
9	--	--

### 3.2 COM2

The base address of COM1 appears in the physical address space at **0x808D\_0000**.

COM2 has RS-232 support only for the TXD and RXD signals. This is sufficient to interface with serial devices that only require transmit and receive data lines. COM2 is accessible on a 10-pin header labeled COM2. Adaptor cables are available to convert these into standard 9-pin SubD male connectors.

**Table 3.2a COM2 Serial Port Header Pin-Outs**

RS-232		Half Duplex RS-485		Full Duplex RS-485	
9-Pin SubD	Signal	9-Pin SubD	Signal	9-Pin SubD	Signal
1		1	TX+ / RX+	1	TX+
2	RXD	2		2	
3	TXD	3		3	
4		4		4	RX+
5	GND	5	GND	5	GND
6		6	TX- / RX-	6	TX -
7		7		7	
8		8		8	
9		9		9	RX -

In addition, COM2 has optional support for full or half-duplex RS-485. See Table 3.2 for COM2 pin-outs.



Note:

The COM2 serial port 10-pin header has both RS-232 and RS-485 signals. Only one set is in use for a given application – it is not possible to use both at the same time.

The pin-outs for the COM2 10-pin header are listed in Table 5.2a. (NC = No Connection)

**Table 3.2b COM2 Serial Port Header Pin-Out (showing non-standard numbering scheme)**

TX-	RX-	NC	NC	TX-
6	7	8	9	10
1	2	3	4	5
TX+	RXD	RXD	RX+	GND



Note:

The COM2 serial port header uses a non-standard numbering scheme. This was done so the header pins would have the same numbering as the corresponding DB-9 pin; i.e. pin 3 (TXD) on the header connects to pin 3 on the DB-9.

### 3.3 RS-485 Support

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An option is available to add support to COM1 for half duplex or full duplex RS-485. RS-485 drivers allow communications between multiple nodes up to 4000 feet (1200 meters) via twisted pair cable. Half-duplex RS-485 requires one twisted pair plus a Ground connection, while full duplex requires two twisted pair plus a Ground.

For half-duplex operation, a single twisted pair is used for transmitting and receiving. The Auto485.exe utility must be run to initialize the automatic RS-485 control logic. For full-duplex operation, two twisted pairs are used and the transmit driver is typically enabled all the time. The auto485.exe utility must be run to put the logic into full-duplex RS-485 mode.

Fail-safe bias resistors are used to bias the TX+, TX- and RX+, RX- lines to the correct state when these lines are not being actively driven. This is an important consideration, since in a typical RS-485 installation, the RS-485 drivers are frequently tri-stated. If fail-safe bias resistors are not present, the 485 bus may be floating and very small amounts of noise can cause spurious characters at the receivers. 4.7KW resistors are used to pull the TX+ and RX+ signals to 5V and also to bias the TX- and RX- signals to ground.

Termination resistors in many installations are not required when cable lengths are less than 50 meters and the baud rate is 9600 or less. Termination resistors may be required for reliable operation when running longer distances or at higher baud rates.

Termination resistors (typically 100-150 ohms) should only be installed at each end of an RS-485 transmission line. In a multi-drop application where there are several drivers and/or receivers attached, only the devices at each end of the transmission line pair should have termination resistors.

A read at I/O location **0x2240\_0000** bit 1 will return a "1" when the RS-485 option is installed.

### 3.4 RS-485 Quick-Start Procedure

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Perform the following steps:

1. Check that the RS-485 option is installed in the TS-7200 (required).
2. Attach the RS-485 cable to the 10-pin header. (Adaptor cables to SubDB9 connector are available from Technologic Systems.)
3. Set the COM2 UART serial parameters (baud rate, data, parity, and stop bits, interrupts, etc) in your source code
4. Use the `TIOC_SBCS485 ioctl()` to enable the automatic RS-485 feature.
5. Simply read `()` and write `()` data to the COM2 UART – the automatic RS-485 logic controls TX enable.

### 3.5 Automatic RS-485 TX Enable

TS-7200 supports fully automatic TX enable control under hardware control. This simplifies the design of half-duplex systems since turning off the transmitter and enabling the receiver in software is typically difficult to implement. If this is implemented in software, then the COM2 UART transmit holding register and the transmit shift register both must be polled until empty before deasserting the TX enable signal to the RS-485 driver. The design gets more complicated when using the TX FIFO or when using a multi-tasking OS such as Linux.

**Table 3.5 COM2 Mode Register**

Value (Hex)	MSB	MID	LSB	Mode
00	0	0	0	RS-232
01	0	0	1	Full-Duplex RS-485
02	0	1	0	-- Reserved
03	0	1	1	-- Reserved
04	1	0	0	Half-Duplex 9600 baud
05	1	0	1	Half-Duplex 19.2Kbaud
06	1	1	0	Half-Duplex 57.6Kbaud
07	1	1	1	Half-Duplex 115.2Kbaud

The implementation on the TS-7200 uses hardware in a Xilinx PLD to automatically control when the RS-485 drivers and receivers are selected. The automatic RS-485 logic eliminates the need for any software polling and supervision. A counter in the Xilinx PLD is used to keep track of the bits shifting out the COM2 UART. This circuit automatically turns on/off the RS-485 transceiver and receiver at the correct times. This only requires the COM2 Mode registers in the PLD to be initialized once based on baud rate and data format.

COM2 will default to RS-232 mode at reset (COM2 mode register = Hex 00). In order to switch COM2 into Full duplex RS-485 mode, the COM2 Mode register at 0x22C0\_0000 must be set to Hex 01. In this mode, the TX drivers are always asserted.

In order to switch COM2 into half-duplex RS-485, then the COM2 mode register at 0x22C0\_0000 must be set to Hex 04, 05, 06 or 07 depending upon the baud rate required. Baud rates of 9600, 19.2K, 57.6K and 115.2K are supported. If you need to operate COM2 in half-duplex RS-485 at any other baud rate, then contact Technologic Systems.

A second COM2 Mode register at **0x2300\_0000** must be set to Hex 01 if the COM2 is in half-duplex mode and the data format is using 8 data bits with parity or 8 data bits with 2 stop bits.



**Note:**

COM2 can support half-duplex RS-485 baud rates of 9600, 19.2K, 57.6K and 115.2Kbaud. For any other baud rate, [contact Technologic Systems](#).

### 3.6 Using Automatic RS-485 within Linux

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A special ioctl command has been added to the Linux kernel's serial code to turn off and on the automatic RS-485 feature. The header files needed to be included from the Linux kernel source tree and an applications source code are linux/ts\_sbc.h and linux/include/asm/ioctls.h. These header files can be found in a Linux kernel patched with an appropriate patch from Technologic Systems. The following snippet of code demonstrates the use of this ioctl.

```
#include <linux/ts_sbc.h>
#include <linux/include/asm/ioctls.h>
<snip>
mcr = AUTO485FD
//mcr = AUTO485HD //for half duplex
ioctl (fd, TIOC_SBCS485, &mcr);
//write() and read() from fd

ioctl (fd, TIOC_SBCC485, &mcr);
//further reads() and writes() may not behave
```

### 3.7 Adding Serial Ports

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If your project requires more than two serial ports, additional ports may be added via the PC/104 expansion bus. Technologic Systems offers three different daughter boards (TS-SER1, TS-SER2, and TS-SER4) that add 1, 2, or 4 extra COM ports respectively. These can be configured using PC designations COM1, COM2, or higher. These will appear in the TS-7200 PC/104 address space (0x11A0\_0000 base address). For example, a TS-SER1 daughter board can be jumper selected as COM3 which would correspond to a PC I/O base address of 0x3E8. On the TS-7200, this COM port will appear at the physical base address of 0x11A0\_03E8.

The TS-7200 PC/104 expansion bus has IRQ5, IRQ6, and IRQ7 available for additional serial port interrupts.

Typically each serial port has a dedicated interrupt, but the TS-SER4 daughter board allows all four extra serial ports to share a single interrupt. This is very helpful in systems with a large number of serial ports since there are a limited number of IRQ lines available.



**Note:**

Drivers are available in the TS-Linux distribution to support these extra COM ports.

## 4 Digital I/O

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There are 20 Digital Input/Output (DIO) lines available on the TS-7200. These are available on two headers labeled "DIO" and "LCD". The header labeled LCD can be used as 11 DIO lines or as an alphanumeric LCD interface ([See Section 4.2](#)). The header labeled DIO has 9 DIO pins available. In addition to the DIO signals, each header also has a power pin and Ground available. The LCD header has 5V power available while the DIO header has 3.3V power.

Three pins on the DIO header are used to bring out the EP9302 SPI bus. By using some of the DIO pins as peripheral Chip Select signals, a complete interface is available for SPI peripherals. It is also possible to bring out a fourth SPI bus function [SPI\_Frame] by adding a 10 ohm resistor in the position labeled R1 on TS-7200 RevB boards. This signal is not required for many SPI peripherals but it may prove useful in some applications.

All of the DIO lines are programmable as either inputs or outputs and the direction of each I/O pin can be individually programmed. All DIO control registers are 8-bits wide and aligned on word (32-bit) boundaries. For all registers, the upper 24 bits are not modified when written and are always read back as zeros. Every DIO pin has two registers used to access it, an 8-bit data register and an 8-bit data direction register (DDR). The DDR controls whether each DIO pin is an input or an output ("1" = output). Writing to the data register only affects pins that are configured as outputs. Reading the data register always returns the state of the DIO pin.

Many of the DIO pins (DIO\_0 thru DIO\_8 and LCD\_0 thru LCD\_7) can also be programmed to cause interrupts. The interrupt properties of these pins are individually configurable -- each interrupt can be either high or low level sensitive or either rising or falling edge triggered. It is also possible to enable debouncing on any of these interrupts. Debouncing is implemented using a 2-bit shift register clocked by a 128 Hz clock. [Download the EP9301 User Manual](#) and see Chapter 21 for details.

The TS-7200 RevB boards also allow access to two 12-bit A/D channels on the DIO header.

The 5V power output pin on the LCD header has a 750 mA Poly-Fuse to prevent excessive current. The 3.3V power on the DIO header is current limited to approximately 1 Amp by an LM1117 3.3V regulator.



## 4.1 DIO Header

The DIO port provides +3.3V, GND, the SPI bus, and 9 digital I/O lines that may be used to interface the TS-7200 with a wide range of external devices. DIO lines DIO\_0 thru DIO\_7 are a byte-wide port using Port B on the EP9302 and are accessed via the data register at physical address location 0x8084\_0004. The DDR for this port is at 0x8084\_0014.

DIO\_8 is accessed via bit 0 of Port F in the EP9302 and is accessed via the data register at physical address location 0x8084\_0030. The DDR for this port is at 0x8084\_0034. It is important not to change the other bit positions in these Port F registers since these other DIO pins are being used on the TS-7200. All accesses to these registers should use read-modify-write cycles.



### Warning:

All pins on the DIO header use 0-3.3V logic levels. Do not drive these lines to 5V.

When the DIO pins are configured as outputs, they can source 4 mA or sink 8 mA and have logic swings between 3.3V and ground. When configured as inputs, they have standard TTL level thresholds and must not be driven below 0 Volts or above 3.3 Volts. DIO lines DIO\_0 thru DIO\_3 have 4.7 Kohm pull-up resistors to 3.3V biasing these signals to a logic "1". The other DIO pins have 100 Kohm bias resistors biasing these inputs to a logic "1".

DIO signals DIO\_0 thru DIO\_7 are physically arranged to allow a 16-pin (2x8) ribbon cable to directly connect a 4x4 **matrix keypad**. Drivers are available for this interface.



### Note:

The SPI interface is described in [section 4.3](#).

**Table 4.1 DIO Header Pin-Out**

Header Pin	Description
1	DIO_0
2	GND
3	DIO_1
4	EP9302 ADC0
5	DIO_2
6	EP9302 ADC4 or SPI_Frame
7	DIO_3
8	DIO_8
9	DIO_4
10	SPI_MISO
11	DIO_5
12	SPI_MOSI
13	DIO_6
14	SPI_CLK
15	DIO_7
16	3.3 V

## A/D Converter

The DIO Port pins 4 and 6 are connected to two of the EP9302 12-bit A/D converter inputs. These can be used to measure analog signals in the range of 0 to 3.3V.

## 4.2 LCD Header

The LCD Port can be used as 11 additional digital I/O lines or it can be used to interface to a standard alphanumeric LCD display. The header has been arranged to allow a 14-pin ribbon cable to directly connect to industry standard LCD displays. Technologic Systems has available a 2x24 LCD display with software drivers for rapid development.

DIO lines LCD\_0 thru LCD\_7 are a byte-wide port using Port A on the EP9302 and are accessed via the data register at physical address location 0x8084\_0000. The DDR for this port is at 0x8084\_0010.

Since this port is interfacing to a 5V LCD, 1.0 Kohm resistors have been added in series between the EP9302 and the LCD\_0 thru LCD\_7 pins. This is required since the LCD data bus could be driving these lines above 3.3V. The series resistors prevent the LCD from overdriving the EP9302 Port A pins. If using these pins for general purpose DIO, the current sourcing and sinking capability of these DIO pins is limited by the 1.0 Kohm resistors.

LCD\_EN, LCD\_RS, and LCD\_WR are DIO pins using EP9302 Port H bits 3 through 5 respectively and are accessed via the data register at physical address location 0x8084\_0040. The DDR for this port is at 0x8084\_0044. When these DIO pins are configured as outputs, they can source 4 mA or sink 8 mA and have logic swings between 3.3V and ground. When configured as inputs, they have standard TTL level thresholds and must not be driven below 0 Volts or above 3.3 Volts. These DIO pins have 100 KW bias resistors biasing these inputs to a logic "1". It is important not to change the other bit positions in these Port H registers since the other DIO pins are being used on the TS-7200. All accesses to these registers should use read-modify-write cycles.

**Table 4.2 LCD Header Pin-Out**

Header Pin	Description
1	5V
2	GND
3	LCD_RS
4	Bias
5	LCD_EN
6	LCD_WR
7	LCD_1
8	LCD_0
9	LCD_3
10	LCD_2
11	LCD_5
12	LCD_4
13	LCD_7
14	LCD_6



**Warning:**

LCD pins 3, 5, and 6 use 0-3.3V logic levels. Do not drive these lines to 5V.

Pin 4 on this header (labeled Bias) is a 620 ohm resistor to ground for LCD contrast biasing.

The 5V power on the LCD header has a 750 mA Poly-Fuse to limit the current.

### 4.3 Using DIO Header for SPI Bus

The EP9302 Synchronous Serial Port is available on the DIO header. This port can implement either a master or slave interface to peripheral devices that have either Motorola **SPI** or National Semiconductor **Microwire** serial interfaces. The transmit and receive data paths are buffered with internal FIFO memories allowing up to eight 16-bit values to be stored for both transmit and receive modes. The clock rate is programmable up to 3.7 MHz and has programmable phase and polarity. The data frame size is programmable from 4 to 16 bits.

By using some of the DIO Header pins as peripheral Chip Select signals, a complete interface is available for addressing up to 9 SPI peripherals. The SPI bus pins are defined in the table below.

**Table 4.3 DIO Header Pin-Outs**

Header Pin	Name	Function
10	SPI_MISO	Master Output / Slave Input
12	SPI_MOSI	Master Output / Slave Input
14	SPI_CLK	Clock
6	SPI_Frame	R1 must be added to enable



**Warning:**

The SPI bus pins use 0-3.3V logic levels. Do not drive these lines to 5V.

[Download the EP9301 User's Manual](#) and see Chapter 19 for more details on using the SPI bus.

## 4.4 LCD Interface

A 14-pin LCD connector is provided on the TS-7200 for interfacing with standard alphanumeric LCD displays. These displays use a common controller, the Hitachi HD44780 or equivalent. While software written for the HD44780 works with all displays using the controller, the cable needed is dependent on the display used. For most displays, a straight-through type ribbon cable can be used. The connector on the LCD display is typically mounted on the backside of the display.



### Warning:

Using an incorrect cable or mounting the LCD connector on the front-side can result in a reverse power polarity and can damage the LCD display. Please refer to your LCD data sheets for in-depth information.

**Table 4.4a LCD Header Signals**

PIN	Function	Comments
1	LCD_5V	LCD Power
2	LCD_GND	
3	LCD_RS	Register select
4	Bias	620 Ohm to GND
5	LCD_EN	Active high enable
6	LCD_WR#	Active low write
7	LCD_D1	D0 - D7: Buffered bi-directional data bus
8	LCD_D0	
9	LCD_D3	
10	LCD_D2	
11	LCD_D5	
12	LCD_D4	
13	LCD_D7	
14	LCD_D6	

Technologic Systems has available a 2x24 LCD display with software drivers for rapid development.

The pin-outs in the above table are not the standard given for LCD displays. However, these pin-outs allow a standard ribbon cable to be used when the ribbon cable is attached to the **backside** of the LCD.

Sample code is available for the LCD. [Contact Technologic Systems](#) for more information.

**Table 4.4b LCD Header Pin-Outs**

2	4	6	8	10	12	14
1	3	5	7	9	11	13

## 5 A/D Converter

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### 5.1 EP9302 5 Channel A/D Converter

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The Cirrus EP9302 features a 5 channel, 12-bit Analog to Digital Converter with an analog multiplexor, with an input range of 0 to 3.3 V. Only the top and bottom channels (ADC0 and ADC4) are brought out to on the TS-7200. The EP9302 A/D converter can do a maximum of 925 samples per second, and requires a settling time of 2 milliseconds between channel switches. The EP9302 A/D converter is standard on all TS-7200 boards. Note that the Cirrus A/D converter is **not** the same as the optional, full-featured MAX197 A/D converter. To maintain 12-bit accuracy, the analog signal being measured must have a low source impedance (less than 10 ohms). Otherwise, an operational amplifier may need to be added to buffer the A/D input. The EP9302 A/D converter should not be driven by a source impedance greater than 10 ohms to ensure accurate results (the EP9302 A/D converter has an input impedance that is not completely linear and may be as low as 10K ohms). For detailed information, please see the Cirrus EP9301 User's Guide, page 518, as well as the Cirrus EP9315 User's Manual, page 53. For high-performance applications, the optional MAX197 A/D converter is preferred.

The following steps outline how to use the Cirrus A/D converter.

1. Unlock the software lock before setting the TSEN bit in the ADCClk register by writing 0xAA to the ADCSWLock register (0x8090\_00C0 )
2. OR in the TSEN bit (bit 31) to the ADCClkDiv register (0x8093\_0090)
3. Unlock the software lock (again) before OR'ing in the ADCEN (ADC clock enable, bit 31) to 0x8093\_0080
4. Clear bit 2, the ADCPD (ADC Power Down) bit, at 0x8093\_0080. This bit **MUST** be set to 0 (see page 91 of the EP9302 user's manual)
5. After unlocking the software lock, write the channel's magic value (see the following table, or Cirrus EP9302 User's Guide, table 20-2) to the ADCSwitch register (0x8090\_0018) to select that channel for the next data acquisition
6. Poll the ADCResult register (0x8090\_0008) until bit 31 is not set
7. Using a 32 bit read operation, read the result from 0x8090\_0008, masking off the upper 16 bits

**Table 5.1 Cirrus ADCSwitch Values**

Input to Measure	ADCSwitch Value
ADC0	0x0000_0608
ADC4	0x0000_0610

## 5.2 Interpreting EP9302 A/D Converter

The EP9302 on-chip A/D converter is a successive approximation A/D converter. The bottom and top channels of the EP9302 A/D channel is calibrated on the TS-7200 and these 16-bit values are stored in non-volatile EEPROM. These calibration values minimize the offset errors and gain errors in the EP9302 A/D. It is important for the user program to use these values as per our sample code, which can be found either on our web-site or in the CD included in the Developer's Kit. Two reference points, 0 and 2.5 Volts, with the corresponding reference values stored in EEPROM. Bytes 0x07EB through 0x07FE of the EEPROM hold a two dimensional array, [channel number][0V ref. point, 2.5V ref. point]. The reference points are stored as a 16 bit value, and should be used to correlate the values returned by the EP9302 A/D converter to voltage.

## 5.3 TS Optional MAX197 8 Channel A/D Converter

The TS-7200 supports an optional eight-channel, 12-bit A/D converter (ADC) with a conversion time of 12  $\mu$ S. This will allow up to 60,000 samples per second. Each channel is independently software programmable for a variety of analog input ranges: -10V to +10V, -5V to +5V, 0V to +10V, or 0V to +5V. This allows an effective dynamic range of 14 bits.

Each channel is overvoltage tolerant from -16V to + 16V, and a fault condition on any channel will not affect the conversion result of the selected channel. This is all accomplished with a 5V only power supply; no negative supply voltage is required. The Maxim MAX197 chip can be replaced with a MAX199 chip if a lower range of analog input levels is required (-4V to +4V, -2V to +2V, 0V to 4V, and 0V to 2V).

A read at I/O location **0x2240\_0000** bit 0 returns a "1" when the A/D option is installed on the TS-7200.

**Table 5.3a A/D Registers**

I/O Address	Action
10C0_0000 Write	Initiate A/D Conversion
10C0_0000 Read	LSB of Conversion
10C0_0001 Read	MSB of Conversion
2240_0000 Read	Bit 0 = 1 if A/D option installed
1080_0000 Read	Bit 7 = 0 when Conversion completed

**Table 5.3b A/D Control Register (0x10C0\_0000 Write)**

Bit	Description	Details
0-2	Analog channel select	Channels 0-7
3	Unipolar / Bipolar	0 = Unipolar (i.e. 0 to +5V) 1 = Bipolar (i.e. -5V to +5V)
4	Range select	0 = 5V range 1 = 10V range
5-7	Mode bits	Set to 0, 1, 0

## 5.4 Single Sample Acquisition Procedure

An acquisition is initiated by writing to I/O location 0x10C0\_0000. The value written to this location determines the channel to convert (bits 0-2) and selects one of four input ranges (bits 3 and 4). Bits 5, 6, and 7 should be set to 0, 1, 0 respectively. After the write cycle to location 0x10C0\_0000, the MAX197 completes the A/D conversion in about 12 mS. Bit 7 at I/O location 0x2240\_0000 may be polled to determine when the conversion is complete (zero = complete). The conversion result is now available at locations 0x10C0\_0000 (LSB) and 0x10C0\_0001 (MSB). A single word read at 0x10C0\_0000 can also be used. When using unipolar modes, the result is in binary format with the upper 4 bits of the MSB equal to zero. When a bipolar mode is used, the result is in two's-complement binary with the upper 4 bits (Bits 12-15) equal to bit 11 (sign extended).

**Table 5.4a ADC Header**

Pin	Description
1	Channel 0
3	Channel 1
5	Channel 2
7	Channel 3
9	Channel 4
11	Channel 5
13	Channel 6
15	Channel 7
Even	Analog GND

If more details on the A/D converter specifications are required, go to the Maxim web site and search for MAX197.

**Table 5.4b ADC Header Pinout**

2	4	6	8	10	12	14	16
1	3	5	7	9	11	13	15

The following is sample Linux C code for initiating and printing an ADC conversion on channel 1.

```
#include<unistd.h>
#include<sys/types.h>
#include<sys/mman.h>
#include<stdio.h>
#include<fcntl.h>
#include<assert.h>
int main(int argc, char **argv) {
    volatile unsigned short * complete;
    volatile unsigned char * lsb, * msb, * control;
    int res;
    int fd = open("/dev/mem", O_RDWR);
    assert(fd != -1);
    lsb = control = (unsigned char *)mmap(0, getpagesize(),
PROT_READ|PROT_WRITE, MAP_SHARED, fd, 0x10c00000);
    msb = lsb + 1;
    complete = (unsigned short *)mmap(0, getpagesize(),
PROT_READ|PROT_WRITE, MAP_SHARED, fd, 0x10800000);
    // Initiate conversion, channel #1, unipolar, 5V
    *control = 0x41;
    // Wait for completion
    while ((*complete & 0x80) != 0);
    // Print result on a scale from 0 to 2^12 - 1
    res = *lsb;
    res |= *msb << 8;
    printf("result: %d\n", res);
    close(fd);
    return 0;
}
```

## 6 Matrix Keypad Support

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DIO signals DIO\_0 thru DIO\_7 are physically arranged to allow a 16-pin (2x8) ribbon cable to directly connect a 4x4 **matrix keypad**. Sample code is available for the Matrix Keypad. [Contact Technologic Systems](#) for more information.



## 7 Real-Time Clock

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The TS-7200 has an option for a Non-volatile Battery-backed real-time clock (RTC). This option (TS-5620) is very low-cost daughter board that is only 1.1 x 3.5 inches (2.8 x 9.0 cm) and uses an ST Micro M48T86PC1 module for the real-time clock function. This module contains the lithium battery, 32.768 kHz crystal, and a RTC chip with 114 bytes of battery-backed CMOS RAM. It is guaranteed to maintain clock operation for a minimum of 10 years in the absence of power.

The 114 bytes of non-volatile RAM that is located inside the RTC chip is not reserved for TS-7200 functionality. This RAM is available for any user functions as required. Call Technologic Systems for driver support.

The schematic for the TS-5620 is posted on our web site. The TS-5620 design only uses two chips. This circuitry can be freely used on any customer daughter board design if the battery-backed RTC feature is necessary.

The RTC is accessed using two registers. The write-only index register is located at physical address location 0x1080\_0000 and the RTC data register is location at physical address location 0x1170\_0000. These are byte-wide registers with the index register being write only and the data register being read/write. Valid index register values are between 0 and 127 decimal. The first 14 index locations are used for accessing the RTC time and date registers.

The next 114 locations are non-volatile RAM locations.

## 8 The 10/100 Base-T Ethernet Port

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The EP9302 Ethernet LAN controller incorporates all the logic needed to interface directly to any MII compatible Ethernet PHY chip. A low-power Micrel KS8721 chip is used to implement the Ethernet PHY function and an integrated RJ-45 connector with built-in 10/100 transformer and LED indicators completes the Ethernet sub-system.

The TS-7200 has both a LINK/ACTIVITY LED and a 10/100 speed LED built into each RJ-45 connector that indicates the current Ethernet status. The LINK LED (left side of connector, green) is active when a valid Ethernet link is detected. This LED should be ON whenever the TS-7200 is powered on and properly connected to a 10/100BaseT Ethernet network. The LINK/ACTIVITY LED will blink to indicate network activity for either inbound or outbound data. The SPEED LED (right side of connector, amber) will be on when a 100Mb network is detected and off for a 10Mb network. Both of these LEDs are controlled by the KS8721 and do not require any overhead by the processor.

The Ethernet PHY chip can be powered down to save about 90 mA of power consumption. This is controlled by the EP9302 Digital output on Port H bit 2. A logic zero will power down the KS8721 PHY chip.

## 9 LINUX TCP/IP Configuration

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When using the TS-7200 with TS-Linux, the driver for the Ethernet is already compiled into the kernel.

The TCP/IP settings for the demonstrative TS-Linux OS are configured in the file `/etc/sysconfig/ifcfg-eth0`. Below is a listing.

```
DEVICE=eth0           # Name of Ethernet interface
IPADDR=192.168.0.50   #IP address of this Ethernet interface
NETMASK=255.255.255.0 # Used with NETWORK to determine local IP's
NETWORK=192.168.0.0   #Used with NETMASK to determine local IP's
BROADCAST=192.168.0.255 # broadcast IP for system wide messages
ENABLE=yes           # Initialize on startup
```

The TCP/IP network settings are configured in the file `/etc/sysconfig/network_cfg`. Below is a listing.

```
### Technologic Systems
### General Network Configuration File
###
NETWORKING=yes
GATEWAY=192.168.0.1 # Gateway for internet access
GW_DEV=eth0 # Gateway device to use
Hostname="ts7200" # Host name for this computer
BOOTPROTO=static
DEFRAG_IPV4=no
FORWARD_IPV4=no
```

The TCP/IP name resolution server is configured in the file `/etc/resolv.conf`. Below is a sample.

```
nameserver 192.168.0.1 # Name server for domain name lookups.
```

To access the web server, open a web browser and enter **192.168.0.50** as the address. This displays the sample web page which demonstrates some of the functionality of Apache with PHP. Use the `ifconfig` command at the bash prompt to display the status of the Ethernet ports. See the [TS-Linux for ARM support page](#) for more information.

The OS installed on the Compact Flash is Debian, and therefore, has a different configuration framework for configuring the network devices. Please visit the Debian website ([www.debian.org](http://www.debian.org)) for further details.

## 10 Watchdog Timer

The TS-7200 implements a watchdog timer (WDT) unit in the Xilinx PLD. The WDT can be used to prevent a system “hanging” due to a software failure. The WDT causes a full system reset when the WDT times out, allowing a guaranteed recovery time from a software error. To prevent a WDT timeout, the application must periodically “feed” the WDT by writing a specific value to a specific memory location.

The WDT Control register must be initialized with the timeout period desired. This may be as short as 250 mS or may be as high as 8 seconds. After the WDT has been enabled, the WDT counter starts counting. The application software can reset this counter at any time by “Feeding the WDT”. If the WDT counter reaches the timeout period, then a full system reset occurs.

In order to load the WDT Control register, the WDT must first be “fed”, and then within 30 uS, the WDT control register must be written. Writes to this register without first doing a “WDT feed”, have no effect.

In order to clear the WDT counter (feeding the watchdog), a value of 05 must be written to the WDT Feed register.



**Warning:**

Do not attempt to use the Watchdog Timer in the EP9302.

When using the Linux OS, the watchdog can be reached from user C code by using the `mmap()` system call on the `/dev/mem` special file to map the areas of physical address space into process user address space. A user process does not have the physical address space of the watchdog registers mapped by default.

**Table 10a Watchdog Timeout Register**

Value (Hex)	MSB	MID	LSB	Timeout Period
00	0	0	0	Watchdog Disabled
01	0	0	1	250 mS
02	0	1	0	500 mS
03	0	1	1	1 second
04	1	0	0	-- Reserved
05	1	0	1	2 seconds
06	1	1	0	4 seconds
07	1	1	1	8 seconds

**Table 10b Watchdog Control Registers**

Register	Address	Access
WDT Control register	0x2380_0000	Read/Write
WDT Feed register	0x23C0_0000	Write Only

## 11 LED, Jumpers, and Push-Button Reset

The TS-7200 has two LEDs (one Red and one Green) available for user software. These LEDs may be used for diagnostics, status messages, and simple output. When power is first supplied to the TS-7200, both LEDs are immediately turned on under hardware control. Once the processor begins execution, the LEDs are turned off, then flashed on and off again briefly. After booting is complete, these LEDs can be used for user applications.

The status of all jumpers can be read – see the table below.

**Table 11 Jumper Listing**

Jumper	Function
JP1	<b>Boot to Serial Port COM1</b> – This is a recovery mechanism that allows the TS-7200 to boot using COM1 instead of the on-board Flash chip.
JP2	<b>Enable Serial Console</b> – COM1 is used as the Console. (If JP4 is not installed).
JP3	<b>Write Enable Flash</b> – Remove this jumper to write protect the Flash drive.
JP4	<b>Console swapped to COM2</b> – (requires JP2 installed to enable console).
JP5	<b>Test Jumper</b> – Used to put the TS-7200 into factory-test mode.
JP6	<b>User Jumper</b> –

The Push-Button causes a full-system reset, exactly the same as if the power were cycled. (See the bootup sequence description on page 6.)

Jumpers 2, 3, 4, and 5 can be read at physical address location 0x1080\_0000.

JP2 is bit 0 Logic "1" = Jumper ON  
 JP3 is bit 1 Logic "1" = Jumper ON  
 JP4 is bit 3 Logic "0" = Jumper ON  
 JP5 is bit 4 Logic "0" = Jumper ON

Jumper 6 can be read at physical address location 0x2280\_0000. When bit 0 is a 1, JP6 is on.

The RED and Green LEDs can be controlled at physical address location 0x8084\_0020. Bit 1 is the RED LED and bit 0 is the Green LED. A Logic "1" turns the LED on.

## 12 PC/104 Bus Expansion

The PC/104 is a compact implementation of the PC/AT ISA bus ideal for embedded applications. Designers benefit from using an already-developed standard, rather than creating their own. Further, the presence of a compact form-factor PC compatible standard has encouraged the development of a broad array of off-the-shelf products, allowing a very quick time to market for new products.

**Table 12a PC/104 Memory Map**

Physical Address Region	Emulates x86 cycle
11E0_0000 thru 11E0_03FF	8-bit I/O cycles
21E0_0000 thru 21E0_03FE	16-bit I/O cycles
11A0_0000 thru 11AF_FFFF	8-bit Memory cycles
21A0_0000 thru 21AF_FFFE	16-bit Memory cycles

The electrical specification for the PC/104 expansion bus is identical to the PC ISA bus. The mechanical specification allows for the very compact implementation of the ISA bus tailor made for embedded systems. The full PC/104 specification is available from the IEEE Standards Office under # IEEE P996.1 ([see Appendix D](#) for further information). Basically, this bus allows multiple daughter boards in a 3.6 inch by 3.8 inch form factor to be added in a self-stacking bus. Since the electrical specs are identical (except for drive levels) to a standard PC ISA bus, standard peripherals such as COM ports, Digital I/O, Ethernet ports, and LCD drivers may be easily added.

The TS-7200 implements a sub-set of the full PC/104 bus. This allows the support of many common I/O daughter boards. Some of the PC/104 signals are not supported such as the DMA signals. These pins are used on the TS-7200 to support data lines D8-D15. This means that a full 16-bit data bus implementation of the PC/104 bus is possible by only using the 64-pin connector. The supplemental 40-pin connector is only required for legacy boards – any new design can implement a full 16-bit data bus with only the 64-pin connector.

PC/104 peripherals will appear in the TS-7200 physical address space in one of four address regions depending upon whether it is emulating an x86 Memory cycle or I/O cycle and whether it needs to be a 8-bit cycle or a 16-bit cycle. Each region is a full 1MB in size, even though the I/O region will typically only use a 1 Kbyte region for legacy products.

I/O cycles on the PC/104 expansion bus strobe either IOR# or IOW#, while Memory cycles strobe the MEMR# or MEMW# signals.

For example, a TS-SER1 daughter board can be jumper-selected as COM3, which would correspond to a PC I/O base address of 0x3E8. Since this is an 8-bit peripheral, this COM port must be accessed at the physical base address of 0x11A0\_03E8.

Table 12b Signals on the 8-Bit Bus

PIN	Signal Name	PIN	Signal Name
A1	BHE# †	B1	GND
A2	Data 7	B2	Reset
A3	Data 6	B3	+5V
A4	Data 5	B4	Data 8 †
A5	Data 4	B5	Reserved
A6	Data 3	B6	RTC_CS †
A7	Data 2	B7	Reserved
A8	Data 1	B8	RTC_ALE †
A9	Data 0	B9	Reserved
A10	IOCHRDY	B10	GND
A11	ADD 20 †	B11	MEMW#
A12	ADD 19	B12	MEMR#
A13	ADD 18	B13	IOW#
A14	ADD 17	B14	IOR#
A15	ADD 16	B15	Reserved
A16	ADD 15	B16	Reserved
A17	ADD 14	B17	Data 9 †
A18	ADD 13	B18	Data 10 †
A19	ADD 12	B19	ADD 21 †
A20	ADD 11	B20	Data 12 †
A21	ADD 10	B21	IRQ7
A22	ADD 09	B22	IRQ6
A23	ADD 08	B23	IRQ5
A24	ADD 07	B24	GND †
A25	ADD 06	B25	Data 11 †
A26	ADD 05	B26	Data 13 †
A27	ADD 04	B27	Data 14 †
A28	ADD 03	B28	Data 15 †
A29	ADD 02	B29	+5V
A30	ADD 01	B30	OSC (14.3 MHz)
A31	ADD 00	B31	GND
A32	GND	B32	GND

† These signals have a non-standard usage

## 13 Loading or Transferring Files

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Three methods are available for transferring files between a desktop PC and your TS-7200: Compact Flash, Ethernet downloads, and Zmodem downloads. Full descriptions of each are detailed below. Other programs that use serial ports to transfer should work as well.

### 13.1 Transferring Files via the Ethernet Port

---

The default JFFS2 Linux root file system includes a small FTP server that can be used for uploading/downloading of files across an Ethernet network. Simply point your preferred FTP client to your TS-7200 IP address (default is 192.168.0.50). You can login as root or any valid user previously created from the useradd utility. By default, the JFFS2 image will not accept anonymous FTP.

### 13.2 Transferring Files via Compact Flash

---

The TS-7200 removable Compact Flash card can be used to easily move files from a host system. We suggest using a low-cost SanDisk USB Compact Flash card interface for your host system. This is included in the TS-7200 Developer's Kit.

For best results, we have noticed that it is best to boot the host PC with a Compact Flash card installed in the SanDisk USB Reader. The Compact Flash card can then be hot swapped (inserted or removed without rebooting the host PC).

There are two other options for connecting a Compact Flash to your host computer. A Compact Flash to PCMCIA adapter, which can map a Compact Flash as a hard drive on your laptop host computer. Or, a Compact Flash to IDE adapter, which connects to the 40 pin IDE interface on you host computer. The IDE adapter will allow you can boot to CF, run fdisk, format, etc.



### 13.3 Zmodem Downloads

---

Using the Zmodem protocol to send files to and from the TS-7200 is simple and straightforward. The only requirement is a terminal emulation program that supports Zmodem, and virtually all do. If you are using Windows 95 or later for your development work, the HyperTerminal accessory works well.

To download a file to the TS-7200 from your host PC, execute **rz** at the Linux command line on the TS-7200 (while using console-redirection from within your terminal emulator) and begin the transfer with your terminal emulator. In HyperTerminal, this is 'Send File...' from the 'Transfer' menu.

To upload a file from the TS-7200 to your host PC, execute **sz <FILENAME>** at the Linux command line on the TS-7200 and start the transfer in your terminal emulator. Many emulators, HyperTerminal among them, will automatically begin the transfer themselves.

Occasionally there may be errors in transmission due to background operations. This is not a problem -- Zmodem uses very accurate CRC checks to detect errors and simply resends bad data. Once the file transfer is complete the file is completely error free.

For best results when using HyperTerminal, the hardware handshaking must be enabled in HyperTerminal.

## 14 Debugging

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There are two main methods for debugging on the TS-7200: Debugging from a running Linux OS with gdb, or from RedBoot (before the Linux kernel is executed)

### 14.1 Debugging with gdb

---

The GNU debugger is a sophisticated open source debugger. It can be used with java, c, c++, or even Fortran. Please see the [GNU Debugger Documentation homepage](#) for more information. The following quickly walks through debugging a sample helloworld application. The source code in this example is:

```
int squareit(int n)
{
    int x;
    x = n * n;
    return x;
}
main ( )
{
    int i;
    for (i = 0; i < 4; i++)
    {
        printf("number %d\t", i);
        printf("number squared: %d\n", squareit(i));
    }
    return 0;
};
```

Boot to the CF card, login as root

```
apt-get install vim (for a text editor)
```

```
apt-get install gdb (ensure that the debugger is installed)
```

Write the above source code into helloworld.c

```
gcc -g -o hello helloworld.c (compile the source with debugging symbols)
```

```
gdb ./hello
```

```
(gdb) list 1 (shows the source code)
```

```
(gdb) break 6 (sets a breakpoint at line number 6... this line would be return x; from the squareit function)
```

```
(gdb) run (start the program)
```

```
(gdb) c (continue past the break point)
```

```
(gdb) set x=0 (this time, the return value is set to 0 instead of 1)
```

```
(gdb) c (continue and you'll see displayed on the screen "number 1 number squared 0")
```

```
quit (exit gdb)
```

## 14.2 Low Level Debugging with RedBoot

---

To provide simple, direct access to the TS-7200 hardware, RedBoot has an integrated debugger that can perform standard low-level debugger functions. It can be used to view or set values in memory using the dump and memfill commands. For example, the command

```
dump -b 0x80840020
```

shows that the first byte is filled with zeros, indicating that both the green and red led are turned off. the -b refers to a location in memory to display.

```
memfill -b 0x80840020 -p 0x03 -l 0x04
```

will result in the both the green and red LEDs being turned on. The -b, again, refers to a location in memory. The -p indicates the pattern to write into memory, and the -l refers to the length of the data being written out.

To verify that the write was successful,

```
dump -b 0x80840020
```

shows the first byte being having a value of 0x03 (bits 0 and 1 being set).

## 14.3 Using Other Debuggers

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Other Linux-capable debuggers will work with the TS-7200. Please refer to your debugger's manual for both installation and use.

## 15 Console on the TS-7200

---

The TS-7200 has no video controller or keyboard interface. This was done to keep the board size small and the cost low. COM1 is typically used as a console port to interface the TS-7200 to a standard terminal emulation program on a Host PC.

Simply connect an ANSI terminal (or emulator) to COM1 using a null modem cable (this is included in the TS-7200 Development Kit), using serial parameters of 115,200 baud, 8 data bits, no parity, 1 stop bit, and make sure jumper **JP2** is installed.

The console can be changed to COM2 by installing **JP4** (with JP2 also installed).

If your application does not require a console or both COM ports are required, then removing the jumper **JP2** easily disables all console output.

## 16 Software and Support

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- Free system software and documentation updates available on our web site
- Free technical support by phone, fax, or email
- 30-day, money back guarantee on evaluation units
- One-year, full warranty

### 16.1 Linux OS Support

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The TS-7200 is shipped standard with the Linux OS using Version 2.4.26 kernel. 2MB of the on-board Flash is reserved for the Linux boot loader and the Linux kernel, with the remaining 6MB of Flash formatted as a 6 MB JFFS2 file system. The root file system can be any of the following:

- 6MB JFFS2 file system image in the on-board Flash (RedBoot should include the option `root=/dev/mtdblock1` to instruct the kernel to boot here)
- Compact Flash card (RedBoot should include the option `root=/dev/hda`)
- NFS root (via Ethernet port) (RedBoot should include relevant kernel command line options: e.g. `root=/dev/nfs nfsroot=192.168.0.11:/u/nfsroot ip=dhcp`)

### 16.2 Other OS Support

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The TS-7200 can be loaded with other operating systems such as Windows CE, NetBSD, etc. Technologic Systems will provide support for these, and possibly other operating systems, in the near future. Currently, only Linux and NetBSD are supported on the TS-7200.

### 16.3 Development Kit and Supplemental CD

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The development kit contains a 256Mb Compact Flash that includes a self-hosting ARM installation of the Debian 2.0 distribution compiled for ARM complete with toolchain.

The supplemental CD contains:

- Fully preinstalled Debian Tarball (for use as an NFS root or on a very large Compact Flash)
- Cross GCC toolchain
- Patched kernel source code
- Patched ECOS/RedBoot source code
- Supporting documentation

## 17 Installing the TS-7200

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### 17.1 Electrostatic Discharge (ESD) Precautions

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Before performing any set up or placement procedures, take the precautions outlined in this section. Be sure to take appropriate Electrostatic Discharge (ESD) precautions. Disconnect the power source before moving, cabling, or performing any set up procedures.

### 17.2 Setup and Installation Instructions

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Follow these guidelines for safety and maximum product performance:

- Observe local health and safety requirements and guidelines for manual material handling.

#### Setup Tools

Depending on placement and cabling, you may need the following tools:

- Small flat-blade screwdriver
- Small Phillips screwdriver

#### Setup Procedure

After locating, setting up, grounding, and cabling the TS-7200,

- Apply power.
- Monitor the TS-7200 using a terminal emulator to verify that the board is operating properly.

#### Disconnecting AC Power

- Unplug from the power source.
- Disconnect other cables as required.

## 18 Environmental Specifications

To ensure optimum product operation you must maintain the operational environmental specifications listed in the table below.

Environmental Specifications	Standard Temp Products	Extended Temp Products
<p><b>Ambient Temperature</b></p>	<p>-20 to 70° C The internal temperature must not exceed +70° C.</p>	<p>Extended temperature range is optional  <b>Note:</b> Refer to your product manual, or <a href="#">contact Technologic Systems</a> if the environmental temperature of the location is in doubt.</p>
<p><b>Relative Humidity</b></p>	<p>0 to 90% relative humidity Not to exceed 90% noncondensing</p>	<p>Not to exceed 90% noncondensing.</p>

## 19 Options and Other Features

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### 19.1 Options

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View the following options on the [TS-7200 Options page](#)

<b>Upgrade</b>	Up to 16 MB Flash
<b>PS-5VDC-110V</b>	Regulated 5VDC Power Supply, 110 VAC Input
<b>KIT-7200</b>	Development kit with 256MB Compact Flash, Power Supply, Cables, USB-CF Adapter (TS-7200 not included)
<b><a href="#">TS-ENC720</a></b>	Metal Enclosure with Power Converter
<b>OP-ADC</b>	12-bit 8 chan. A/D converter, data sheet
<b>TS-5620</b>	Battery-backed Real Time Clock
<b>OP-485-FD</b>	Full Duplex RS-485
<b>OP-485-HD</b>	Half Duplex RS-485
<b>OP-EXTTEMP</b>	Extended Temperature Range (-40 - 85 deg C)
<b>OP-16BIT-104</b>	16-bit PC/104 Connector
<b>OP-STHRU-104</b>	16-bit Pass-Thru PC/104 Connector
<b>OP-TMPSENSE</b>	On-Board Temperature Sensor
<b>RC-DB9</b>	COM2 adapter cable to DB-9
<b>OP-EJECT</b>	Compact Flash Ejector
<b>Compact Flash</b>	Up to 1GB Compact Flash Card
<b>OP-LCD-LED</b>	Alphanumeric 2x24 LCD with backlight and cable
<b>OP-KPAD</b>	Matrix keypad with cable

### 19.2 Peripheral Boards

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<b><a href="#">TS-NVRAM</a></b>	Up to 512K Bytes Non-Volatile SRAM
<b><a href="#">TS-12W</a></b>	Power supply 12-38 VDC input provides regulated +5 VDC output
<b><a href="#">TS-ETH10</a></b>	10Mb Ethernet PC/104 card
<b><a href="#">TS-MODEM</a></b>	33.6K or 56K modem, jumper configurable
<b><a href="#">TS-MODEM2</a></b>	Supports all MultiTech "socket modems" including cellular
<b><a href="#">TS-SER1</a></b>	One additional serial port
<b><a href="#">TS-SER2</a></b>	Two additional serial ports, one parallel port, RS485 optional
<b><a href="#">TS-SER4</a></b>	Four additional serial ports, RS485 optional
<b><a href="#">TS-ISO485</a></b>	Two additional serial ports, optoisolated with RS485 drivers
<b><a href="#">TS-DIO24</a></b>	24 Digital I/O with high current drive on 8 channels
<b><a href="#">TS-9700</a></b>	12-bit A/D with 0.2% accurate Vref, 12-bit DAC optional
<b><a href="#">TS-9500</a></b>	VGA, keyboard, mouse, Compact Flash interface
<b><a href="#">TS-9300</a></b>	'Blast' board production tool for installing customized Flash drives
<b><a href="#">TS-9420</a></b>	Production tool for replicating SBC Flash images
<b><a href="#">TS-9422</a></b>	POST code display board for debugging



## 19.3 Accessories

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Accessories can be viewed on the [Technologic Systems Accessories page](#).

## 20 Feedback and Updates to the Manual

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To help our customers make the most of our products, we are continually making additional and updated resources available on the [Technologic Systems web site](#).

These include manuals, application notes, programming examples, and updated software and firmware. Check in periodically to see what's new!

When we are prioritizing work on these updated resources, feedback from customers (and prospective customers) is the number one influence. If you have questions, comments, or concerns about your TS-7200 Embedded PC, [please let us know](#).

## 21 Limited Warranty

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Technologic Systems warrants this product to be free of defects in material and workmanship for a period of one year from date of purchase.

During this warranty period Technologic Systems will repair or replace the defective unit in accordance with the following process:

A copy of the original invoice must be included when returning the defective unit to Technologic Systems, Inc. at the address below.

This limited warranty does not cover damages resulting from lightning or other power surges, misuse, abuse, abnormal conditions of operation, or attempts to alter or modify the function of the product.

**This warranty is limited to the repair or replacement of the defective unit. In no event shall Technologic Systems be liable or responsible for any loss or damages, including but not limited to any lost profits, incidental or consequential damages, loss of business, or anticipatory profits arising from the use or inability to use this product.**

Repairs made after the expiration of the warranty period are subject to a repair charge and the cost of return shipping. Please [contact Technologic Systems](#) to arrange for any repair service and to obtain repair charge cost information.

## 22 FCC Advisory Statement

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### **Warning:**

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used properly (that is, in strict accordance with the manufacturer's instructions), may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the owner at his own expense will be required to correct the interference.

If this equipment does cause interference, which can be determined by turning the unit on and off, the user is encouraged to try the following measures to correct the interference:

- Reorient the receiving antenna.
- Relocate the unit with respect to the receiver.
- Plug the unit into a different outlet so that the unit and receiver are on different branch circuits.
- Ensure that mounting screws and connector attachment screws are tightly secured.
- Ensure that good quality, shielded, and grounded cables are used for all data communications.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The following booklets prepared by the Federal Communications Commission (FCC) may also prove helpful:

**How to Identify and Resolve Radio-TV Interference Problems** (Stock No. 004-000-000345-4)

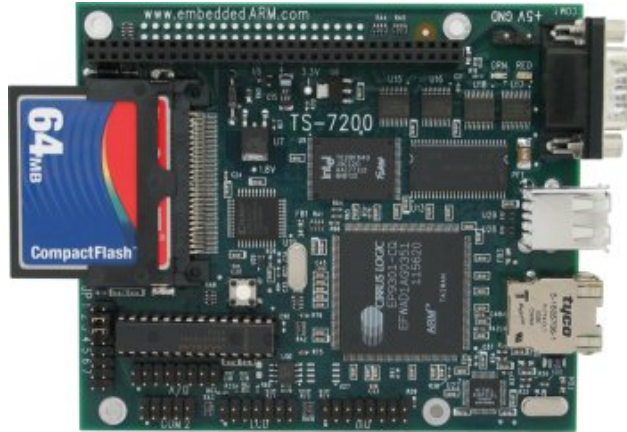
**Interface Handbook** (Stock No. 004-000-004505-7)

These booklets may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402

## Appendix A: Product Views

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Click on the following images of the TS- 7200 Single Board Computer to view more images.



[Download the TS-7200 mechanical drawing](#)

## Appendix B: User Manual Revisions

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Date of Issue/Revision	Revision Number	Comments
August 2004	Preliminary DRAFT	PRELIMINARY release for first customer ship
August 26, 2004	1.0	Initial release
December 16, 2004	1.1	Overall clean-up
May 2005	1.2	Changes to sections 2, 4, 5 and 9 and completion of the system memory map
June 2005	1.3	Deletion of components sections and completion of options section

## Appendix C: System Memory Map

Address Region	Name
0xF000_0000 - 0xFFFF_FFFF	nCS0 (not used)
0xE000_0000 - 0xEFFF_FFFF	SDRAM (TS-7250)
0xD000_0000 - 0xDFFF_FFFF	SDRAM (not used)
0xC000_0000 - 0xCFFF_FFFF	SDRAM (not used)
0x8084_0000 - 0x8084_00C8	GPIO control registers
0x8000_0000 - 0x800F_FFFF	AHB mapped registers
0x71C0_0000 - 0x71FF_FFFF	CS7 PC/104 8/16 bit I/O (user selectable timing)
0x7180_0000 - 0x71BF_FFFF	CS7 PC/104 8/16 bit Memory (selectable timing)
0x7000_0000 - 0x70FF_FFFF	TS-9420 Flash
0x7000_0000 - 0x7FFF_FFFF	CS7 (bit bus cycles)
0x6000_0000 - 0x60FF_FFFF	on-board Flash (TS-7200)
0x6000_0000 - 0x6FFF_FFFF	CS6 (Flash)
0x3000_0000 - 0x3FFF_FFFF	CS3 (not used)
0x21C0_0000 - 0x21FF_FFFE	PC/104 16-bit I/O
0x2180_0000 - 0x21BF_FFFF	PC/104 16-bit Memory
0x2000_0000 - 0x2FFF_FFFF	CS2 (16-bit bus cycles)
0x11C0_0000 - 0x11FF_FFFF	PC/104 8-bit I/O
0x1180_0000 - 0x11BF_FFFF	PC/104 8-bit Memory
0x1000_0000 - 0x1FFF_FFFF	CS1 (8-bit bus cycles)
0x0001_0000 - 0x0000_FFFF	SDRAM region

Register	Name
0x8090_0020	Cirrus A/D lock register
0x8090_0018	Cirrus A/D channel select register
0x8090_0008	Cirrus A/D result register (RO)
0x808D_0000 - 0x808D_FFFF	UART2 control registers
0x808C_0000 - 0x808C_FFFF	UART1 control registers
0x808A_0000 - 0x808A_FFFF	SPI control registers
0x8084_0044	LCD_EN, LCD_RS, LCD_WR direction register (bits 3-5)
0x8084_0040	LCD_EN, LCD_RS, LCD_WR data register (bits 3-5)
0x8084_0034	DIO_8 direction register (bit 0)
0x8084_0030	DIO_8 data register (bit 0)
0x8084_0020	On-board LEDs register (bits 0, 1)
0x8084_0018	Port C direction register
0x8084_0014	DIO_0 thru DIO_7 direction register (R/W)
0x8084_0010	LCD_0 thru LCD_7 direction register (R/W)

Register	Name
0x8084_0008	(TS-7250) 1000 mA driver output on DIO (bit 0)
0x8084_0004	DIO_0 thru DIO_7 data register (R/W)
0x8084_0000	LCD_0 thru LCD_7 data register (R/W)
0x8081_0000 - 0x8081_FFFF	Timer Control registers
0x800B_0000 - 0x800B_FFFF	VIC 0 registers
0x8006_0000 - 0x8006_FFFF	SDRAM control registers
0x8002_0000 - 0x8002_FFFF	USB registers
0x8001_0000 - 0x8001_FFFF	Ethernet MAC registers
0x6000_0000	(TS-7250) NAND Flash data register
0x6040_0000	(TS-7250) NAND Flash control register (bits 0-2)
0x6080_0000	(TS-7250) NAND Flash Busy status (bit 5)
0x23C0_0000	TS-7xxx WDT Feed register (bits 0-2)
0x2380_0000	TS-7xxx WDT Control register (bits 0-2)
0x2340_0000	PLD version (bits 0-2)
0x22C0_0000	COM2 RS-485 control register (bits 0-2)
0x2280_0000	JP6 (bit 0)
0x2280_0000	Booting from TS-9420 (bit 1)
0x2280_0000	TS-9420 present (bit 2)
0x2240_0000	MAX197 A/D option present (bit 0)
0x2240_0000	COM2 RS-485 option present (bit 1)
0x2200_0000	Model Number (bits 0-2)
0x21E0_0000 - 0x21E0_03FE	PC/104 16-bit I/O (legacy support)
0x2100_0000	CF IDE 16-bit register
0x11E0_0000 - 0x11E0_03FF	PC/104 8-bit I/O (legacy support)
0x11A0_0000 - 0x11AF_FFFF	PC/104 8-bit Memory (legacy support)
0x1170_0000	TS-7xxx RTC R/W data register
0x1100_0001 - 0x1100_0007	CF IDE 8-bit registers
0x10F0_0000 - 0x10F0_0001	MAX197 A/D registers
0x1080_0000	MAX197 A/D busy bit (bit 7) (RO)
0x1080_0000	JP2-JP5 (bits 0,1,3,4) (RO)
0x1080_0000	COM1 DCD (bit 6) (RO)
0x1080_0000	TS-7xxx RTC Write Only index register
0x1040_0006 - 0x1040_0007	CF AUX IDE 8-bit registers



## **Appendix D: Further References**

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[Download the EP9301 User's Manual](#)

[Download the EP9302 Data Sheet](#)

## Appendix E: Schematic

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[Download the TS-7200 Schematic PDF file](#)

## Contact Information

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