



STPC CONSUMER-S

PC Compatible Embedded Microprocessor

ADVANCED DATA

- POWERFUL x86 PROCESSOR
- 64-BIT 66MHz SDRAM UMA CONTROLLER
- VGA & SVGA CRT CONTROLLER
- 2D GRAPHICS ENGINE
- VIDEO INPUT PORT
- VIDEO PIPELINE
 - UP-SCALER
 - VIDEO COLOR SPACE CONVERTER
 - CHROMA & COLOUR KEY SUPPORT
- TV OUTPUT
 - 3-LINE FLICKER FILTER
 - CCIR 601/656 SCAN CONVERTER
 - NTSC / PAL COMPOSITE, RGB, S-VIDEO
- PCI MASTER / SLAVE CONTROLLER
- ISA MASTER / SLAVE CONTROLLER
- INTEGRATED PERIPHERAL CONTROLLER
 - DMA CONTROLLER
 - INTERRUPT CONTROLLER
 - TIMER / COUNTERS
- OPTIONAL 16-BIT LOCAL BUS INTERFACE
- EIDE CONTROLLER
- I C INTERFACE
- POWER MANAGEMENT UNIT
- 3.3V OPERATION

STPC CONSUMER-S OVERVIEW

The STPC Consumer-S integrates a standard 5th generation x86 core, a Synchronous DRAM controller, a graphics subsystem, a video input port, video pipeline, and support logic including PCI, ISA, and IDE controllers to provide a single consumer orientated PC compatible subsystem on a single device.

The device is based on a tightly coupled Unified Memory Architecture (UMA), sharing the same memory array between the CPU main memory and the graphics and video frame buffers.

The STPC Consumer-S is packaged in a 388 Plastic Ball Grid Array (PBGA).

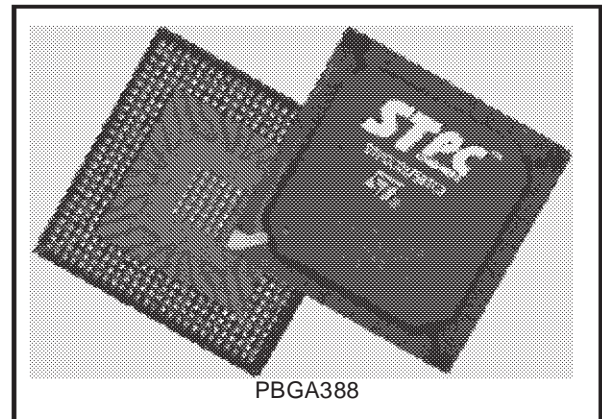
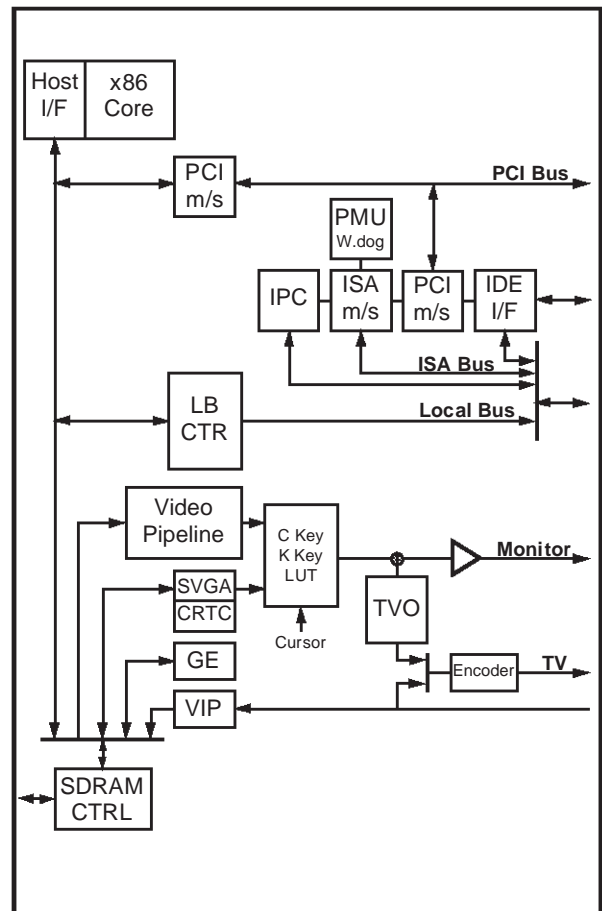


Figure 1. Logic Diagram



■ **X86 Processor core**

- Fully static 32-bit 5-stage pipeline, x86 processor fully PC compatible.
- Can access up to 4GB of external memory.
- 8Kbyte unified instruction and data cache with write back and write through capability.
- Parallel processing integral floating point unit, with automatic power down.
- Fully static design for dynamic clock control.
- Low power and system management modes.

■ **SDRAM Controller**

- 64-bit data bus.
- Up to 66MHz SDRAM clock speed.
- Integrated system memory, graphic frame memory and video frame memory.
- Supports 2MB up to 128 MB memory.
- Supports 8MB, 16M, and 32MB DIMMs.
- Supports buffered, non buffered, and registered DIMMs
- 4-line write buffers for CPU to DRAM and PCI to DRAM cycles.
- 4-line read prefetch buffers for PCI masters.
- Programmable latency
- Programmable timing for DRAM parameters.
- Supports -8, -10, -12, -13, -15 memory parts
- Supports 1MB up to 8MB memory hole.
- 32-bit accesses not supported.
- Autoprecharge not supported.
- Power down not supported.
- FPM and EDO not supported.

■ **Graphics Controller**

- 64-bit windows accelerator.
- Compatibility to VGA & SVGA standards.
- Hardware acceleration for text, bitblts, transparent blts and fills.
- Up to 64 x 64 bit graphics hardware cursor.
- Up to 4MB long linear frame buffer.
- 8-, 16-, and 24-bit pixels.

■ **CRT Controller**

- Integrated 135MHz triple RAMDAC allowing for 1024 x 768 x 75Hz display.
- 8-, 16-, 24-bit pixels.
- Interlaced or non-interlaced output.

■ **Video Input port**

- Accepts video inputs in CCIR 601 mode.
- Optional 2:1 decimator
- Stores captured video in off setting area of the onboard frame buffer.
- Video pass through to the onchip PAL/NTSC encoder for full screen video images.
- HSYNC and B/T generation or lock onto external video timing source.

■ **Video Pipeline**

- Two-tap interpolative horizontal filter.
- Two-tap interpolative vertical filter.
- Color space conversion.
- Programmable window size.
- Chroma and color keying for integrated video overlay.

■ **TV Output**

- Programmable two tap filter with gamma correction or three tap flicker filter.
- Progressive to interlaced scan converter.
- NTSC-M, PAL-M, PAL-B,D,G,H,I, PAL-N easy programmable video outputs.
- CCIR601 encoding with programmable color subcarrier frequencies.
- Line skip/insert capability
- Interlaced or non-interlaced operation mode.
- 625 lines/50Hz or 525 lines/60Hz 8 bit multiplexed CB-Y-CR digital input.
- CVBS and R,G,B simultaneous analog outputs through 10-bit DACs.
- Cross color reduction by specific trap filtering on luma within CVBS flow.
- Power down mode available on each DAC.

■ **PCI Controller**

- Fully compliant with PCI 2.1 specification.
- Integrated PCI arbitration interface. Up to 3 masters can connect directly. External PAL allows for greater than 3 masters.
- Translation of PCI cycles to ISA bus.
- Translation of ISA master initiated cycle to PCI.
- Support for burst read/write from PCI master.
- PCI clock is 1/3 or 1/2 Host clock .

■ **ISA master/slave controller**

- Generates the ISA clock from either 14.318MHz oscillator clock or PCI clock
- Supports programmable extra wait state for ISA cycles
- Supports I/O recovery time for back to back I/O cycles.
- Fast Gate A20 and Fast reset.
- Supports the single ROM that C, D, or E. blocks shares with F block BIOS ROM.
- Supports flash ROM.
- Supports ISA hidden refresh.
- Buffered DMA & ISA master cycles to reduce bandwidth utilization of the PCI and Host bus. NSP compliant.

■ **Integrated Peripheral Controller**

- 2X8237/AT compatible 7-channel DMA controller.
- 2X8259/AT compatible interrupt Controller. 16 interrupt inputs - ISA and PCI.
- Three 8254 compatible Timer/Counters.
- Co-processor error support logic.
- Supports external RTC.

■ **Local Bus interface**

- Multiplexed with ISA interface.
- Low latency bus
- 22-bit address bus.
- 16-bit data bus with word steering capability.
- Programmable timing (Host clock granularity)
- 2 Programmable Flash Chip Select.
- 5 Programmable I/O Chip Select.
- Supports 32-bit Flash burst.
- 2-level hardware key protection for Flash boot block protection.
- Supports 2 banks of 8MB flash devices with boot block shadowed to 0x000F0000.

■ **IDE Interface**

- Supports PIO and Bus Master IDE
- Supports up to Mode 5 Timings
- Transfer Rates to 22 MBytes/sec
- Supports up to 4 IDE devices
- Concurrent channel operation (PIO & DMA modes) - 4 x 32-Bit Buffer FIFO per channel
- Support for PIO mode 3 & 4.
- Support for DMA mode 1 & 2.
- Support for 11.1/16.6 MB/s, I/O Channel Ready PIO data transfers.
- Supports 13.3/16.6 MB/s DMA data transfers
- Bus Master with scatter/gather capability
- Multi-word DMA support for fast IDE drives
- Individual drive timing for all four IDE devices
- Supports both legacy & native IDE modes
- Supports hard drives larger than 528MB
- Support for CD-ROM and tape peripherals
- Backward compatibility with IDE (ATA-1).

■ **Power Management**

- Four power saving modes: On, Doze, Standby, Suspend.
- Programmable system activity detector
- Supports SMM.
- Supports STOPCLK.
- Supports IO trap & restart.
- Independent peripheral time-out timer to monitor hard disk, serial & parallel ports.
- Supports RTC, interrupts and DMAs wake-up

1 GENERAL DESCRIPTION

At the heart of the STPC Consumer-S is an advanced 64-bit processor block, dubbed the 5ST86. The 5ST86 includes a 486 processor core along with a 64-bit SDRAM controller, advanced 64-bit accelerated graphics and video controller, a high speed PCI local-bus controller and Industry standard PC chip set functions (Interrupt controller, DMA Controller, Interval timer and ISA bus).

The STPC Consumer-S makes use of a tightly coupled Unified Memory Architecture (UMA), where the same memory array is used for CPU main memory and graphics frame-buffer. This means a reduction in total system memory for system performances that are equal to that of a comparable frame buffer and system memory based system, and generally much better, due to the higher memory bandwidth allowed by attaching the graphics engine directly to the 64-bit processor host interface running at the speed of the processor bus rather than the traditional PCI bus.

The 64-bit wide memory array provides the system with 528MB/s peak bandwidth. This allows for higher resolution screens and greater color depth.

The 'standard' PC chipset functions (DMA, interrupt controller, timers, power management logic) are integrated together with the x86 processor core; additional functions such as communications ports are accessed by the STPC Consumer-S via internal ISA bus.

The PCI bus is the main data communication link to the STPC Consumer-S chip. The STPC Consumer-S translates appropriate host bus I/O and Memory cycles onto the PCI bus. It also supports generation of Configuration cycles on the PCI bus. The STPC Consumer-S, as a PCI bus agent (host bridge class), fully complies with PCI specification 2.1. The chip-set also implements the PCI mandatory header registers in Type 0 PCI configuration space for easy porting of PCI aware system BIOS. The device contains a PCI arbitration function for three external PCI devices.

The STPC Consumer-S has two functional blocks **sharing the same balls**: The ISA / IPC / IDE block and the Local Bus / IDE block (see Table 3). Any board with the STPC Consumer-S should be built using only one of these two configurations.

At reset, the configuration is done by 'strap options' which initialises the STPC Consumer-S to the right settings. It is a set of pull-up or pull-down resistors on the memory data bus, checked on reset, which auto-configure the STPC Consumer-S.

GRAPHICS FUNCTIONS

Graphics functions are controlled through the on-chip SVGA controller and the monitor display is produced through the 2D graphics display engine.

This Graphics Engine is tuned to work with the host CPU to provide a balanced graphics system with a low silicon area cost. It performs limited graphics drawing operations which include hardware acceleration of text, bitblts, transparent blts and fills. The results of these operations change the contents of the on-screen or off-screen frame buffer areas of DRAM memory. The frame buffer can occupy a space up to 4 Mbytes anywhere in the physical main memory and always starts from the bottom of the main physical memory.

The graphics resolution supported is a maximum of 1280x1024 in 65536 colours and 1024x768 in true color at 75Hz refresh rate and is VGA and SVGA compatible. Horizontal timing fields are VGA compatible while the vertical fields are extended by one bit to accommodate above display resolution.

VIDEO FUNCTIONS

The STPC Consumer-S provides several additional functions to handle MPEG or similar video streams. The Video Input Port accepts an encoded digital video stream in one of a number of industry standard formats, decodes it, optionally decimates it, and deposits it into an off screen area of the frame buffer. An interrupt request can be generated when an entire field or frame has been captured. The video output pipeline incorporates a video-scaler and color space converter function and provisions in the CRT controller to display a video window. While repainting the screen the CRT controller fetches both the video as well as the normal non-video frame buffer in two separate internal FIFOs. The video stream can be color-space converted (optionally) and smooth scaled. Smooth interpolative scaling in both horizontal and vertical direction are implemented. Color and Chroma key functions are also implemented to allow mixing video stream with non-video frame buffer.

The video output passes directly to the RAMDAC for monitor output or through another optional color space converter (RGB to 4:2:2 YCrCb) to the programmable anti-flicker filter. The flicker filter is configured as either a two line filter with gamma correction (primarily designed for DOS type text) or a 3 line flicker filter (primarily designed for Windows type displays). The flicker filter is optional and can be software disabled for use with large screen area's of video.

The Video output pipeline of the STPC Consumer-S interfaces directly to the internal digital TV encoder. It takes a 24 bit RGB non-interlaced pixel stream and converts to a multiplexed 4:2:2 YCrCb 8 bit output stream, the logic includes a progressive to interlaced scan converter and logic to insert appropriate CCIR656 timing reference codes into the output stream. It facilitates the high quality display of VGA or full screen video streams received via the Video input port to standard NTSC or PAL televisions.

The digital PAL/NTSC encoder outputs interlaced or non-interlaced video in PAL-B,D,G,H,I PAL-N, PAL-M or NTSC-M standards and "NTSC- 4.43" is also possible.

The four frame (for PAL) or 2 frame (for NTSC) burst sequences are internally generated, subcarrier generation being performed numerically with CKREF as reference. Rise and fall times of synchronisation tips and burst envelope are internally controlled according to the relevant ITU-R and SMPTE recommendations.

Video output signals are directed to four analog output pins through internal D/A converters giving, simultaneous R,G,B and composite CVBS outputs.

IDE INTERFACE

An industry standard EIDE (ATA 2) controller is built into the STPC Consumer-S. The IDE port is capable of supporting a total of four devices.

POWER MANAGEMENT

The STPC Consumer-S core is compliant with the Advanced Power Management (APM) specification to provide a standard method by which the BIOS can control the power used by personal computers. The Power Management Unit module (PMU) controls the power consumption providing a comprehensive set of features that control the power usage and supports compliance with the United States Environmental Protection Agency's Energy Star Computer Program. The PMU provides following hardware structures to assist the software in managing the power consumption by the system.

- System Activity Detection.
- Three power down timers.
- Doze timer for detecting lack of system activity for short durations.
- Stand-by timer for detecting lack of system activity for medium durations
- Suspend timer for detecting lack of system activity for long durations.
- House-keeping activity detection.

- House-keeping timer to cope with short bursts of house-keeping activity while dozing or in stand-by state.

- Peripheral activity detection.

- Peripheral timer for detecting lack of peripheral activity

- SUSP# modulation to adjust the system performance in various power down states of the system including full power on state.

- Power control outputs to disable power from different planes of the board.

Lack of system activity for progressively longer period of times is detected by the three power down timers. These timers can generate SMI interrupts to CPU so that the SMM software can put the system in decreasing states of power consumption. Alternatively, system activity in a power down state can generate SMI interrupt to allow the software to bring the system back up to full power on state. The chip-set supports up to three power down states: Doze state, Stand-by state and Suspend mode. These correspond to decreasing levels of power savings.

POWER DOWN

Power down puts the STPC Consumer-S into suspend mode. The processor completes execution of the current instruction, any pending decoded instructions and associated bus cycles. During the suspend mode, internal clocks are stopped. Removing power down, the processor resumes instruction fetching and begins execution in the instruction stream at the point it had stopped. Because of the static nature of the core, no internal data is lost.

GENERAL DESCRIPTION

Figure 2. Functionnal description.

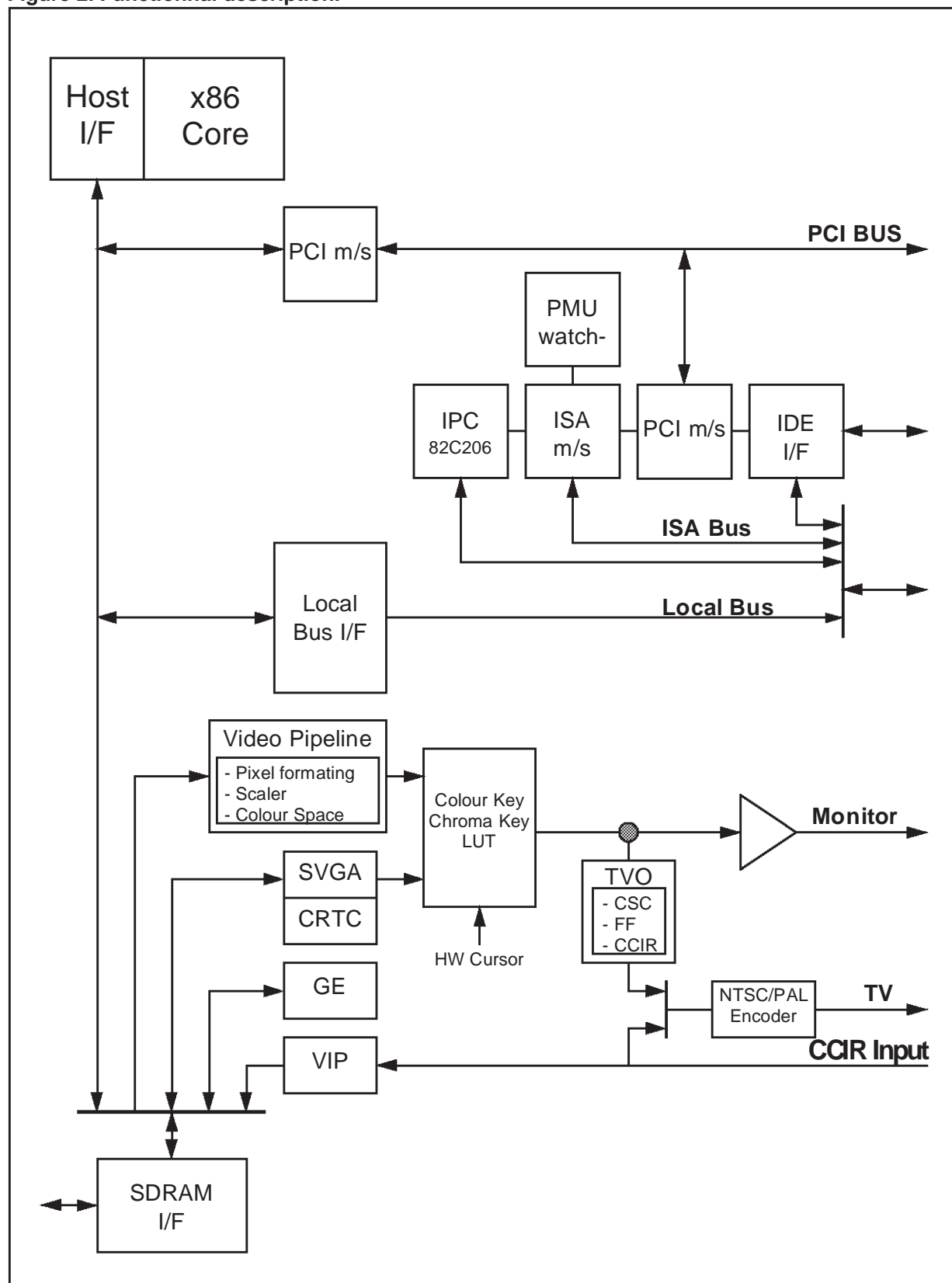
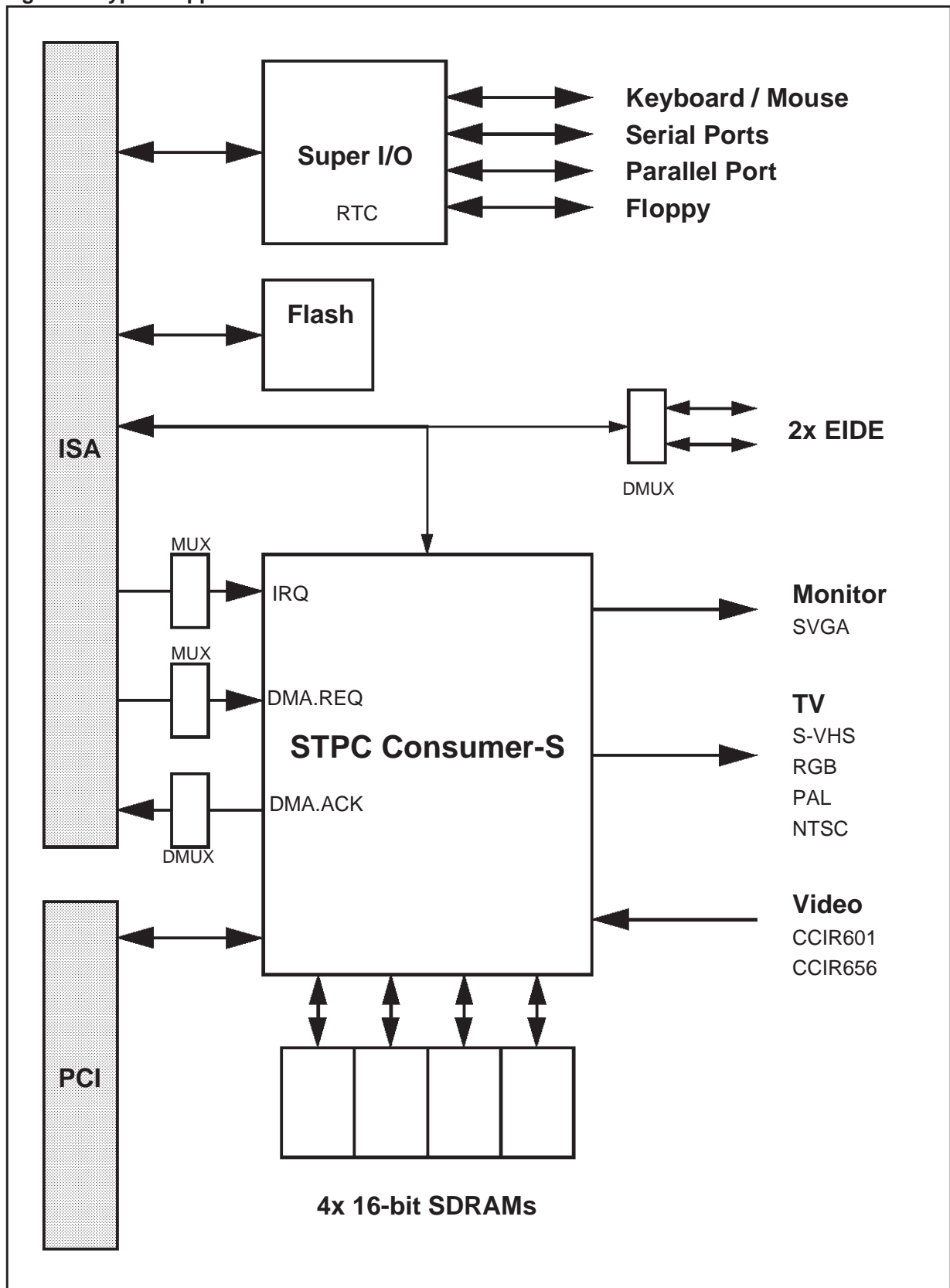


Figure 3. Typical Application



GENERAL DESCRIPTION



1.1 UPDATE HISTORY FOR VIDEO CONTROLLER CHAPTER

The following changes have been made to the General Description Chapter on 29/10/99.

| Section | Change | Text |
|---------|---------|---|
| 1 | Removed | "The STPC Consumer S has in addition to the 5ST86 a TFT output, a Local Bus interface, a WatchDog and a JTAC interface." |

2 PIN DESCRIPTION

2.1 INTRODUCTION

The STPC Consumer-S integrates most of the functionalities of the PC architecture. As a result, many of the traditional interconnections between the host PC microprocessor and the peripheral devices are totally internal to the STPC Consumer-S. This offers improved performance due to the tight coupling of the processor core and these peripherals. As a result many of the external pin connections are made directly to the on-chip peripheral functions.

Figure 2.1 shows the STPC Consumer-S external interfaces. It defines the main busses and their function. Table 2.1 describes the physical implementation listing signals type and their functionality. Table 2.2 provides a full pin listing and description of pins. Table 2.5 provides a full listing of pin locations of the STPC Consumer-S package by physical connection.

Table 2.1. Signal Description

| Group name | | Qty |
|--|----|-----|
| System Clocks & Resets | | 11 |
| Memory Interface | | 95 |
| PCI interface | | 60 |
| ISA | 79 | 89 |
| IDE | 34 | |
| Local Bus | 49 | |
| Video Input | | 11 |
| TV Output | | 8 |
| VGA Monitor interface | | 8 |
| Grounds | | 71 |
| V _{DD} | | 29 |
| Analog specific V _{CC} /V _{DD} | | 6 |
| Total Pin Count | | 388 |

Note: Several interface pins are multiplexed with other functions, refer to Table 2.3 and Table 2.4 for further details

Figure 2.1. STPC Consumer-S External Interfaces

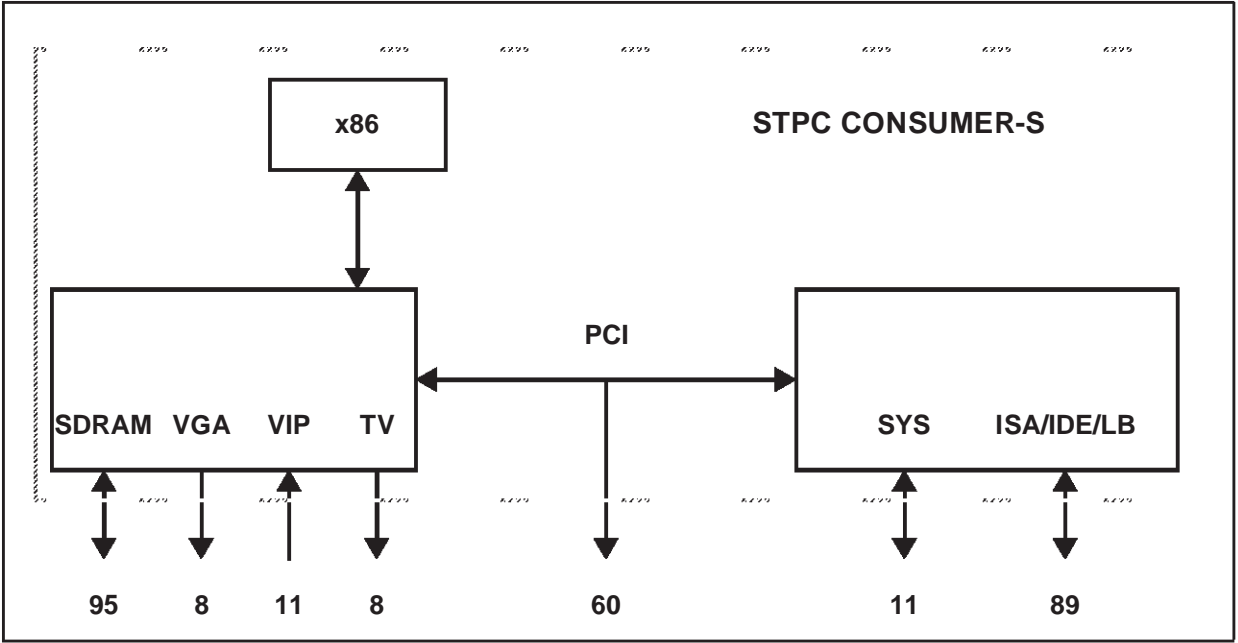


Table 2.2. Definition of Signal Pins

| Signal Name | Dir | Description | Qty |
|-------------------------|-----|---|-----|
| BASIC CLOCKS AND RESETS | | | |
| SYSRSTI# | I | System Power Good Input | 1 |
| SYSRSTO# | O | System Reset Output | 1 |
| XTALI | I | 14.3MHz Crystal Input | 1 |
| XTALO | I/O | 14.3MHz Crystal Output - External Oscillator Input | 1 |
| HCLK | I/O | Host Clock (Test) | 1 |
| DEV_CLK | O | 24MHz Peripheral Clock (floppy drive) | 1 |
| DCLK | I/O | 27-135MHz Graphics Dot Clock | 1 |
| MEMORY INTERFACE | | | |
| MCLKI | I | Memory Clock Input | 1 |
| MCLKO | O | Memory Clock Output | 1 |
| CS#[3:0] | O | DIMM Chip Select | 4 |
| MA[11:0] | O | Memory Row & Column Address | 12 |
| MD[63:0] | I/O | Memory Data | 64 |
| RAS#[1:0] | O | Row Address Strobe | 2 |
| CAS#[1:0] | O | Column Address Strobe | 2 |
| MWE# | O | Write Enable | 1 |
| DQM[7:0] | O | Data Input/Output Mask | 8 |
| PCI INTERFACE | | | |
| PCI_CLKI | I | 33MHz PCI Input Clock | 1 |
| PCI_CLKO | O | 33MHz PCI Output Clock (from internal PLL) | 1 |
| AD[31:0] | I/O | PCI Address / Data | 32 |
| CBE#[3:0] | I/O | Bus Commands / Byte Enables | 4 |
| FRAME# | I/O | Cycle Frame | 1 |
| IRDY# | I/O | Initiator Ready | 1 |
| TRDY# | I/O | Target Ready | 1 |
| LOCK# | I | PCI Lock | 1 |
| DEVSEL# | I/O | Device Select | 1 |
| STOP# | I/O | Stop Transaction | 1 |
| PAR | I/O | Parity Signal Transactions | 1 |
| SERR# | O | System Error | 1 |
| PCIREQ#[2:0] | I | PCI Request | 3 |
| PCI_GNT#[2:0] | O | PCI Grant | 3 |
| PCI_INT[3:0] | I | PCI Interrupt Request | 4 |
| VDD5 | I | 5V Power Supply for PCI ESD protection | 4 |
| ISA CONTROL | | | |
| ISA_CLK | O | ISA Clock Output - Multiplexer Select Line For IPC | 1 |
| ISA_CLK2X | O | ISA Clock x2 Output - Multiplexer Select Line For IPC | 1 |
| OSC14M | O | ISA bus synchronisation clock | 1 |
| LA[23:17] | O | Unlatched Address | 7 |
| SA[19:0] | I/O | Latched Address | 20 |
| SD[15:0] | I/O | Data Bus | 16 |
| ALE | O | Address Latch Enable | 1 |
| MEMR#, MEMW# | I/O | Memory Read and Memory Write | 2 |
| SMEMR#, SMEMW# | O | System Memory Read and Memory Write | 2 |

PIN DESCRIPTION

Table 2.2. Definition of Signal Pins

| Signal Name | Dir | Description | Qty |
|----------------------------|-----|--|-----|
| IOR#, IOW# | I/O | I/O Read and Write | 2 |
| MCS16#, IOCS16# | I | Memory/I/O Chip Select16 | 2 |
| BHE# | O | System Bus High Enable | 1 |
| ZWS# | I | Zero Wait State | 1 |
| REF# | O | Refresh Cycle. | 1 |
| MASTER# | I | Add On Card Owns Bus | 1 |
| AEN | O | Address Enable | 1 |
| IOCHCK# | I | I/O Channel Check. | 1 |
| IOCHRDY | I/O | I/O Channel Ready (ISA) - Busy/Ready (IDE) | 1 |
| ISAOE# | O | ISA/IDE Selection | 1 |
| GPIOCS# | I/O | General Purpose Chip Select | 1 |
| IRQ_MUX[3:0] | I | Time-Multiplexed Interrupt Request | 4 |
| DREQ_MUX[1:0] | I | Time-Multiplexed DMA Request | 2 |
| DACK_ENC[2:0] | O | Encoded DMA Acknowledge | 3 |
| TC | O | ISA Terminal Count | 1 |
| RTCAS | O | Real Time Clock Address Strobe | 1 |
| RMRTCCS# | I/O | ROM/RTC Chip Select | 1 |
| KBCS# | I/O | Keyboard Chip Select | 1 |
| RTCRW# | I/O | RTC Read/Write | 1 |
| RTCDS | I/O | RTC Data Strobe | 1 |
| LOCAL BUS | | | |
| PA[21:0] | O | Address Bus | 22 |
| PD[15:0] | I/O | Data Bus | 16 |
| PRD1#, PRD0# | O | Peripheral Read Control | 2 |
| PWR1#, PWR0# | O | Peripheral Write Control | 2 |
| PRDY# | I | Data Ready | 1 |
| FCS1#, FCS0# | O | Flash Chip Select | 2 |
| IOCS#[3:0] | O | I/O Chip Select | 4 |
| IDE CONTROL | | | |
| DA[2:0] | O | Address Bus | 3 |
| DD[15:0] | I/O | Data Bus | 16 |
| PCS3#, PCS1#, SCS3#, SCS1# | O | Primary & Secondary Chip Selects | 4 |
| DIORDY | O | Data I/O Ready | 1 |
| PIRQ, SIRQ | I | Primary & Secondary Interrupt Request | 2 |
| PDRQ, SDRQ | I | Primary & Secondary DMA Request | 2 |
| PDAK#, SDACK# | O | Primary & Secondary DMA Acknowledge | 2 |
| PDIOR#, SDIOR# | O | Primary & Secondary I/O Channel Read | 2 |
| PDIOW#, SDIOW# | O | Primary & Secondary I/O Channel Write | 2 |
| MONITOR INTERFACE | | | |
| RED, GREEN, BLUE | O | Analog Red, Green, Blue | 3 |
| VSYNC | O | Vertical Sync | 1 |
| HSYNC | O | Horizontal Sync | 1 |
| VREF_DAC | I | DAC Voltage reference | 1 |
| RSET | I | Resistor Set | 1 |
| COMP | I | Compensation | 1 |

Table 2.2. Definition of Signal Pins

| Signal Name | Dir | Description | Qty |
|---------------------------|-----|---|-----|
| VIDEO INPUT | | | |
| VCLK | I | 27-33MHz Video Input Port Clock | 1 |
| VIN | I | CCIR 601 or 656 YUV Video Data Input | 8 |
| VCS | I/O | Composite Synch or Horizontal line SYNC output | 1 |
| ODD_EVEN | I/O | Frame Synchronisation | 1 |
| ANALOG TV OUTPUT | | | |
| RED_TV, GREEN_TV, BLUE_TV | O | Analog RGB or S-VHS outputs | 3 |
| CVBS | O | Analog video composite output | 1 |
| IREF1_TV | I | Reference current of 9bit DAC for CVBS | 1 |
| VREF1_TV | I | Reference voltage of 9bit DAC for CVBS | 1 |
| IREF2_TV | I | Reference current of 8bit DAC for R,G,B | 1 |
| VREF2_TV | I | Reference voltage of 8bit DAC for R,G,B | 1 |
| VSSA_TV | I | Analog Vss for DAC | 1 |
| VDDA_TV | I | Analog Vdd for DAC | 1 |
| MISCELLANEOUS | | | |
| SPKRD | O | Speaker Device Output | 1 |
| SCL | I/O | I C Interface - Clock / Can be used for VGA DDC[1] signal | 1 |
| SDA | I/O | I C Interface - Data / Can be used for VGA DDC[0] signal | 1 |
| SCAN_ENABLE | I | Reserved (Test pin) | 1 |

2.2 SIGNAL DESCRIPTIONS

2.2.1 BASIC CLOCKS AND RESETS

SYSRSTI# *System Reset/Power good.* This input is low when the reset switch is depressed. Otherwise, it reflects the power supply's power good signal. This input is asynchronous to all clocks, and acts as a negative active reset. The reset circuit initiates a hard reset on the rising edge of this signal.

SYSRSTO# *Reset Output to System.* This is the system reset signal and is used to reset the rest of the components (not on Host bus) in the system. The ISA bus reset is an externally inverted buffered version of this output and the PCI bus reset is an externally buffered version of this output.

XTALI *14.3MHz Crystal Input*

XTALO *14.3MHz Crystal Output.* These pins are connected to the 14.318 MHz crystal to provide the reference clock for the internal frequency synthesizer to generate all the other clocks.

A 14.318 MHz Series Cut Crystal should be connected between these two pins. Balance capacitors of 15 pF should also be added. In the event of an external quartz oscillator providing the master

clock signal to the STPC Consumer-S device, the TTL signal should be provided on XTALO.

HCLK *Host Clock.* This clock supplies the CPU and the host related blocks. This clock can be doubled inside the CPU and is intended to operate in the range of 25 to 100 MHz. This clock is generated internally from a PLL but can be driven directly from the external system.

DCLK *Dot Clock / Pixel clock.* This clock supplies the display controller, the video pipeline, the ramdac, and the TV output logic. Its value is dependent on the selected display mode.

Its frequency can be as high as 135 MHz. This signal is either driven by the internal PLL either by an external oscillator. The direction can be controlled by a strap option or an internal register bit.

DEV_CLK *24MHz Peripheral Clock.* This 24MHz signal is provided as a convenience for the system integration of a Floppy Disk driver function in an external chip.

PIN DESCRIPTION

2.2.2 MEMORY INTERFACE

MCLKO *Memory Clock Output*. This clock is driving the DIMMs on board and is generated from an internal PLL. The default value is 66MHz.

MCLKI *Memory Clock Input*. This clock is driving the SDRAM controller, the graphics engine and display controller. This input should be a buffered version of the MCLKO signal with the track lengths between the buffer and the pin matched with the track lengths between the buffer and the DIMMs.

CS#[3:0] *Chip Select* These signals are used to disable or enable device operation by masking or enabling all SDRAM inputs except MCLK, CKE, and DQM.

MA[11:0] *Memory Address*. Multiplexed row and column address lines.

MD[63:0] *Memory Data*. This is the 64-bit memory data bus. MD[40-0] are read by the device strap option registers during rising edge of SYSRSTI#.

RAS#[1:0] *Row Address Strobe*. These signals enable row access and precharge. Row address is latched on rising edge of MCLK when RAS# is low.

CAS#[1:0] *Column Address Strobe*. These signals enable column access. Column address is latched on rising edge of MCLK when CAS# is low.

MWE# *Write Enable*. Write enable specifies whether the memory access is a read (MWE# = H) or a write (MWE# = L).

DQM#[7:0] *Data Mask*. Makes data output Hi-Z after the clock and masks the SDRAM outputs. Blocks SDRAM data input when DQM active.

2.2.3 PCI INTERFACE

PCI_CLKI *33MHz PCI Input Clock*. This signal is the PCI bus clock input and should be driven from the PCI_CLKO pin.

PCI_CLKO *33MHz PCI Output Clock*. This is the master PCI bus clock output.

AD[31:0] *PCI Address/Data*. This is the 32-bit multiplexed address and data bus of the PCI. This bus is driven by the master during the address phase and data phase of write transactions. It is driven by the target during data phase of read transactions.

CBE#[3:0] *Bus Commands/Byte Enables*. These are the multiplexed command and byte enable signals of the PCI bus. During the address phase they define the command and during the data phase they carry the byte enable information. These pins are inputs when a PCI master other than the STPC Consumer-S owns the bus and outputs when the STPC Consumer-S owns the bus.

FRAME# *Cycle Frame*. This is the frame signal of the PCI bus. It is an input when a PCI master owns the bus and is an output when STPC Consumer-S owns the PCI bus.

IRDY# *Initiator Ready*. This is the initiator ready signal of the PCI bus. It is used as an output when the STPC Consumer-S initiates a bus cycle on the PCI bus. It is used as an input during the PCI cycles targeted to the STPC Consumer-S to determine when the current PCI master is ready to complete the current transaction.

TRDY# *Target Ready*. This is the target ready signal of the PCI bus. It is driven as an output when the STPC Consumer-S is the target of the current bus transaction. It is used as an input when STPC Consumer-S initiates a cycle on the PCI bus.

LOCK# *PCI Lock*. This is the lock signal of the PCI bus and is used to implement the exclusive bus operations when acting as a PCI target agent.

DEVSEL# *I/O Device Select.* This signal is used as an input when the STPC Consumer-S initiates a bus cycle on the PCI bus to determine if a PCI slave device has decoded itself to be the target of the current transaction. It is asserted as an output either when the STPC Consumer-S is the target of the current PCI transaction or when no other device asserts DEVSEL# prior to the subtractive de-code phase of the current PCI transaction.

STOP# *Stop Transaction.* Stop is used to implement the disconnect, retry and abort protocol of the PCI bus. It is used as an input for the bus cycles initiated by the STPC Consumer-S and is used as an output when a PCI master cycle is targeted to the STPC Consumer-S.

PAR *Parity Signal Transactions.* This is the parity signal of the PCI bus. This signal is used to guarantee even parity across AD[31:0], CBE#[3:0], and PAR. This signal is driven by the master during the address phase and data phase of write transactions. It is driven by the target during data phase of read transactions. (Its assertion is identical to that of the AD bus delayed by one PCI clock cycle)

SERR# *System Error.* This is the system error signal of the PCI bus. It may, if enabled, be asserted for one PCI clock cycle if target aborts a STPC Consumer-S initiated PCI transaction. Its assertion by either the STPC Consumer-S or by another PCI bus agent will trigger the assertion of NMI to the host CPU. This is an open drain output.

PCIREQ#[2:0] *PCI Request.* This pin are the three external PCI master request pins. They indicate to the PCI arbiter that the external agents desire use of the bus.

PCI_GNT#[2:0] *PCI Grant.* These pins indicate that the PCI bus has been granted to the master requesting it on its PCIREQ#.

PCI_INT[3:0] *PCI Interrupt Request.* These are the PCI bus interrupt signals.

VDD5 *5V Power Supply.* These power pins are necessary for 5V ESD protection. In case the PCI bus is used in 3.3V only, these pins can be connected to 3.3V.

2.2.4 ISA INTERFACE

ISA_CLK, ISA_CLKX2 *ISA Clock x1, x2.* These pins generate the Clock signal for the ISA bus and a Doubled Clock signal. They are also used as the multiplexor control lines for the Interrupt Controller Interrupt input lines. ISA_CLK is generated from either PCICLK/4 or OSC14M/ 2.

OSC14M *ISA bus synchronisation clock Output.* This is the buffered 14.318 Mhz clock for the ISA bus.

LA[23:17] *Unlatched Address.* When the ISA bus is active, these pins are ISA Bus unlatched address for 16-bit devices. When ISA bus is accessed by any cycle initiated from PCI bus, these pins are in output mode. When an ISA bus master owns the bus, these pins are in input mode.

SA[19:0] *ISA Address Bus.* System address bus of ISA on 8-bit slot. These pins are used as an input when an ISA bus master owns the bus and are outputs at all other times.

SD[15:0] *I/O Data Bus.* These pins are the external databus to the ISA bus.

ALE *Address Latch Enable.* This is the address latch enable output of the ISA bus and is asserted by the STPC Consumer-S to indicate that LA23-17, SA19-0, AEN and SBHE# signals are valid. The ALE is driven high during refresh, DMA master or an ISA master cycles by the STPC Consumer-S. ALE is driven low after reset.

MEMR# *Memory Read.* This is the memory read command signal of the ISA bus. It is used as an input when an ISA master owns the bus and is an output at all other times. The MEMR# signal is active during refresh.

MEMW# *Memory Write.* This is the memory write command signal of the ISA bus. It is used as an input when an ISA master owns the bus and is an output at all other times.

SMEMR# *System Memory Read.* The STPC Consumer-S generates SMEMR# signal of the ISA bus only when the address is below one megabyte or the cycle is a refresh cycle.

PIN DESCRIPTION

SMEMW# *System Memory Write*. The STPC Consumer-S generates SMEMW# signal of the ISA bus only when the address is below one megabyte.

IOR# *I/O Read*. This is the IO read command signal of the ISA bus. It is an input when an ISA master owns the bus and is an output at all other times.

IOW# *I/O Write*. This is the IO write command signal of the ISA bus. It is an input when an ISA master owns the bus and is an output at all other times.

MCS16# *Memory Chip Select16*. This is the decode of LA23-17 address pins of the ISA address bus without any qualification of the command signal lines. MCS16# is always an input. The STPC Consumer-S ignores this signal during IO and refresh cycles.

IOCS16# *IO Chip Select16*. This signal is the decode of SA15-0 address pins of the ISA address bus without any qualification of the command signals. The STPC Consumer-S does not drive IOCS16# (similar to PC-AT design). An ISA master access to an internal register of the STPC Consumer-S is executed as an extended 8-bit IO cycle.

BHE# *System Bus High Enable*. This signal, when asserted, indicates that a data byte is being transferred on SD15-8 lines. It is used as an input when an ISA master owns the bus and is an output at all other times.

ZWS# *Zero Wait State*. This signal, when asserted by addressed device, indicates that current cycle can be shortened.

REF# *Refresh Cycle*. This is the refresh command signal of the ISA bus. It is driven as an output when the STPC Consumer-S performs a refresh cycle on the ISA bus. It is used as an input when an ISA master owns the bus and is used to trigger a refresh cycle.

The STPC Consumer-S performs a pseudo hidden refresh. It requests the host bus for two host clocks to drive the refresh address and capture it in external buffers. The host bus is then relinquished while the refresh cycle continues on the ISA bus.

MASTER# *Add On Card Owns Bus*. This signal is active when an ISA device has been granted bus ownership.

AEN *Address Enable*. Address Enable is enabled when the DMA controller is the bus owner to indicate that a DMA transfer will occur. The enabling of the signal indicates to IO devices to ignore the IOR#/IOW# signal during DMA transfers.

IOCHCK# *IO Channel Check*. IO Channel Check is enabled by any ISA device to signal an error condition that can not be corrected. NMI signal becomes active upon seeing IOCHCK# active if the corresponding bit in Port B is enabled.

IOCHRDY *Channel Ready*. IOCHRDY is the IO channel ready signal of the ISA bus and is driven as an output in response to an ISA master cycle targeted to the host bus or an internal register of the STPC Consumer-S. The STPC Consumer-S monitors this signal as an input when performing an ISA cycle on behalf of the host CPU, DMA master or refresh.

ISA masters which do not monitor IOCHRDY are not guaranteed to work with the STPC Consumer-S since the access to the system memory can be considerably delayed due UMA architecture.

ISAOE# *Bidirectional OE Control*. This signal controls the \overline{OE} signal of the external transceiver that connects the IDE DD bus and ISA SA bus.

GPIOCS# *I/O General Purpose Chip Select*. This output signal is used by the external latch on ISA bus to latch the data on the SD[7:0] bus. The latch can be use by PMU unit to control the external peripheral devices or any other desired function.

IRQ_MUX[3:0] *Multiplexed Interrupt Request*. These are the ISA bus interrupt signals. They have to be encoded before connection to the STPC Consumer-S using ISACLK and ISACLKX2 as the input selection strobes.

Note that IRQ8B, which by convention is connected to the RTC, is inverted before being sent to the interrupt controller, so that it may be connected directly to the \overline{IRQ} pin of the RTC.

DREQ_MUX[1:0] *ISA Bus Multiplexed DMA Request*. These are the ISA bus DMA request signals. They are to be encoded before connection to the STPC Consumer-S using ISACLK and ISACLKX2 as the input selection strobes.

DACK_ENC[2:0] *DMA Acknowledge.* These are the ISA bus DMA acknowledge signals. They are encoded by the STPC Consumer-S before output and should be decoded externally using ISACK and ISACKX2 as the control strobes.

TC *ISA Terminal Count.* This is the terminal count output of the DMA controller and is connected to the TC line of the ISA bus. It is asserted during the last DMA transfer, when the byte count expires.

2.2.5 X-Bus Interface pins

RTCAS# *Real time clock address strobe.* This signal is asserted for any I/O write to port 70H.

RMRTCCS# *ROM/Real Time clock chip select.* This signal is asserted if a ROM access is decoded during a memory cycle. It should be combined with MEMR# or MEMW# signals to properly access the ROM. During a IO cycle, this signal is asserted if access to the Real Time Clock (RTC) is decoded. It should be combined with IOR or IOW# signals to properly access the real time clock.

KBCS# *Keyboard Chip Select.* This signal is asserted if a keyboard access is decoded during a I/O cycle.

RTCRW# *Real Time Clock RW.* This pin is a multi-function pin. When ISAOE# is active, this signal is used as RTCRW#. This signal is asserted for any I/O write to port 71H.

RTCDS# *Real Time Clock DS.* This pin is a multi-function pin. When ISAOE# is active, this signal is used as RTCDS. This signal is asserted for any I/O read to port 71H.

Note: RMRTCCS#, KBCS#, RTCRW# and RTCDS# signals must be ORed externally with ISAOE# and then connected to the external device. An LS244 or equivalent function can be used if OE# is connected to ISAOE# and the output is provided with a weak pull-up resistor as shown in Figure 2.2.

2.2.6 LOCAL BUS

PA[21:0] *Address Bus Output.*

PD[15:0] *Data Bus.* This is the 16-bit data bus. D[7:0] is the LSB and PD[15:8] is the MSB.

PWR#[1:0] *Write Control output.* PWR0# is used to write the LSB and PWR1# to write the MSB.

PRD#[1:0] *Read Control output.* PRD0# is used to read the LSB and PRD1# to read the MSB.

PRDY# *Data Ready input.* This signal is used to create wait states on the bus. When low, it completes the current cycle.

FCS#[1:0] *Flash Chip Select output.* These are the Programmable Chip Select signals for up to 2 banks of Flash memory.

IOCS#[3:0] *I/O Chip Select output.* These are the Programmable Chip Select signals for up to 4 external I/O devices.

PIN DESCRIPTION

2.2.7 IDE INTERFACE

PCS1#, PCS3# *Primary Chip Select.* These signals are used as the active high primary master & slave IDE chip select signals. These signals must be externally ANDed with the ISAOE# signal before driving the IDE devices to guarantee it is active only when ISA bus is idle.

SCS1#, SCS3# *Secondary Chip Select.* These signals are used as the active high secondary master & slave IDE chip select signals. These signals must be externally ANDed with the ISAOE# signal before driving the IDE devices to guarantee it is active only when ISA bus is idle.

DA[2:0] *Address.* These signals are connected to DA[2:0] of IDE devices directly or through a buffer. If the toggling of signals are to be masked during ISA bus cycles, they can be externally ORed with ISAOE# before being connected to the IDE devices.

DD[15:0] *Databus.* When the IDE bus is active, they serve as IDE signals DD[11:0]. IDE devices are connected to SA[19:8] directly and ISA bus is connected to these pins through two LS245 transceivers as described in Figure 2.2.

DIORDY *Busy/Ready.* This pin serves as IDE signal DIORDY.

PIRQ *Primary Interrupt Request.*
SIRQ *Secondary Interrupt Request.*
Interrupt request from IDE channels.

PDRQ *Primary DMA Request.*
SDRQ *Secondary DMA Request.*
DMA request from IDE channels.

PDACK# *Primary DMA Acknowledge.*
SDACK# *Secondary DMA Acknowledge.*
DMA acknowledge to IDE channels.

PDIOR#, PDIOW# *Primary I/O Read & Write.*
SDIOR#, SDIOW# *Secondary I/O Read & Write.*
Primary & Secondary channel read & write.

2.2.8 Monitor Interface

RED, GREEN, BLUE *RGB Video Outputs.* These are the 3 analog color outputs from the RAMDACs

VSYNC *Vertical Synchronisation Pulse.* This is the vertical synchronization signal from the VGA controller.

HSYNC *Horizontal Synchronisation Pulse.* This is the horizontal synchronization signal from the VGA controller.

VREF_DAC *DAC Voltage reference.* An external voltage reference is connected to this pin to bias the DAC.

RSET *Resistor Current Set.* This reference current input to the RAMDAC is used to set the full-scale output of the RAMDAC.

COMP *Compensation.* This is the RAMDAC compensation pin. Normally, an external capacitor (typically 10nF) is connected between this pin and V_{DD} to damp oscillations.

2.2.9 VIDEO INTERFACE

VCLK *Pixel Clock Input.* This signal is used to synchronise data being transferred from an external video device to either the frame buffer, or alternatively out the TV output in bypass mode. This pin can be sourced from STPC if no external VCLK is detected, or can be input from an external video clock source.

VIN[7:0] *YUV Video Data Input CCIR 601 or 656.* Time multiplexed 4:2:2 luminance and chrominance data as defined in ITU-R Rec601-2 and Rec656 (except for TTL input levels). This bus typically carries a stream of Cb,Y,Cr,Y digital video at VCLK frequency, clocked on the rising edge (by default) of VCLK.

VCS *Line synchronisation Output.* This pin is an input in ODDEV+HSYNC or VSYNC + HSYNC or VSYNC slave modes and an output in all other modes (master/slave)

ODD_EVEN *Frame Synchronisation Output.* This pin supports the Frame synchronisation signal. It is an input in slave modes, except when sync is extracted from YCrCb data, and an output in master mode and when sync is extracted from YCrCb data

The signal is synchronous to rising edge of DCLK.
The default polarity for this pin is:
- odd (not-top) field : LOW level
- even (bottom) field : HIGH level

2.2.10 TV OUTPUT

RED_TV / C_TV *Analog video outputs synchronized with CVBS.* This output is current-driven and must be connected to analog ground over a load resistor (R_{LOAD}). Following the load resistor, a simple analog low pass filter is recommended. In S-VHS mode, this is the Chrominance Output.

GREEN_TV / Y_TV *Analog video outputs synchronized with CVBS.* This output is current-driven and must be connected to analog ground over a load resistor (R_{LOAD}). Following the load resistor, a simple analog low pass filter is recommended. In S-VHS mode, this is the Luminance Output.

BLUE_TV / CVBS *Analog video outputs synchronized with CVBS.* This output is current-driven and must be connected to analog ground over a load resistor (R_{LOAD}). Following the load resistor, a simple analog low pass filter is recommended. In S-VHS mode, this is a second composite output.

CVBS *Analog video composite output (luminance/chrominance).* CVBS is current-driven and must be connected to analog ground over a load resistor (R_{LOAD}). Following the load resistor, a simple analog low pass filter is recommended.

IREF1_TV *Ref. current* for CVBS 10-bit DAC.

IREF2_TV *Reference current* for RGB 9-bit DAC.

VREF1_TV *Ref. voltage* for CVBS 10-bit DAC.

VREF2_TV *Reference voltage* for RGB 9-bit DAC.

VSSA_TV *Analog V_{SS}* for DACs.

VDDA_TV *Analog V_{DD}* for DACs.

PIN DESCRIPTION

2.2.11 MISCELLANEOUS

SPKRD *Speaker Drive*. This the output to the speaker and is AND of the counter 2 output with bit 1 of Port 61, and drives an external speaker driver. This output should be connected to 7407 type high voltage driver.

SCL, SDA I C Interface. These bidirectional pins are connected to CRTC register 3Fh to implement DDC capabilities. They conform to I²C electrical specifications, they have open-collector output drivers which are internally connected to V_{DD} through pull-up resistors. They can be used for the DDC1 (SCL) and DDC0 (SDA) lines of the VGA interface.

SCAN_ENABLE *Reserved*. The pin is reserved for Test and Miscellaneous functions.

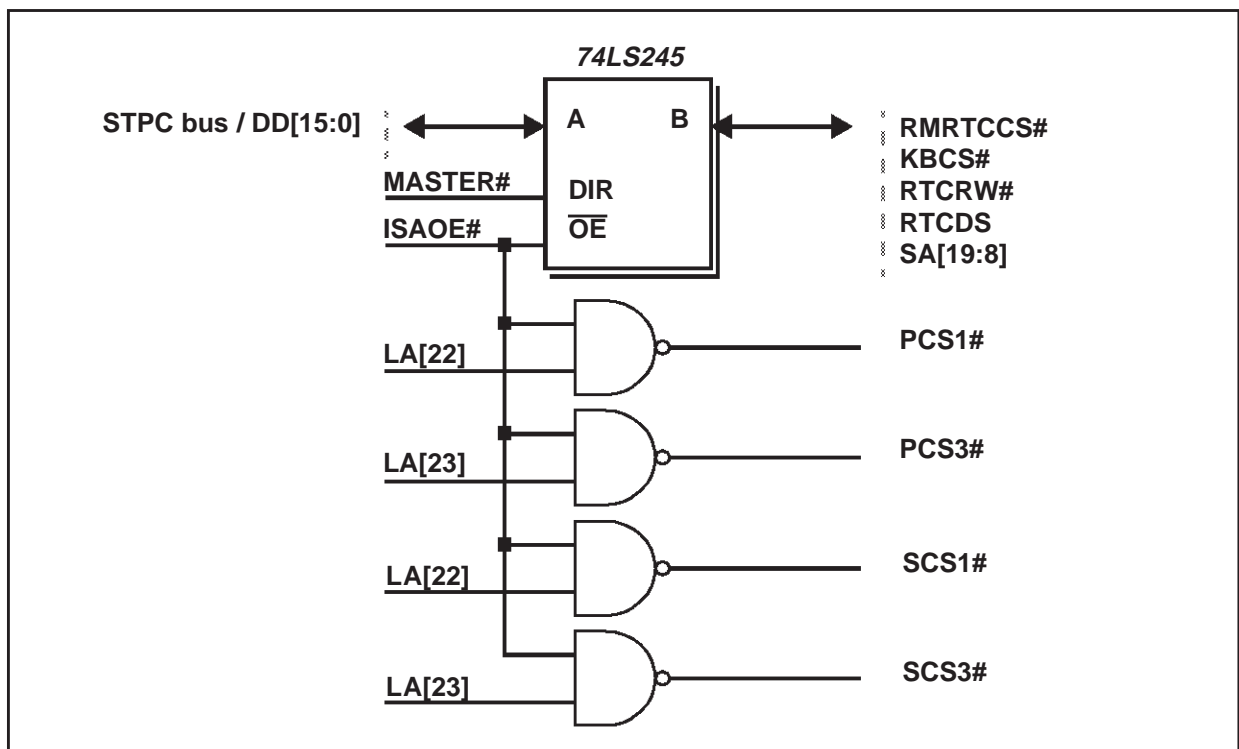
Table 2.3. ISA / IDE dynamic multiplexing

| ISA BUS (ISAOE# = 0) | IDE (ISAOE# = 1) |
|-------------------------|---------------------|
| RMRTCCS# | DD[15] |
| KBCS# | DD[14] |
| RTCRW# | DD[13] |
| RTCDS | DD[12] |
| SA[19:8] | DD[11:0] |
| LA[23] | SCS3# |
| LA[22] | SCS1# |
| SA[21] | PCS3# |
| SA[20] | PCS1# |
| LA[19:17] | DA[2:0] |
| IOCHRDY | DIORDY |

Table 2.4. ISA / Local Bus pin sharing

| ISA / IPC | LOCAL BUS |
|-------------------|------------|
| SD[15:0] | PD[15:0] |
| DREQ_MUX[1:0] | PA[21:20] |
| SMEMR# | PA[19] |
| MEMW# | PA[18] |
| BHE# | PA[17] |
| AEN | PA[16] |
| ALE | PA[15] |
| MEMR# | PA[14] |
| IOR# | PA[13] |
| IOW# | PA[12] |
| REF# | PA[11] |
| IOCHCK# | PA[10] |
| GPIOCs# | PA[9] |
| ZWS# | PA[8] |
| SA[7:4] | PA[7:4] |
| TC, DACK_ENC[2:0] | PA[3:0] |
| SA[3] | PRDY |
| ISAOE#, SA[2:0] | IOCS#[3:0] |
| DEV_CLK, RTCAS# | FCS#[1:0] |
| IOCS16#, MASTER# | PRD#[1:0] |
| SMEMW#, MCS16# | PWR#[1:0] |
| ISACLK, ISA_CLK2X | |

Figure 2.2. Typical ISA/IDE Demultiplexing



PIN DESCRIPTION

Table 2.5. Pinout.

| Pin # | Pin name |
|-------|----------|
| AF3 | SYSRSTI# |
| AE4 | SYSRSTO# |
| A3 | XTALI |
| C4 | XTALO |
| G23 | HCLK |
| H24 | DEV_CLK |
| AD11 | DCLK |
| AF15 | MCLKI |
| AB23 | MCLKO |
| AE16 | MA[0] |
| AD15 | MA[1] |
| AF16 | MA[2] |
| AE17 | MA[3] |
| AD16 | MA[4] |
| AF17 | MA[5] |
| AE18 | MA[6] |
| AD17 | MA[7] |
| AF18 | MA[8] |
| AE19 | MA[9] |
| AE20 | MA[10] |
| AC19 | MA[11] |
| AF22 | CS#[0] |
| AD21 | CS#[1] |
| AE24 | CS#[2] |
| AD23 | CS#[3] |
| AF23 | RAS#[0] |
| AD22 | RAS#[1] |
| AE21 | CAS#[0] |
| AC20 | CAS#[1] |
| AF20 | DQM#[0] |
| AD19 | DQM#[1] |
| AF21 | DQM#[2] |
| AD20 | DQM#[3] |
| AE22 | DQM#[4] |
| AE23 | DQM#[5] |
| AF19 | DQM#[6] |
| AD18 | DQM#[7] |
| AC22 | MWE# |
| R1 | MD[0] |
| T2 | MD[1] |
| R3 | MD[2] |
| T1 | MD[3] |
| R4 | MD[4] |
| U2 | MD[5] |
| T3 | MD[6] |
| U1 | MD[7] |
| U4 | MD[8] |
| V2 | MD[9] |

| Pin # | Pin name |
|-------|----------|
| U3 | MD[10] |
| V1 | MD[11] |
| W2 | MD[12] |
| V3 | MD[13] |
| Y2 | MD[14] |
| W4 | MD[15] |
| Y1 | MD[16] |
| W3 | MD[17] |
| AA2 | MD[18] |
| Y4 | MD[19] |
| AA1 | MD[20] |
| Y3 | MD[21] |
| AB2 | MD[22] |
| AB1 | MD[23] |
| AA3 | MD[24] |
| AB4 | MD[25] |
| AC1 | MD[26] |
| AB3 | MD[27] |
| AD2 | MD[28] |
| AC3 | MD[29] |
| AD1 | MD[30] |
| AF2 | MD[31] |
| AF24 | MD[32] |
| AE26 | MD[33] |
| AD25 | MD[34] |
| AD26 | MD[35] |
| AC25 | MD[36] |
| AC24 | MD[37] |
| AC26 | MD[38] |
| AB25 | MD[39] |
| AB24 | MD[40] |
| AB26 | MD[41] |
| AA25 | MD[42] |
| Y23 | MD[43] |
| AA24 | MD[44] |
| AA26 | MD[45] |
| Y25 | MD[46] |
| Y26 | MD[47] |
| Y24 | MD[48] |
| W25 | MD[49] |
| V23 | MD[50] |
| W26 | MD[51] |
| W24 | MD[52] |
| V25 | MD[53] |
| V26 | MD[54] |
| U25 | MD[55] |
| V24 | MD[56] |
| U26 | MD[57] |
| U23 | MD[58] |

| Pin # | Pin name |
|-------|----------|
| T25 | MD[59] |
| U24 | MD[60] |
| T26 | MD[61] |
| R25 | MD[62] |
| R26 | MD[63] |
| F24 | PCI_CLKI |
| D25 | PCI_CLKO |
| B20 | AD[0] |
| C20 | AD[1] |
| B19 | AD[2] |
| A19 | AD[3] |
| C19 | AD[4] |
| B18 | AD[5] |
| A18 | AD[6] |
| B17 | AD[7] |
| C18 | AD[8] |
| A17 | AD[9] |
| D17 | AD[10] |
| B16 | AD[11] |
| C17 | AD[12] |
| B15 | AD[13] |
| A15 | AD[14] |
| C16 | AD[15] |
| B14 | AD[16] |
| D15 | AD[17] |
| A14 | AD[18] |
| B13 | AD[19] |
| D13 | AD[20] |
| A13 | AD[21] |
| C14 | AD[22] |
| B12 | AD[23] |
| C13 | AD[24] |
| A12 | AD[25] |
| C12 | AD[26] |
| A11 | AD[27] |
| D12 | AD[28] |
| B10 | AD[29] |
| C11 | AD[30] |
| A10 | AD[31] |
| D10 | CBE[0] |
| C10 | CBE[1] |
| A9 | CBE[2] |
| B8 | CBE[3] |
| A8 | FRAME# |
| B7 | TRDY# |
| D8 | IRDY# |
| A7 | STOP# |
| C8 | DEVSEL# |
| B6 | PAR |

PIN DESCRIPTION

| Pin # | Pin name |
|-------|--------------|
| D7 | SERR# |
| A6 | LOCK# |
| D20 | PCI_REQ#[0] |
| C21 | PCI_REQ#[1] |
| A21 | PCI_REQ#[2] |
| C22 | PCI_GNT#[0] |
| A22 | PCI_GNT#[1] |
| B21 | PCI_GNT#[2] |
| A5 | PCI_INT[0] |
| C6 | PCI_INT[1] |
| B4 | PCI_INT[2] |
| D5 | PCI_INT[3] |
| A16 | VDD5 |
| B11 | VDD5 |
| B9 | VDD5 |
| D18 | VDD5 |
| | |
| F2 | LA[17]/DA[0] |
| G4 | LA[18]/DA[1] |
| F3 | LA[19]/DA[2] |
| F1 | LA[20]/PCS1# |
| G2 | LA[21]/PCS3# |
| G1 | LA[22]/SCS1# |
| H2 | LA[23]/SCS3# |
| J4 | SA[0] |
| H1 | SA[1] |
| H3 | SA[2] |
| J2 | SA[3] |
| J1 | SA[4] |
| K2 | SA[5] |
| J3 | SA[6] |
| K1 | SA[7] |
| K4 | SA[8] |
| L2 | SA[9] |
| K3 | SA[10] |
| L1 | SA[11] |
| M2 | SA[12] |
| M1 | SA[13] |
| L3 | SA[14] |
| N2 | SA[15] |
| M4 | SA[16] |
| M3 | SA[17] |
| P2 | SA[18] |
| P4 | SA[19] |
| K25 | SD[0] |
| L24 | SD[1] |
| K26 | SD[2] |
| K23 | SD[3] |
| J25 | SD[4] |

| Pin # | Pin name |
|-------|-------------|
| K24 | SD[5] |
| J26 | SD[6] |
| H25 | SD[7] |
| H26 | SD[8] |
| J24 | SD[9] |
| G25 | SD[10] |
| H23 | SD[11] |
| D24 | SD[12] |
| C26 | SD[13] |
| A25 | SD[14] |
| B24 | SD[15] |
| | |
| AD4 | ISA_CLK |
| AF4 | ISA_CLK2X |
| C9 | OSC14M |
| P25 | ALE |
| AE8 | ZWS# |
| R23 | BHE# |
| P26 | MEMR# |
| R24 | MEMW# |
| N25 | SMEMR# |
| N23 | SMEMW# |
| N26 | IOR# |
| P24 | IOW# |
| N24 | MCS16# |
| M26 | IOCS16# |
| M25 | MASTER# |
| L25 | REF# |
| M24 | AEN |
| L26 | IOCHCK# |
| T24 | IOCHRDY |
| M23 | ISAOE# |
| A4 | RTCAS# |
| P3 | RTCDs# |
| R2 | RTCRW# |
| P1 | RMRTCCS# |
| AE3 | GPIOCs# |
| E23 | IRQ_MUX[0] |
| D26 | IRQ_MUX[1] |
| E24 | IRQ_MUX[2] |
| C25 | IRQ_MUX[3] |
| A24 | DREQ_MUX[0] |
| B23 | DREQ_MUX[1] |
| C23 | DACK_ENC[0] |
| A23 | DACK_ENC[1] |
| B22 | DACK_ENC[2] |
| D22 | TC |
| C5 | SPKRD |
| N3 | KBCS# |

| Pin # | Pin name |
|-------|----------|
| B1 | PIRQ |
| C2 | SIRQ |
| C1 | PDRQ |
| D2 | SDRQ |
| D3 | PDACK# |
| D1 | SDACK# |
| E2 | PDIOR# |
| E4 | PDIOW# |
| E3 | SDIOR# |
| E1 | SDIOW# |
| | |
| AF9 | RED |
| AE9 | GREEN |
| AD8 | BLUE |
| AC5 | VSYNc |
| AE5 | HSYNc |
| AC10 | VREF_DAC |
| AE10 | RSET |
| AD7 | COMP |
| B5 | SCL |
| C7 | SDA |
| | |
| AE15 | VCLK |
| AD5 | VIN[0] |
| AF7 | VIN[1] |
| AF5 | VIN[2] |
| AE6 | VIN[3] |
| AC7 | VIN[4] |
| AD6 | VIN[5] |
| AF6 | VIN[6] |
| AE7 | VIN[7] |
| | |
| AD10 | RED_TV |
| AF11 | GREEN_TV |
| AE12 | BLUE_TV |
| AE13 | VCS |
| AC12 | ODD_EVEN |
| AF14 | CVBS |
| AE11 | IREF1_TV |
| AF12 | VREF1_TV |
| AE14 | IREF2_TV |
| AC14 | VREF2_TV |
| AD12 | VDDA_TV |
| AF8 | VDD_DAC1 |
| AD9 | VDD_DAC2 |
| AF13 | VSSA_TV |
| AC9 | VSS_DAC1 |
| AF10 | VSS_DAC2 |
| | |



PIN DESCRIPTION

| Pin # | Pin name |
|--------|----------------|
| B3 | SCAN_ENABLE |
| | |
| G24 | VDD_CPUCLK_PLL |
| AD13 | VDD_DCLK_PLL |
| F25 | VDD_DEVCLK_PLL |
| AC17 | VDD_MCLKI_PLL |
| AC15 | VDD_MCLKO_PLL |
| F26 | VDD_HCLK_PLL |
| A20 | VDD |
| C15 | VDD |
| D6 | VDD |
| D11 | VDD |
| D16 | VDD |
| D21 | VDD |
| F4 | VDD |
| F23 | VDD |
| G3 | VDD |
| G26 | VDD |
| L4 | VDD |
| L23 | VDD |
| N1 | VDD |
| T4 | VDD |
| T23 | VDD |
| W1 | VDD |
| AA4 | VDD |
| AA23 | VDD |
| AC6 | VDD |
| AC2 | VDD |
| AC11 | VDD |
| AC16 | VDD |
| AC21 | VDD |
| | |
| E25 | VSS_DLL |
| E26 | VSS_DLL |
| A1:2 | VSS |
| A26 | VSS |
| B2 | VSS |
| B25:26 | VSS |
| C3 | VSS |
| C24 | VSS |
| D4 | VSS |
| D9 | VSS |
| D14 | VSS |
| D19 | VSS |
| D23 | VSS |
| H4 | VSS |
| J23 | VSS |
| L11:16 | VSS |
| M11:16 | VSS |

| Pin # | Pin name |
|--------|----------|
| N4 | VSS |
| N11:16 | VSS |
| P11:16 | VSS |
| P23 | VSS |
| R11:16 | VSS |
| T11:16 | VSS |
| V4 | VSS |
| W23 | VSS |
| AC4 | VSS |
| AC8 | VSS |
| AC13 | VSS |
| AC18 | VSS |
| AC23 | VSS |
| AD3 | VSS |
| AD14 | VSS |
| AD24 | VSS |
| AE1:2 | VSS |
| AE25 | VSS |
| AF1 | VSS |
| AF25 | VSS |
| AF26 | VSS |

3 STRAP OPTIONS

This chapter defines the STPC Consumer-S Strap Options and their location

| Memory Data Lines | Note | Refer to | Designation | Location | Actual Settings | Set to '0' | Set to '1' |
|-------------------|------|-----------|------------------|-----------------|-----------------|------------|------------|
| MD0 | 1 | - | Reserved | - | - | - | - |
| MD1 | | - | Reserved | - | - | - | - |
| MD2 | | - | Reserved | - | - | - | - |
| MD3 | | - | Reserved | - | - | - | - |
| MD4 | | - | Reserved | - | - | - | - |
| MD5 | | - | Reserved | - | - | - | - |
| MD6 | | - | Reserved | - | - | - | - |
| MD7 | | - | Reserved | - | - | - | - |
| MD8 | | - | Reserved | - | - | - | - |
| MD9 | | - | Reserved | - | - | - | - |
| MD10 | | - | Reserved | - | - | - | - |
| MD11 | | - | Reserved | - | - | - | - |
| MD12 | | - | Reserved | - | - | - | - |
| MD13 | | - | Reserved | - | - | - | - |
| MD14 | | - | Reserved | - | - | - | - |
| MD15 | | - | Reserved | - | - | - | - |
| MD16 | | - | Reserved | Index 4C, bit0 | Pull up | - | - |
| MD17 | | PCI Clock | PCI_CLKO Divisor | Index 4C, bit 1 | User defined | HCLK / 3 | HCLK / 2 |
| MD18 | | | Reserved | Index 4C, bit 2 | Pull up | - | - |
| MD19 | | | Reserved | Index 4C, bit 3 | Pull up | | |
| MD20 | | | Reserved | Index 4C, bit4 | Pull up | - | - |
| MD21 | | | Reserved | Index 5F, bit 0 | Pull up | | |
| MD22 | | | Reserved | Index 5F, bit 1 | Pull up | | |
| MD23 | | - | Reserved | Index 5F, bit 2 | Pull up | - | - |
| MD24 | | HCLK | HCLK PLL Speed | Index 5F, bit 3 | User defined | 000 | 25 MHz |
| MD25 | | | | Index 5F, bit 4 | User defined | 001 | 33 MHz |
| MD26 | | | | Index 5F, bit 5 | User defined | 010 | 100 MHz |
| | | | | | | 011 | 50 MHz |
| | | | | | | 100 | 60 MHz |
| | | | | | | 101 | 66 MHz |
| | | | | | | 110 | 75 MHz |
| | | | | | | 111 | 90 MHz |
| MD27 | | | Reserved | | Pull down | | |
| MD28 | | | Reserved | | Pull down | | |
| MD29 | | | Reserved | | Pull down | | |
| MD30 | | | Reserved | | Pull down | | |
| MD31 | | | Reserved | | Pull down | | |
| MD32 | | | Reserved | | Pull down | | |
| MD33 | | | Reserved | | Pull down | | |
| MD34 | | | Reserved | | Pull down | | |
| MD35 | | | Reserved | | Pull down | | |
| MD36 | | | Reserved | | Pull up | | |
| MD37 | | | Reserved | | Pull up | | |
| MD38 | | | Reserved | | Pull up | | |

STRAP OPTIONS

| Memory Data Lines | Note | Refer to | Designation | Location | Actual Settings | Set to '0' | Set to '1' |
|-------------------|------|----------|-------------|----------|-----------------|------------|------------|
| MD39 | | | Reserved | | Pull up | | |
| MD40 | | CPU | CPU Mode | | User defined | DX1 | DX2 |
| MD41 | | | Reserved | | Pull down | | |
| MD42 | | | Reserved | | Pull down | | |
| MD43 | | | Reserved | | Pull down | | |

Note;

1) This Strap Option selects between two different functional blocks, the first is the ISA and the other is the VGA block.

3.1 STRAP REGISTER DESCRIPTION

Strap Option [16:0] are reserved.

3.1.1 STRAP REGISTER 2 INDEX 4CH (STRAP2)

Bits 4-0 of this register reflect the status of pins MD[20:16] respectively. Bit 5 of this register reflect the status of pin MD[23]. Bit 4 is writeable, writes to other bits in this register have no effect. They are use by the chip as follows:

Bit 4-2; Reserved

Bit 1; This bit reflects the **value sampled on MD[17] pin** and controls the PCI clock output as follows:

0: PCI clock output = HCLK / 2

1: PCI clock output = HCLK / 3

Bit 0; Reserved

This register defaults to the values sampled on MD[23] & MD[20:16] pins after reset.

3.1.2 HCLK PLL STRAP REGISTER 0 INDEX 5FH (HCLK_Strap)

Bits 5-0 of this register reflect the status of pins MD[26:21] respectively.

They are use by the chip as follows:

Bits 5-3 These pins reflect the **value sampled on MD[26:24] pins** respectively and control the Host clock frequency synthesizer.

Bit 2-0; Reserved

This register defaults to the values sampled on above pins after reset.

3.1.3 486 CLOCK PROGRAMMING (486_CLK)

The bit MD[40] is used to set the clock multiplication factor of the 486 core. With the MD[40] pin pulled low the 486 will run in DX (x1) mode, while with the MD[40] pin pulled high the 486 will run in DX2 (x2) mode. The default value of the resistor on this strap input should be a resistor to gnd (DX mode).

Strap Options [43:41] and [39:27] are reserved.

4 ELECTRICAL SPECIFICATIONS

4.1 Introduction

The electrical specifications in this chapter are valid for the STPC Consumer-S.

4.2 Electrical Connections

4.2.1 Power/Ground Connections/Decoupling

Due to the high frequency of operation of the STPC Consumer-S, it is necessary to install and test this device using standard high frequency techniques. The high clock frequencies used in the STPC Consumer-S and its output buffer circuits can cause transient power surges when several output buffers switch output levels simultaneously. These effects can be minimized by filtering the DC power leads with low-inductance decoupling capacitors, using low impedance wiring, and by utilizing all of the VSS and VDD pins.

4.2.2 Unused Input Pins

All inputs not used by the designer and not listed in the table of pin connections in Chapter 3 should

be connected either to VDD or to VSS. Connect active-high inputs to VDD through a 20 k Ω ($\pm 10\%$) pull-down resistor and active-low inputs to VSS and connect active-low inputs to VCC through a 20 k Ω ($\pm 10\%$) pull-up resistor to prevent spurious operation.

4.2.3 Reserved Designated Pins

Pins designated reserved should be left disconnected. Connecting a reserved pin to a pull-up resistor, pull-down resistor, or an active signal could cause unexpected results and possible circuit malfunctions.

4.3 Absolute Maximum Ratings

The following table lists the absolute maximum ratings for the STPC Consumer-S device. Stresses beyond those listed under Table 4.1 limits may cause permanent damage to the device. These are stress ratings only and do not imply that operation under any conditions other than those specified in section "Operating Conditions".

Exposure to conditions beyond Table 4.1 may (1) reduce device reliability and (2) result in premature failure even when there is no immediately apparent sign of failure. Prolonged exposure to conditions at or near the absolute maximum ratings (Table 4.1) may also result in reduced useful life and reliability.

Table 4.1. Absolute Maximum Ratings

| Symbol | Parameter | Value | Units |
|---------------------------------|----------------------------------|-----------------|-------|
| V _{DDx} | DC Supply Voltage | -0.3, 4.0 | V |
| V _I , V _O | Digital Input and Output Voltage | -0.3, VDD + 0.3 | V |
| T _{STG} | Storage Temperature | -40, +150 | °C |
| T _{OPER} | Operating Temperature | 0, +70 | °C |
| P _{TOT} | Total Power Dissipation | 4.8 | W |

4.1 DC Characteristics

Table 4.2. DC Characteristics

Recommended Operating conditions : $V_{DD} = 3.3V \pm 0.3V$, $T_{case} = 0$ to $100^{\circ}C$ unless otherwise specified

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|-----------|-----------------------|--|-------|-------|--------------|---------|
| V_{DD} | Operating Voltage | | 3.0 | 3.3 | 3.6 | V |
| P_{DD} | Supply Power | $V_{DD} = 3.3V$, $H_{CLK} = 66MHz$ | | 3.2 | 3.9 | W |
| H_{CLK} | Internal Clock | (Note 1) | | | 75 | Mhz |
| V_{REF} | DAC Voltage Reference | | 1.215 | 1.235 | 1.255 | V |
| V_{OL} | Output Low Voltage | $I_{Load} = 1.5$ to $8mA$ depending of the pin | | | 0.5 | V |
| V_{OH} | Output High Voltage | $I_{Load} = -0.5$ to $-8mA$ depending of the pin | 2.4 | | | V |
| V_{IL} | Input Low Voltage | Except XTALI | -0.3 | | 0.8 | V |
| | | XTALI | -0.3 | | 0.9 | V |
| V_{IH} | Input High Voltage | Except XTALI | 2.1 | | $V_{DD}+0.3$ | V |
| | | XTALI | 2.35 | | $V_{DD}+0.3$ | V |
| I_{LK} | Input Leakage Current | Input, I/O | -5 | | 5 | μA |
| C_{IN} | Input Capacitance | (Note 2) | | | | pF |
| C_{OUT} | Output Capacitance | (Note 2) | | | | pF |
| C_{CLK} | Clock Capacitance | (Note 2) | | | | pF |

Notes:

1. MHz ratings refer to CPU clock frequency.
2. Not 100% tested.

4.1 AC Characteristics

Table 4.4 through Table 4.9 list the AC characteristics including output delays, input setup requirements, input hold requirements and output float delays. These measurements are based on the measurement points identified in Figure 4.1. The rising clock edge reference level V_{REF} , and other reference levels are shown in Table 4.3 below for the STPC Consumer-S. Input or output signals must cross these levels during testing.

Figure 4.1 shows output delay (A and B) and input setup and hold times (C and D). Input setup and hold times (C and D) are specified minimums, defining the smallest acceptable sampling window a synchronous input signal must be stable for correct operation.

Table 4.3. Drive Level and Measurement Points for Switching Characteristics

| Symbol | Value | Units |
|-----------|-------|-------|
| V_{REF} | 1.5 | V |
| V_{IHD} | 3.0 | V |
| V_{ILD} | 0.0 | V |

Note: Refer to Figure 4.1.

ELECTRICAL SPECIFICATIONS

Figure 4.1. Drive Level and Measurement Points for Switching Characteristics

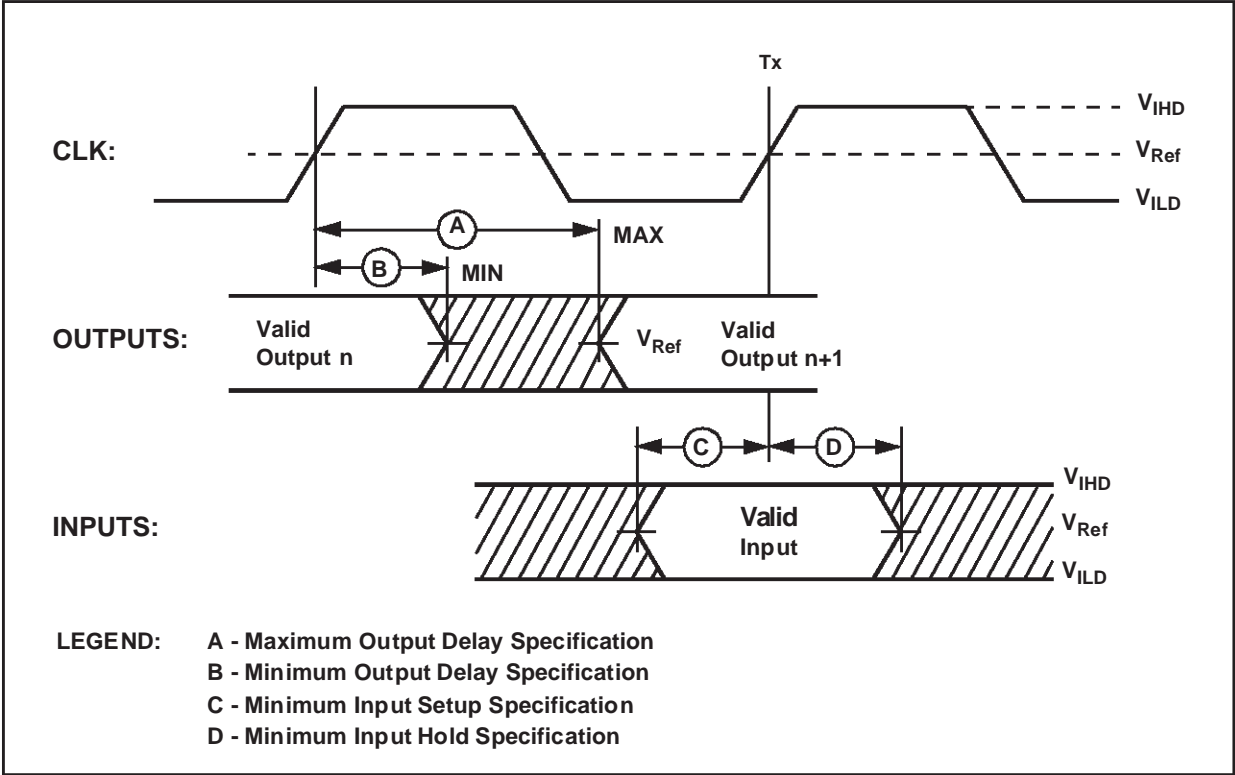


Table 4.4. PCI Bus AC Timing

| Name | Parameter | Min | Max | Unit |
|------|----------------------------------|-----|-----|------|
| t1 | PCI_CLKI to AD[31:0] valid | 2 | 11 | ns |
| t2 | PCI_CLKI to FRAME# valid | 2 | 11 | ns |
| t3 | PCI_CLKI to CBE#[3:0] valid | 2 | 11 | ns |
| t4 | PCI_CLKI to PAR valid | 2 | 11 | ns |
| t5 | PCI_CLKI to TRDY# valid | 2 | 11 | ns |
| T6 | PCI_CLKI to IRDY# valid | 2 | 11 | ns |
| T7 | PCI_CLKI to STOP# valid | 2 | 11 | ns |
| T8 | PCI_CLKI to DEVSEL# valid | 2 | 11 | ns |
| T9 | PCI_CLKI to PCI_GNT# valid | 2 | 12 | ns |
| t10 | AD[31:0] bus setup to PCI_CLKI | 7 | | ns |
| t11 | AD[31:0] bus hold from PCI_CLKI | 0 | | ns |
| t12 | PCI_REQ#[2:0] setup to PCI_CLKI | 10 | | ns |
| t13 | PCI_REQ#[2:0] hold from PCI_CLKI | 0 | | ns |
| t14 | CBE#[3:0] setup to PCI_CLKI | 7 | | ns |
| t15 | CBE#[3:0] hold to PCI_CLKI | 0 | | ns |
| t16 | IRDY# setup to PCI_CLKI | 7 | | ns |
| t17 | IRDY# hold to PCI_CLKI | 0 | | ns |
| t18 | FRAME# setup to PCI_CLKI | 7 | | ns |
| t19 | FRAME# hold from PCI_CLKI | 0 | | ns |

Table 4.5. IDE Bus AC Timing

| Name | Parameter | Min | Max | Unit |
|------|---------------------------------------|-----|-----|------|
| t20 | DD[15:0] setup to PIOR#/SIOR# falling | 15 | | ns |
| t21 | DD[15:0] hold to PIOR#/SIOR# falling | 12 | | ns |

Table 4.6. SDRAM Bus AC Timing

| Name | Parameter | Min | Max | Unit |
|------|-----------|-----|-----|------|
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |
| | | | | ns |

ELECTRICAL SPECIFICATIONS

Table 4.7. Video Input/TV Output AC Timing

| Name | Parameter | Min | Max | Unit |
|------|-----------------------------|-----|-----|------|
| t35 | VIDEO_D[7:0] setup to VCLK | 5 | | ns |
| t36 | VIDEO_D[7:0] hold from VCLK | 2 | | ns |
| t37 | VCLK to VTV_BT# valid | | 15 | ns |
| t38 | VCLK to VTV_HSYNC valid | | 15 | ns |
| t39 | VTB_BT# setup to VCLK | 10 | | ns |
| t40 | VTB_BT# hold from VCLK | 5 | | ns |
| t41 | VTB_HSYNC setup to VCLK | 10 | | ns |
| t42 | VTB_HSYNC hold from VCLK | 5 | | ns |

Table 4.8. Graphics Adapter (VGA) AC Timing

| Name | Parameter | Min | Max | Unit |
|------|---------------------|-----|-----|------|
| t43 | DCLK to VSYNC valid | | 45 | ns |
| t44 | DCLK to HSYNC valid | | 45 | ns |

Table 4.9. ISA Bus AC Timing

| Name | Parameter | Min | Max | Unit |
|------|-------------------------------|-----|-----|------|
| t45 | XTALO to LA[23:17] bus active | | 60 | ns |
| t46 | XTALO to SA[19:0] bus active | | 60 | ns |
| t47 | XTALO to BHE# valid | | 62 | ns |
| t48 | XTALO to SD[15:0] bus active | | 35 | ns |
| t49 | PCI_CLKI to ISAOE# valid | | 28 | ns |
| t50 | XTALO to GPIOCS# valid | | 60 | ns |
| t51 | XTALO to ALE valid | | 62 | ns |
| t52 | XTALO to MEMW# valid | | 50 | ns |
| t53 | XTALO to MEMR# valid | | 50 | ns |
| t54 | XTALO to SMEMW# valid | | 50 | ns |
| t55 | XTALO to SMEMR# valid | | 50 | ns |
| t56 | XTALO to IOR# valid | | 50 | ns |
| t57 | XTALO to IOW# valid | | 50 | ns |

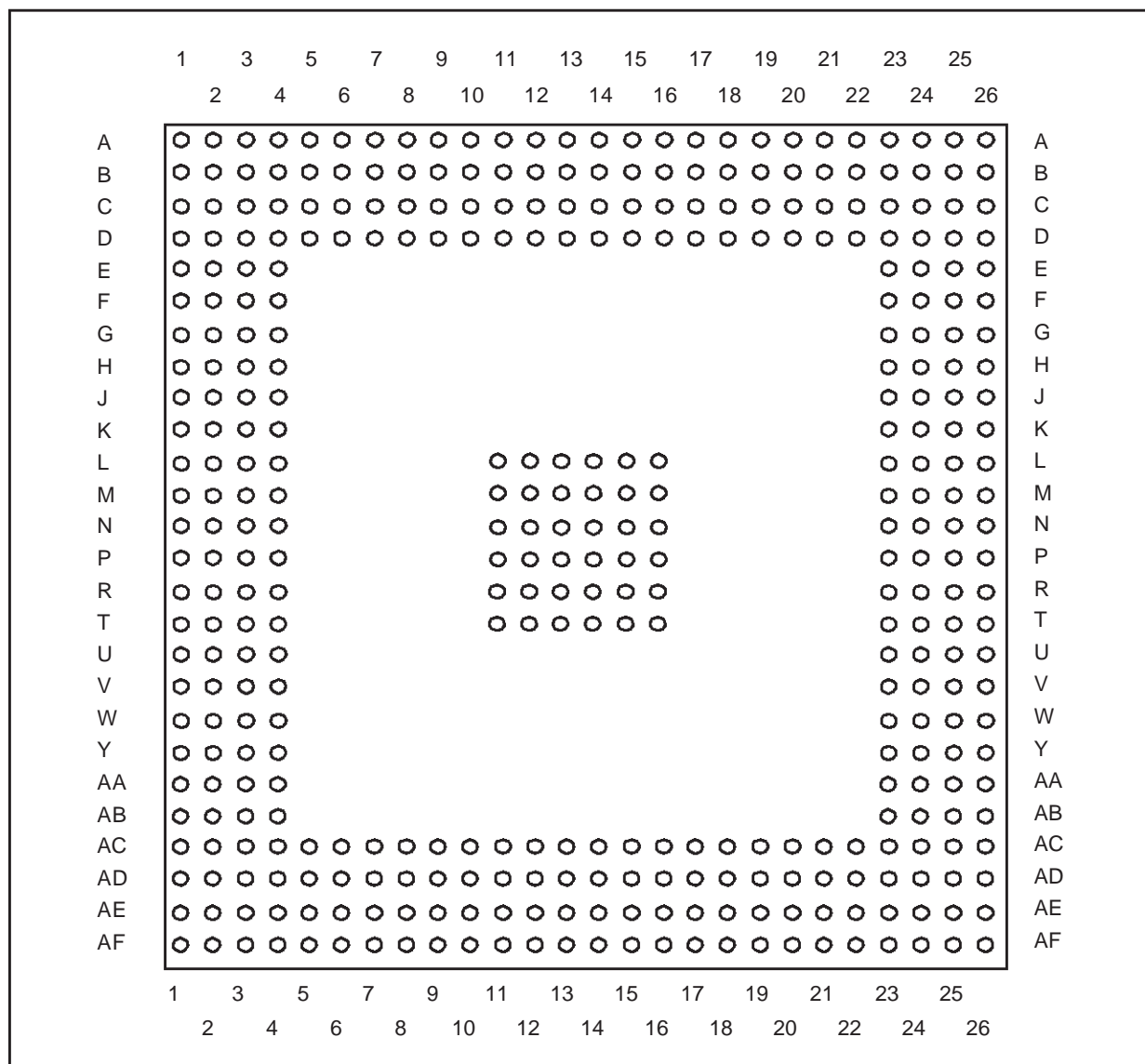
5. MECHANICAL DATA

5.1 388-PIN PACKAGE DIMENSION

The pin numbering for the STPC 388-pin Plastic BGA package is shown in Figure 5-1.

Dimensions are shown in Figure 5-2, Table 5-1 and Figure 5-3, Table 5-2.

Figure 5-1. 388-Pin PBGA Package - Top View



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Figure 5-2. 388-pin PBGA Package - PCB Dimensions

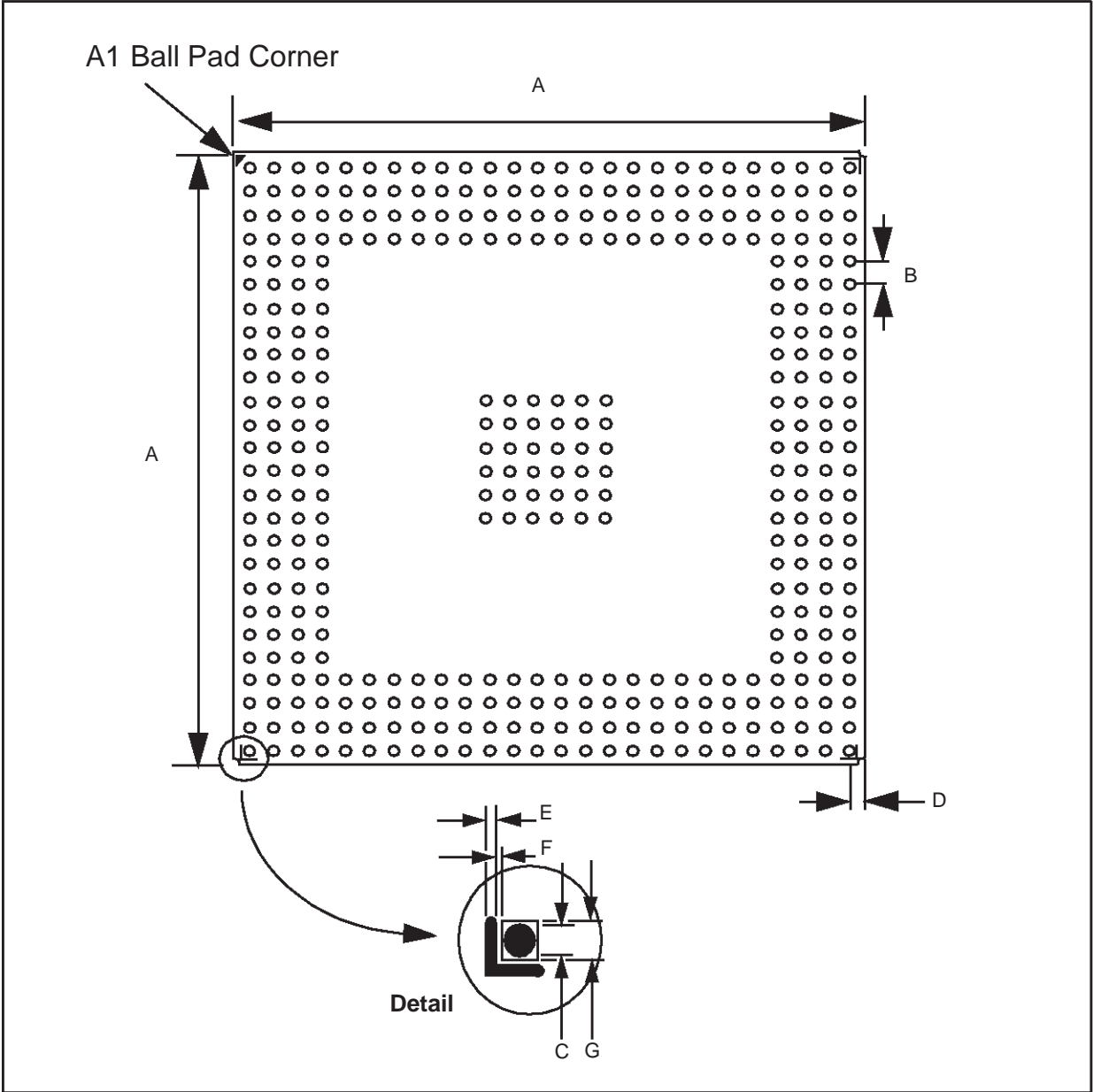


Table 5-1. 388-pin PBGA Package - PCB Dimensions

| Symbols | mm | | | inches | | |
|---------|-------|-------|-------|--------|-------|-------|
| | Min | Typ | Max | Min | Typ | Max |
| A | 34.95 | 35.00 | 35.05 | 1.375 | 1.378 | 1.380 |
| B | 1.22 | 1.27 | 1.32 | 0.048 | 0.050 | 0.052 |
| C | 0.58 | 0.63 | 0.68 | 0.023 | 0.025 | 0.027 |
| D | 1.57 | 1.62 | 1.67 | 0.062 | 0.064 | 0.066 |
| E | 0.15 | 0.20 | 0.25 | 0.006 | 0.008 | 0.001 |
| F | 0.05 | 0.10 | 0.15 | 0.002 | 0.004 | 0.006 |
| G | 0.75 | 0.80 | 0.85 | 0.030 | 0.032 | 0.034 |

Figure 5-3. 388-pin PBGA Package - Dimensions

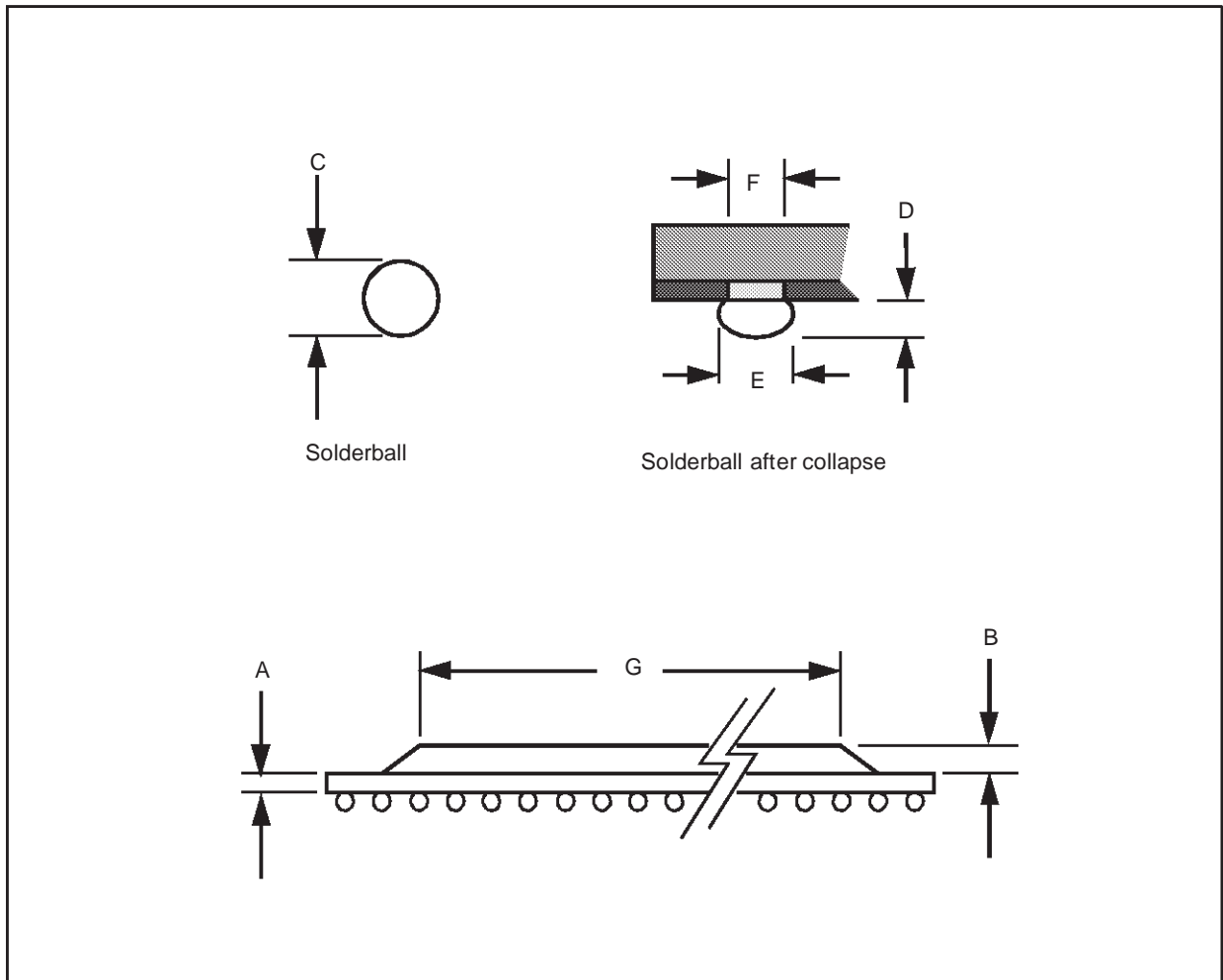


Table 5-2. 388-pin PBGA Package - Dimensions

| Symbols | mm | | | inches | | |
|---------|------|------|------|--------|-------|-------|
| | Min | Typ | Max | Min | Typ | Max |
| A | 0.50 | 0.56 | 0.62 | 0.020 | 0.022 | 0.024 |
| B | 1.12 | 1.17 | 1.22 | 0.044 | 0.046 | 0.048 |
| C | 0.60 | 0.76 | 0.92 | 0.024 | 0.030 | 0.036 |
| D | 0.52 | 0.53 | 0.54 | 0.020 | 0.021 | 0.022 |
| E | 0.63 | 0.78 | 0.93 | 0.025 | 0.031 | 0.037 |
| F | 0.60 | 0.63 | 0.66 | 0.024 | 0.025 | 0.026 |
| G | | 30.0 | | | 11.8 | |

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5.2 388-PIN PACKAGE THERMAL DATA

388-pin PBGA package has a Power Dissipation Capability of 4.5W which increases to 6W when used with a Heatsink.

Structure is shown in Figure 5-4.

Thermal dissipation options are illustrated in Figure 5-5 and Figure 5-6.

Figure 5-4. 388-Pin PBGA structure

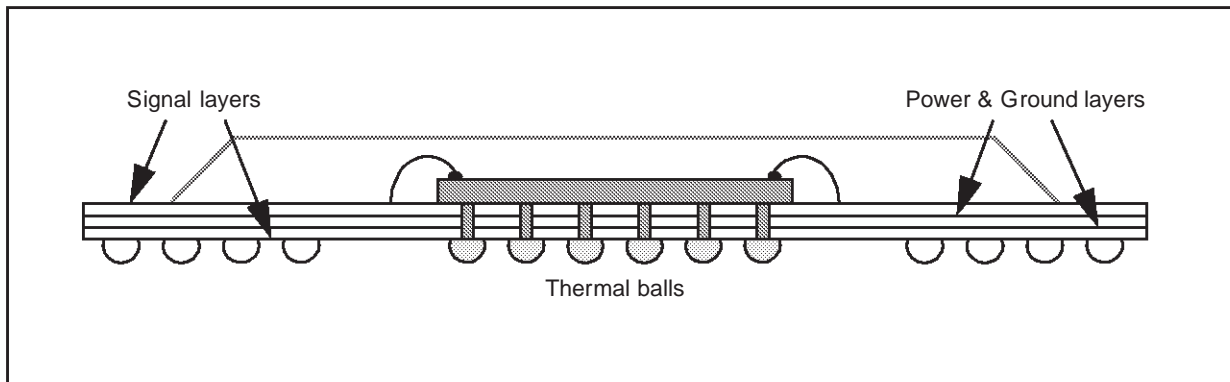


Figure 5-5. Thermal dissipation without heatsink

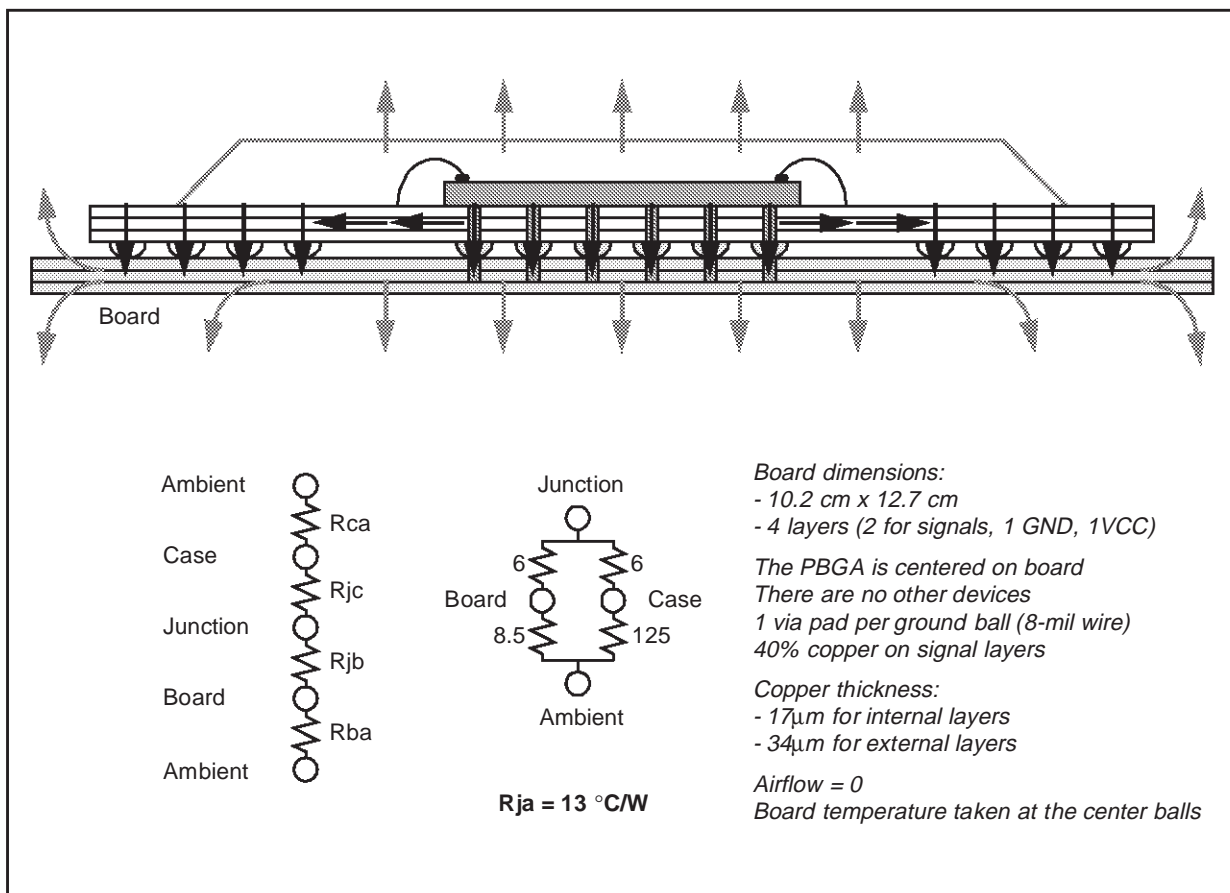
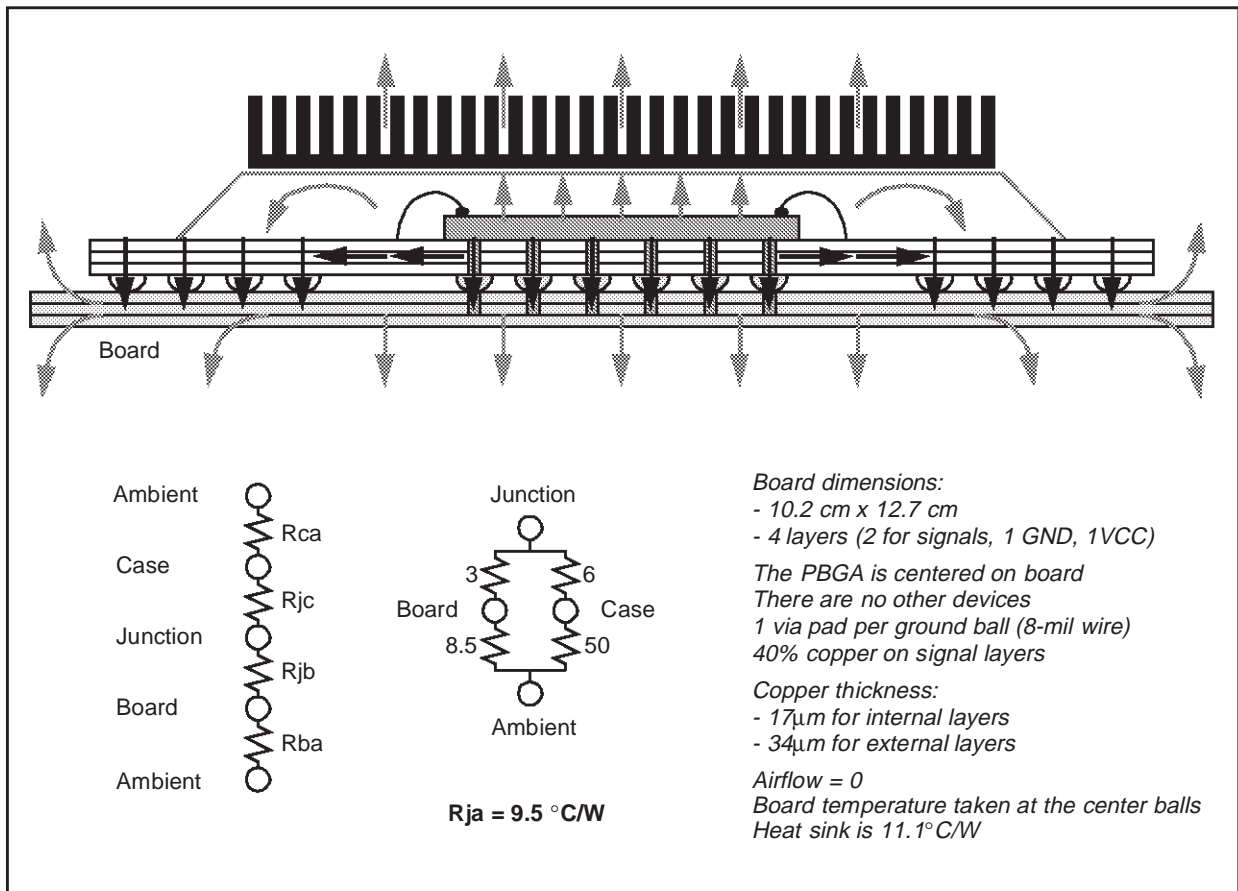


Figure 5-6. Thermal dissipation with heatsink



6 BOARD LAYOUT

6.1 Thermal dissipation

Thermal dissipation of the STPC depends mainly on supply voltage. As a result, when the system does not need to work at 3.3V, it is interesting to reduce the voltage to 3.15V for example. This may save few 100's of mW.

The second area to look at is unused interfaces and functions. Depending on the application, some input signals can be grounded, and some blocks not powered or shutdown. Clock speed dynamic adjustment is also a solution that can be used along with the integrated power management unit.

The standard way to route thermal balls to internal ground layer implements only one via pad for each ball pad, connected using a 8-mil wire.

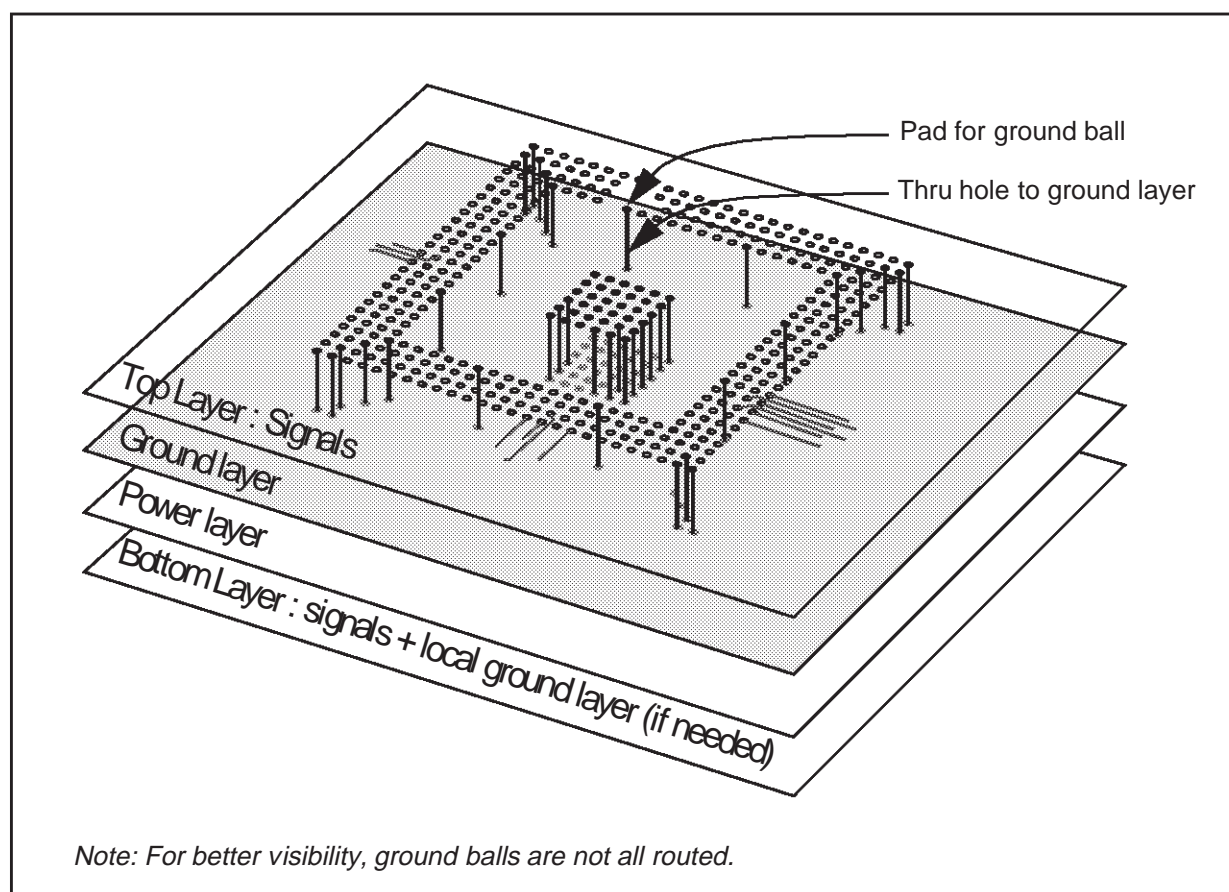
With such configuration the Plastic BGA 388 package does 90% of the thermal dissipation through the ground balls, and especially the central thermal balls which are directly connected to the die, the remaining 10% is dissipated through the case. Adding a heat sink reduces this value to 85%.

As a result, some basic rules has to be applied when routing the STPC in order to avoid thermal problems.

First of all, the whole ground layer acts as a heat sink and ground balls must be directly connected to it as illustrated in Figure 6-1.

If one ground layer is not enough, a second ground plane may be added on solder side.

Figure 6-1. Ground routing



When considering thermal dissipation, the most important - and not the more obvious - part of the layout is the connection between the ground balls and the ground layer.

A 1-wire connection is shown in Figure 6-2. The use of a 8-mil wire results in a thermal resistance of 105°C/W assuming copper is used ($418 \text{ W/m}\cdot^{\circ}\text{K}$). This high value is due to the thickness ($34 \mu\text{m}$) of the copper on the external side of the PCB.

Considering only the central matrix of 36 thermal balls and one via for each ball, the global thermal resistance is 2.9°C/W . This can be easily improved using four 10 mil wires to connect to the four vias around the ground pad link as in Figure 6-3. This gives a total of 49 vias and a global resistance for the 36 thermal balls of 0.6°C/W .

The use of a ground plane like in Figure 6-4 is even better.

To avoid solder wicking over to the via pads during soldering, it is important to have a solder mask of 4 mil around the pad (NSMD pad), this gives a diameter of 33 mil for a 25 mil ground pad.

To obtain the optimum ground layout, place the vias directly under the ball pads. In this case no local board distortion is tolerated.

The thickness of the copper on PCB layers is typically $34 \mu\text{m}$ for external layers and $17 \mu\text{m}$ for internal layers. That means thermal dissipation is not good and temperature of the board is concentrated around the devices and falls quickly with increased distance.

When it is possible to place a metal layer inside the PCB, this improves dramatically the heat spreading and hence thermal dissipation of the board.

Figure 6-2. Recommended 1-wire ground pad layout

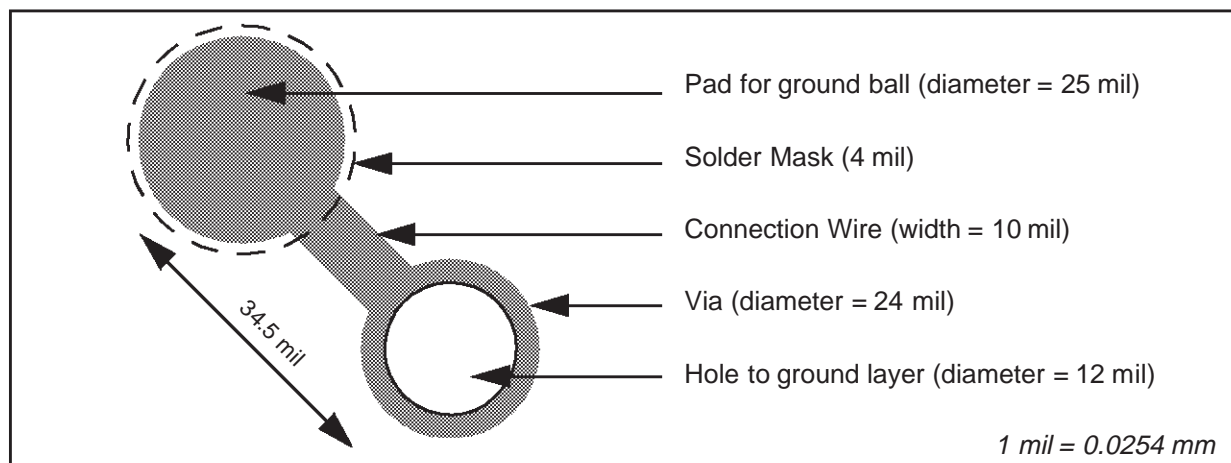


Figure 6-3. Recommended 4-wire ground pad layout

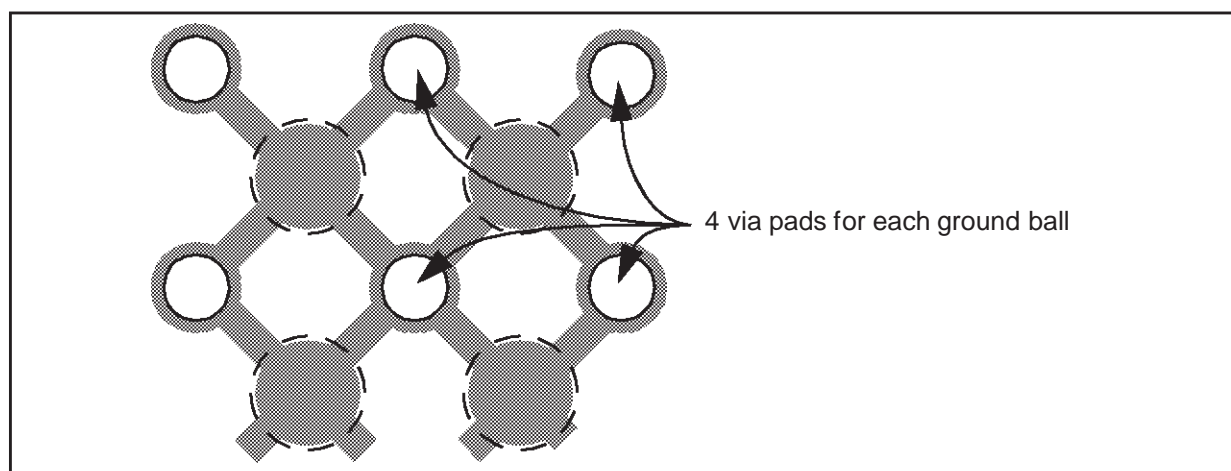
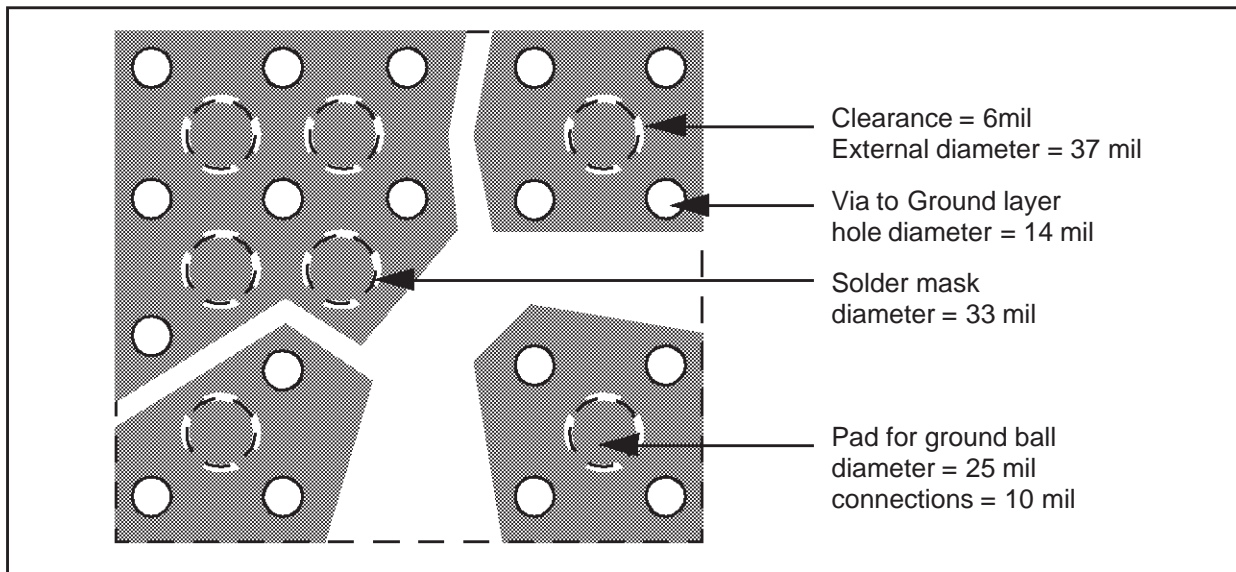


Figure 6-4. Optimum layout for central ground ball



The PBGA Package dissipates also through peripheral ground balls. When a heat sink is placed on the device, heat is more uniformly spread throughout the moulding increasing heat dissipation through the peripheral ground balls.

The more via pads are connected to each ground ball, the more heat is dissipated. The only limitation is the risk of losing routing channels.

Figure 6-5 shows a routing with a good trade off between thermal dissipation and number of routing channels.

Figure 6-5. Global ground layout for good thermal dissipation

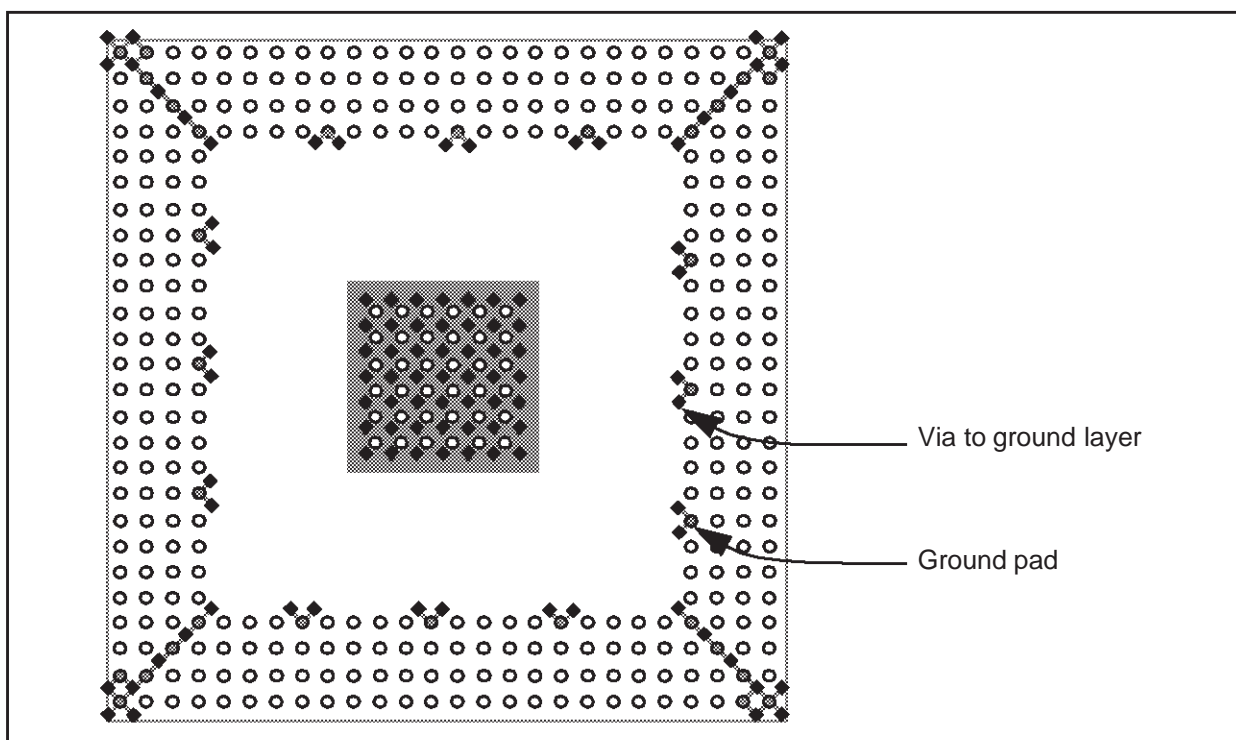
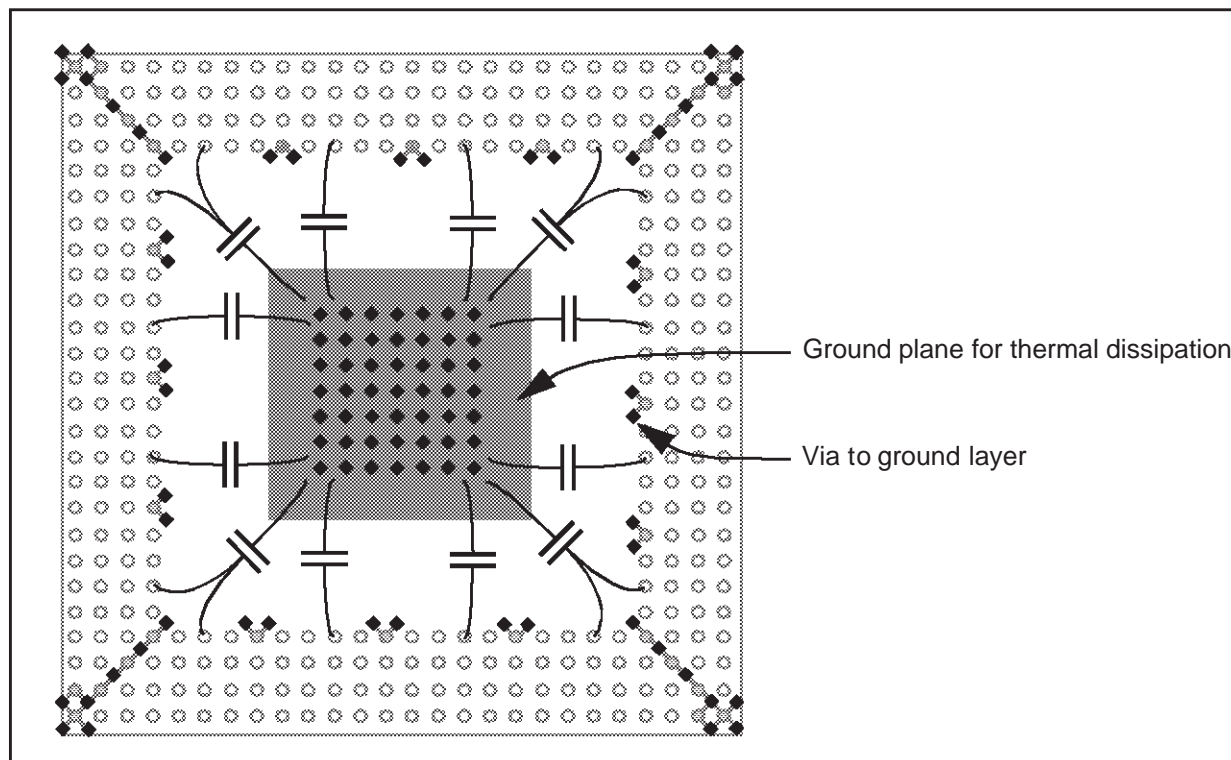


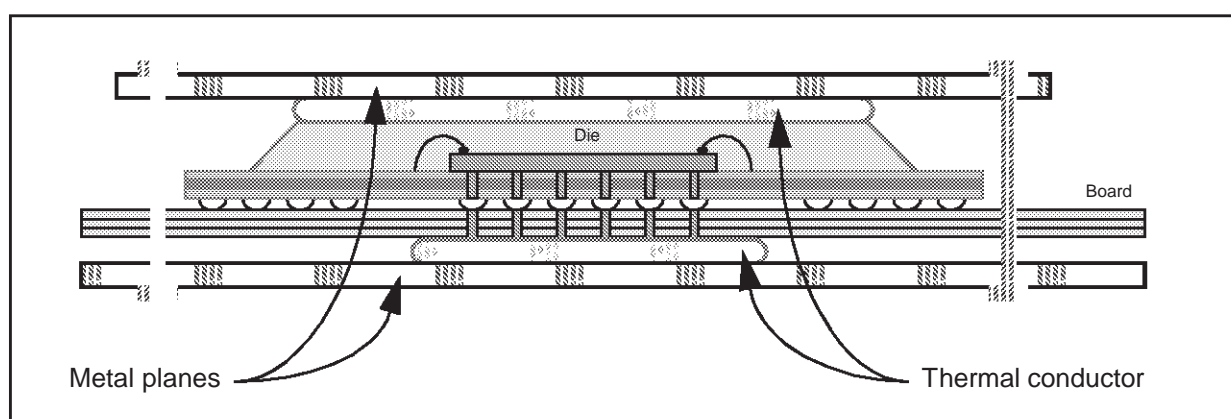
Figure 6-6. Bottom side layout and decoupling



A local ground plane on opposite side of the board as shown in Figure 6-6 improves thermal dissipation. It is used to connect decoupling capacitances but can also be used for connection to a heat sink or to the system's metal box for better dissipation.

This possibility of using the whole system's box for thermal dissipation is very useful in case of high temperature inside the system and low temperature outside. In that case, both sides of the PBGA should be thermally connected to the metal chassis in order to propagate the heat flow through the metal. Figure 6-7 illustrates such implementation.

Figure 6-7. Use of metal plate for thermal dissipation



6.2 High speed signals

Some Interfaces of the STPC run at high speed and have to be carefully routed or even shielded.

Here is the list of these interfaces, in decreasing speed order:

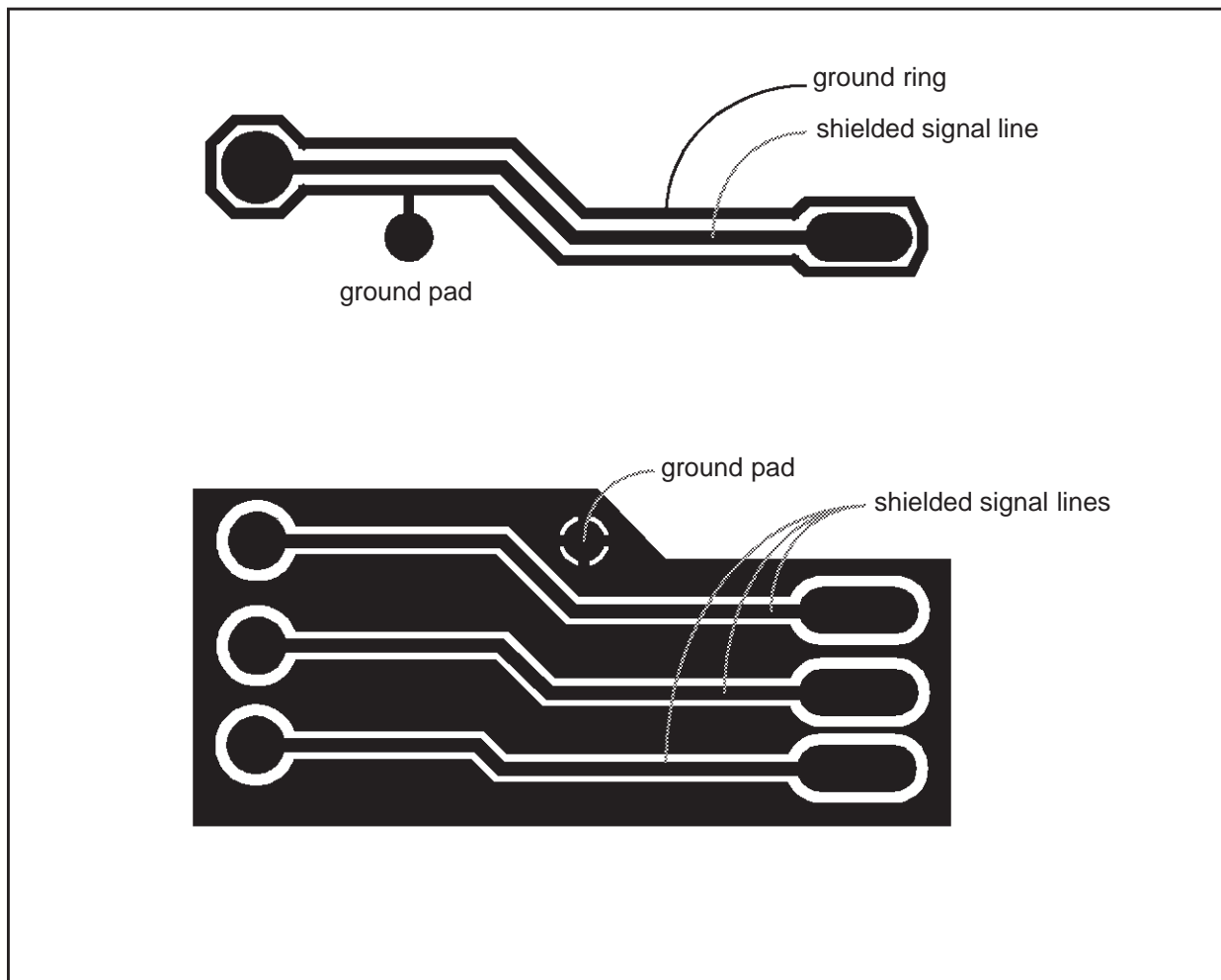
- 1) Memory Interface.
- 2) Graphics and video interfaces
- 3) PCI bus
- 4) 14MHz oscillator stage

All the clocks have to be routed first and shielded for speeds of 27MHz or more. The high speed signals follow the same constraints, like the memory control signals and the PCI control signals.

The next interfaces to be routed are Memory, Video/graphics, and PCI.

All the analog noise sensitive signals have to be routed in a separate area and hence can be routed independently.

Figure 6-8. Shielding signals



6.3 Memory interface

6.3.1 Introduction

In order to achieve SDRAM memory interfaces which work at clock frequencies of 66MHz and above, careful consideration has to be given to the timing of the interface with all the various electrical and physical constraints taken into consideration. The guidelines described below are related to SDRAM components on DIMM modules. For ap-

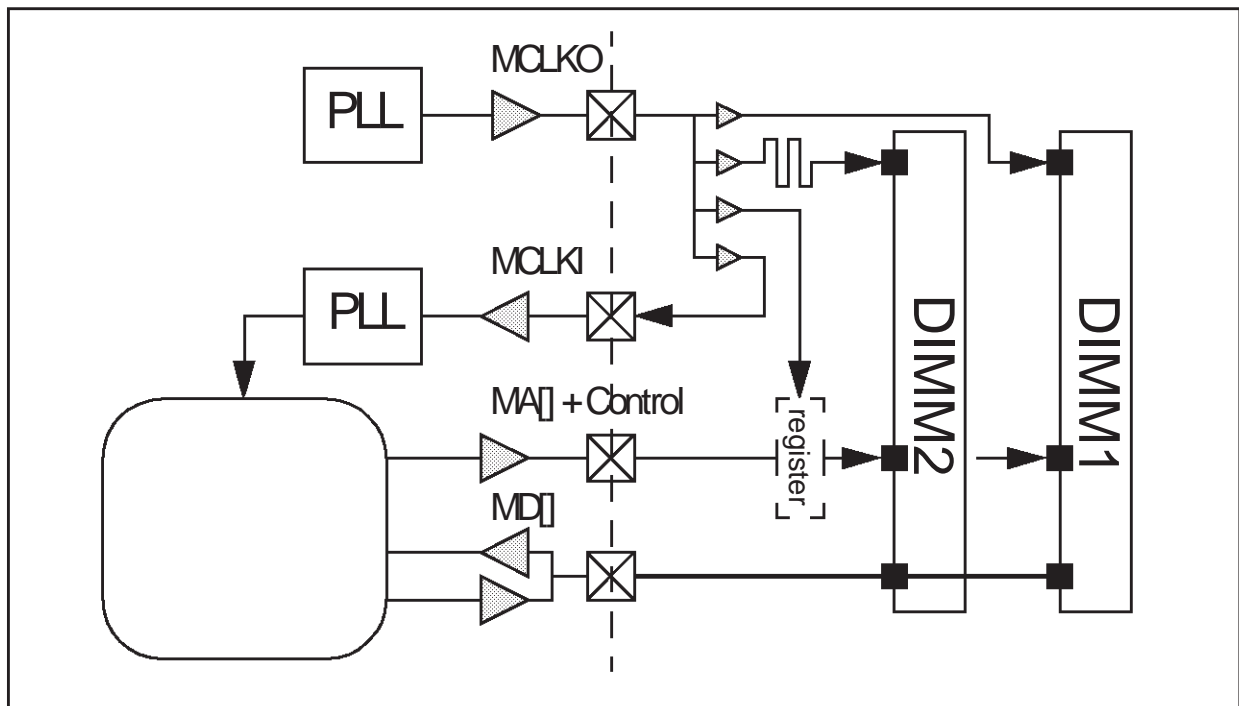
plications where the memories are directly soldered to the motherboard, the PCB should be laid out such that the trace lengths fit within the constraints shown here. The traces could be slightly longer since the extra routing on the DIMM PCB is no longer present but it is then up to the user to verify the timings.

6.3.2 SDRAM Clocking Scheme

The SDRAM Clocking Scheme deserves a special mention here. Basically the memory clock is generated on-chip through a PLL and goes directly to the MCLKO output pin of the STPC. The nominal frequency is 66MHz. Because of the high load

presented to the MCLK on the board by the DIMMs it is recommended to rebuffer the MCLKO signal on the board and balance the skew to the clock ports of the different DIMMs and the MCLKI input pin of STPC.

Figure 6-9. Clock scheme

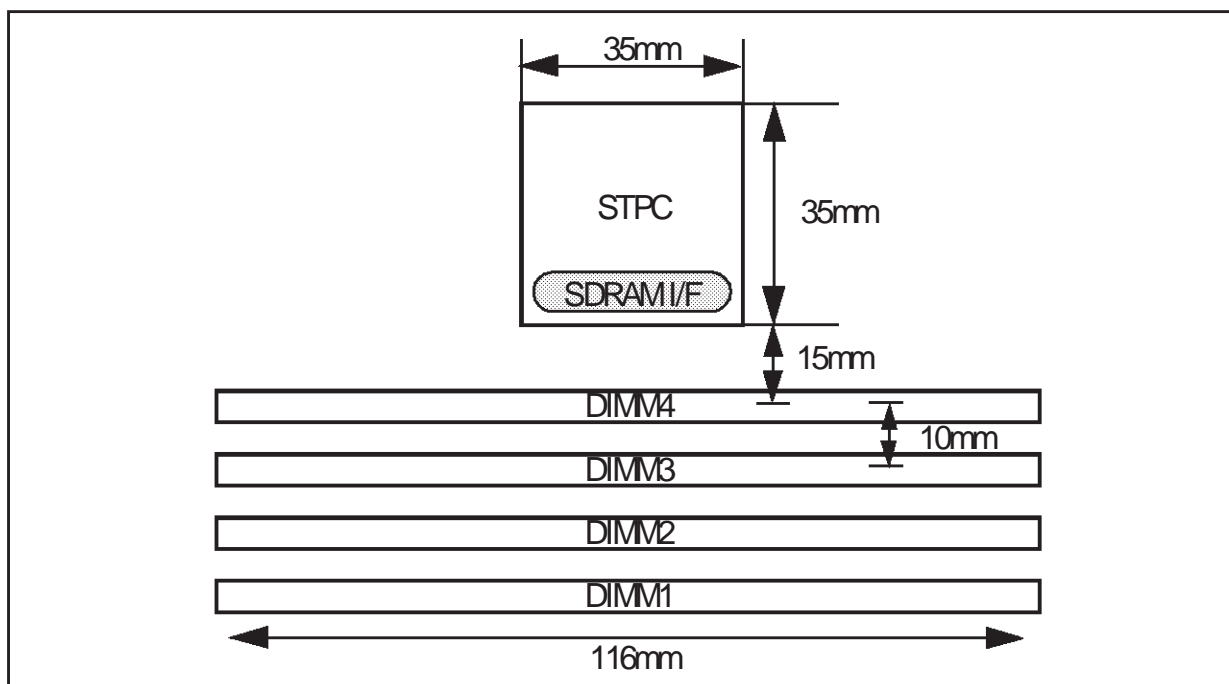


6.3.3 Board Layout Issues

The physical layout of the motherboard PCB assumed in this presentation is as shown in Figure 6-10. Because all the memory interface signal balls are located in the same region of the STPC

device it is possible to orientate the device to reduce the trace lengths. The worst case routing length to the DIMM1 is estimated to be 100mm.

Figure 6-10. DIMM placement



Solid power and ground planes are a must in order to provide good return paths for the signals and to reduce EMI and noise. Also there should be ample high frequency decoupling between the power and ground planes to provide a low impedance path between the planes for the return paths for signal routings which change layers. If possible the traces should be routed adjacent to the same power or ground plane for the length of the trace.

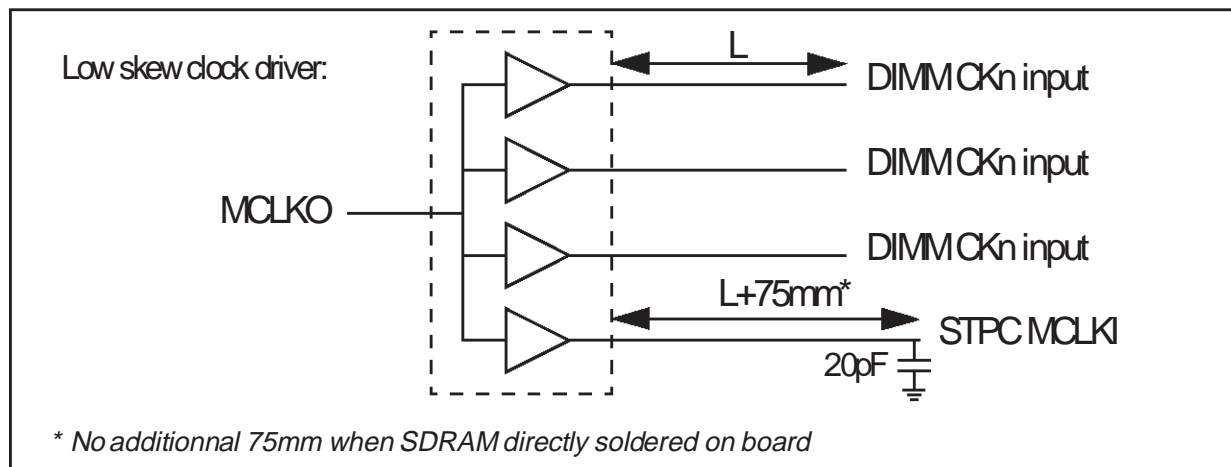
For the SDRAM interface the most critical signal is the clock. Any skew between the clocks at the SDRAM components and the memory controller will impact the timing budget. In order to get well matched clocks at all the components it is recommended that all the DIMM clock pins, STPC memory clock input (MCLKI) and any other component using the memory clock are individually driven from a low skew clock driver with matched routing lengths. This is shown in Figure 6-11.

The maximum skew between pins for this part is 250ps. The important factors for the clock buffer are a consistent drive strength and low skew between the outputs. The delay through the buffer is not important so it does not have to be a zero delay pll type buffer. The trace lengths from the clock

driver to the DIMM CKn pins should be matched exactly. Since the propagation speed can vary between PCB layers the clocks should be routed in a consistent way. The routing to the STPC memory input should be longer by 75mm to compensate for the extra clock routing on the DIMM. Also a 20pF capacitor should be placed as near as possible to the clock input of the STPC to compensate for the DIMM's higher clock load. The impedance of the trace used for the clock routing should be matched to the DIMM clock trace impedance (60-75Ω). To minimise crosstalk the clocks should be routed with spacing to adjacent tracks of at least twice the clock trace width. For designs which use SDRAMs directly mounted on the motherboard PCB all the clock trace lengths should be matched exactly.

The DIMM sockets should be populated starting with the furthest DIMM from the STPC device first (DIMM1). There are 2 types of DIMM devices; single row and dual row. The dual row devices require 2 chip select signals to select between the two rows. A STPC device with 4 chip select control lines could control either 4 single row DIMMs or 2 dual row DIMMs.

Figure 6-11. Clock routing



When using DIMM modules, schematics have to be done carefully in order to avoid data busses completely crossed on the board. This has to be checked at the library level. In order to achieve lay-

out shown in Figure 6-12, schematics have to implement the crossing described on Figure 6-13. The DQM signals must be exchanged using the same order.

Figure 6-12. Optimum data bus layout for DIMM

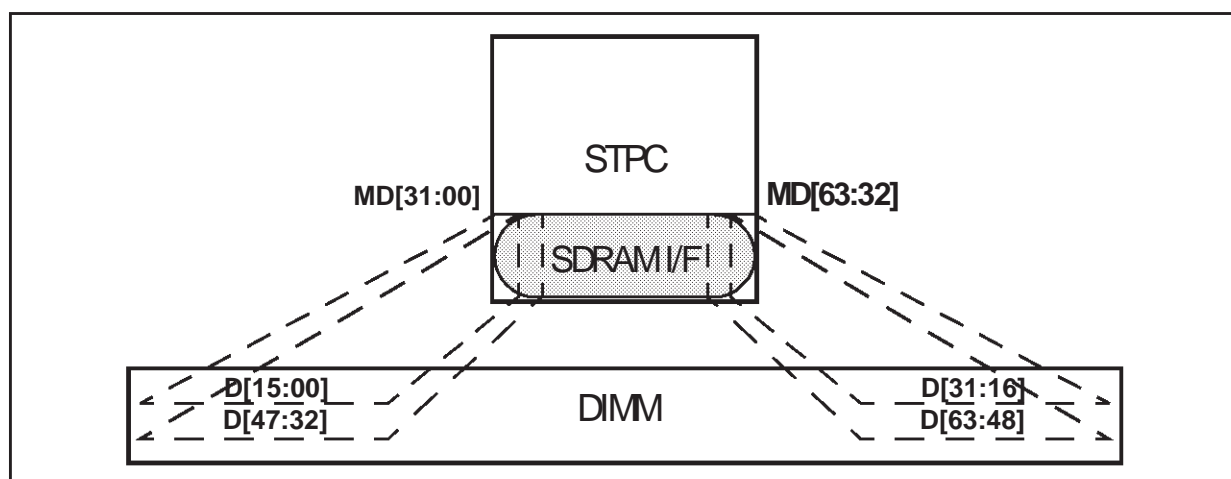
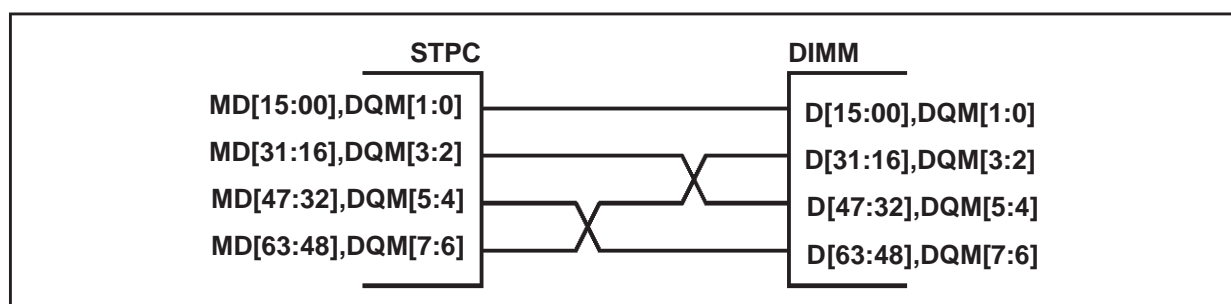


Figure 6-13. Schematics for optimum data bus layout for DIMM

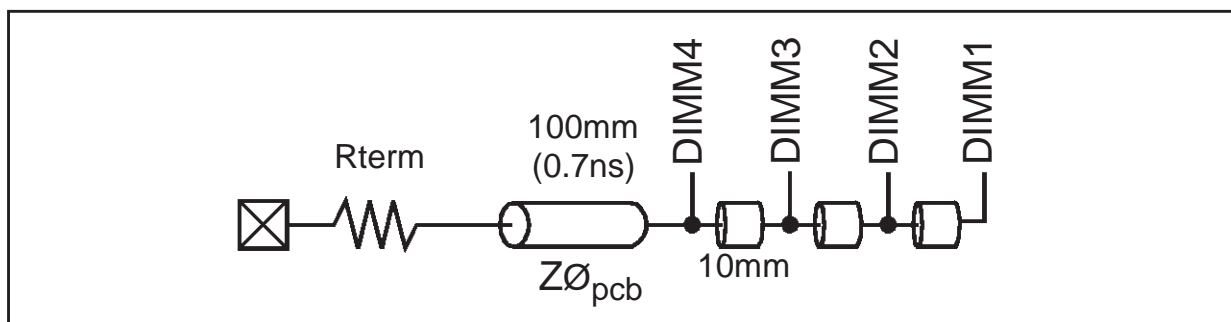


6.3.4 Address & Control Signals

This group encompasses the memory address MA[12:0], bank address BA[0,1], RAS, CAS and write enable WE signals. The load of the DIMM module on these signals is the most important one and depends upon the type of SDRAM components used (x4, x8 or x16) and whether the

DIMM module is single or dual row. The capacitive loading of the SDRAM inputs alone for an x8 single row DIMM will be about 30-40pF. An equivalent circuit for the timing simulation is shown in Figure 6-14. Most of the delays are due to the PCB traces and loading rather than the pad itself.

Figure 6-14. Address/control equivalent circuit

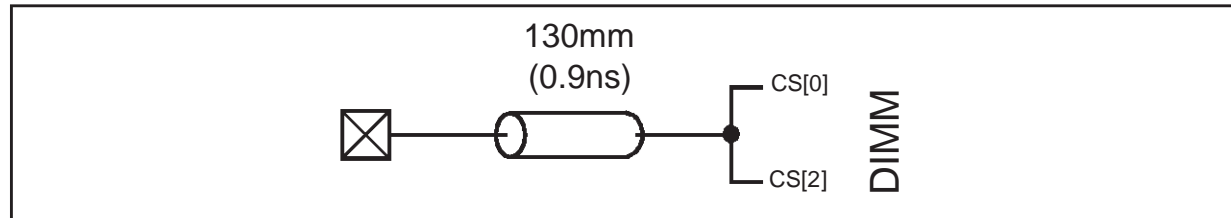


6.3.5 Chip Select Signals (CS#[3:0])

There are 4 chip select pins per DIMM. Chip selects 0 and 2 are always used to select the first row of SDRAMs and chip selects 1 and 3 select

the second row on dual bank SDRAMs. The chip select outputs only have to drive one DIMM each

Figure 6-15. CS# equivalent circuit

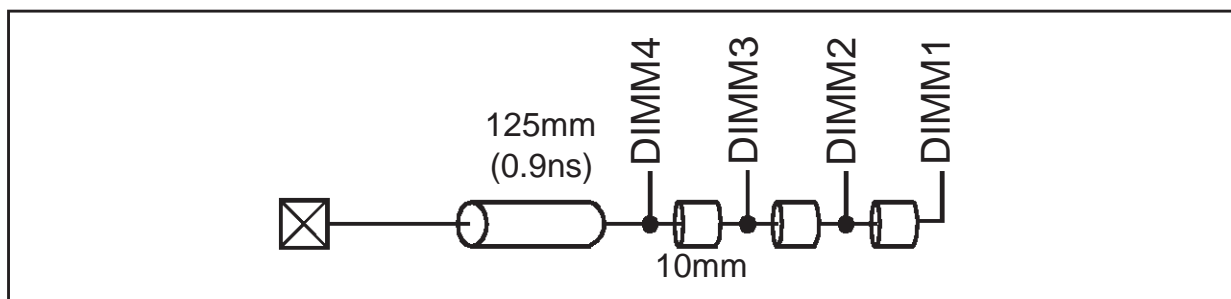


6.3.6 Data Write (MD[63:0])

The load on the data signals is much lower than the address/control signals for an unbuffered DIMM. For a registered DIMM the data signals are the only memory pins of the DIMM which are not

registered. For the design to get maximum benefit from using registered DIMMs the timings should be compared to the timings for registered DIMMs for the other pins..

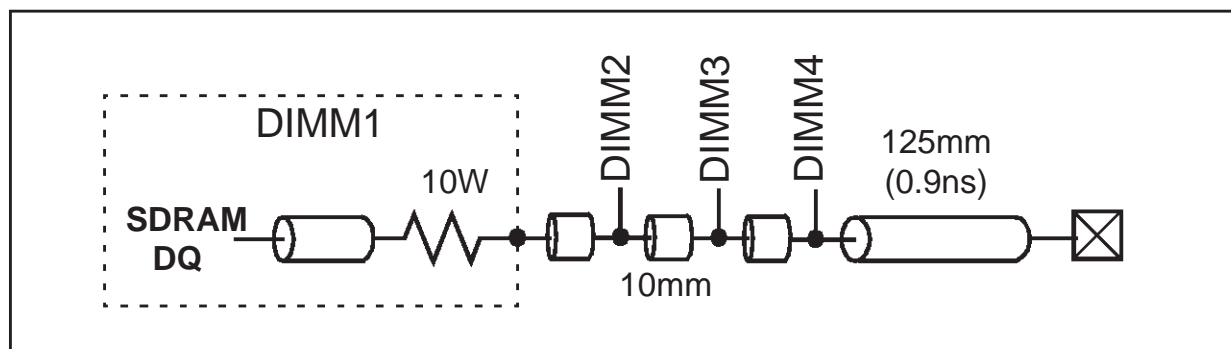
Figure 6-16. Data write equivalent circuit



6.3.7 Data Read (MD[63:0])

The data read simulation circuit is shown below..

Figure 6-17. Data read equivalent circuit



6.3.8 Data Mask (DQM[7:0])

The data mask load is quite similar to that of the data signals.

6.3.9 Summary

For unbuffered DIMMs the address/control signals will be the most critical for timing unless the memory controller can be designed to set up these signals one cycle in advance. The simulations show that for these signals the best way to drive them is to use a parallel termination. For applications where speed is not so critical series termination can be used as this will save power. Using a low impedance such as 50W for these critical traces is recommended as it both reduces the delay and the overshoot.

The other memory interface signals will typically be not as critical as the address/control signals for unbuffered DIMMs. When using registered DIMMs the other signals will probably be just as critical as the address/control signals so to gain maximum benefit from using registered DIMMs the timings should also be considered in that situation. Using lower impedance traces is also beneficial for the other signals but if their timing is not as critical as the address/control signals they could use the default value. Using a lower impedance implies using wider traces which may have an impact on the routing of the board.

ORDERING DATA

7 ORDERING DATA

7.1 Ordering Codes

| | <u>ST</u> | <u>PC</u> | <u>C03</u> | <u>66</u> | <u>BT</u> | <u>C</u> | <u>3</u> |
|---|-----------|-----------|------------|-----------|-----------|----------|----------|
| STMicroelectronics Prefix | | | | | | | |
| Product Family PC: PC Compatible | | | | | | | |
| Product ID C03: Consumer-S | | | | | | | |
| Core Speed 66: 66MHz 75: 75MHz | | | | | | | |
| Package BT: 388 Overmoulded BGA | | | | | | | |
| Temperature Range C: Commercial Case Temperature (Tcase) = 0°C to +100°C I: Industrial Case Temperature (Tcase) = -40°C to +100°C | | | | | | | |
| Operating Voltage 3 : 3.3V ± 0.3V | | | | | | | |



7.2 Available Part Numbers

| Part Number | Core Frequency (MHz) | CPU Mode (DX / DX2) | Tcase Range (°C) | Operating Voltage (V) |
|---------------|---------------------------|--------------------------|-----------------------|----------------------------|
| STPCC0366BTC3 | 66 | DX | 0°C to +100° | 3.3V ± 0.3V |
| STPCC0375BTC3 | 75 | DX | | |
| STPCC0390BTC3 | 90 | DX | | |
| STPCC0310BTC3 | 100 | DX | | |
| STPCC0366BTC3 | 66 | DX | -40°C to +100° | |

ORDERING DATA

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