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Interface Circuits Design

PATA: A Look Back at Parallel ATA

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1. PATA: What Is It?

Parallel Advanced Technology Attachment, or PATA, is an IDE standard used to connect storage devices to the motherboard, such as hard drives and optical discs. In general, cables and connections that follow this standard are referred to as PATA.

PATA was formerly known as ATA, and it wasn't until the new Serial ATA (SATA) emerged that it was renamed Parallel ATA. The P was added to the beginning of ATA, to differentiate it from SATA. P here stands for parallel and highlights the fact that PATA works in parallel.

2. A Brief History

Western Digital invented this storage connector in 1986. The company originally called it Integrated Drive Electronics (IDE). Updated versions of this storage connection standard, known as EIDE or Enhanced IDE, are available today.

PATA was developed as a replacement for the older ISA (Industry Standard Architecture) interface, which was slower and less able to keep up with the demands of modern computers.

The primary function of PATA is to connect to the 16-bit ISA directly. As a result, this standard was originally conceived as an AT Bus Attachment. Officially, it was known as AT accessory, but people shortened it to ATA.

There have been numerous PATA standards published over the years. While some provided 16 megabytes per second, others were able to guarantee 133 megabytes per second. PATA was also improved so that users may connect to devices other than hard discs. Now, people could connect to CD-ROM drives and a variety of other storage devices with ease.

The makers, however, changed the name ATA to Parallel ATA when the firm established SATA in 2013. The developer wanted to make it simpler to distinguish between SATA and PATA connections. During this period, PATA began to phase out of existence as SATA became the standard component for PCs everywhere.

3. PATA's characteristics

A PATA cable has 40-pin connectors on both sides and is typically flat. One of the ends of this plug goes into a port on the motherboard. Most times, it is labeled IDE. The other end of PATA goes into the back of the storage device; this could be a hard drive. Some cables have multiple

PATA connectors positioned halfway along the length. The purpose of this extra connector is to attach to another device, such as an optical disc drive.

Connecting PCs to storage devices is its primary function. Typically, there are 40 or 80 wire designs available. However, in order to effectively meet speed requirements, modern PATA storage devices need 80-wire cables. It can be challenging to distinguish between the two kinds of PATA cables because they usually have 40 pins that appear the same. Most of the 80-wire cable's connections are often grey, black, or even blue. However, the 40-wire line is only available in black.

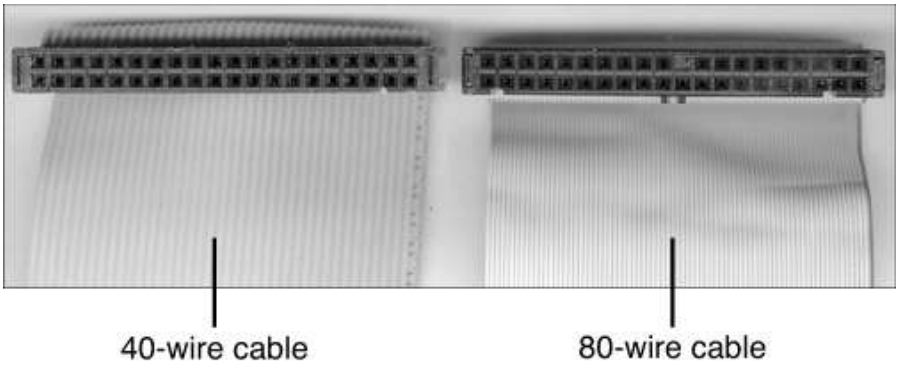

Figure 1 Two types of PATA cable

4. The ATA's Architecture and Signaling

Using a specialized ATA cable to connect a hard drive or other storage device to a computer's motherboard is the basic idea behind ATA. The ATA standard specifies a parallel interface that transmits multiple bits of data at once between the motherboard and the hard disc.

The data is sent in blocks, with each block consisting of several sectors of data. ATA also includes a set of commands that can be used to control the hard drive, such as commands to read and write data, and to control the speed and timing of data transfers. When a computer accesses data on a hard drive, the ATA controller sends commands to the hard drive to read or write the data, and then transfers the data to or from the motherboard using the ATA cable.

Below is a brief description of different layers of OSI implemented in PATA.

1. Physical Layer

The physical layer defines the electrical and mechanical characteristics of PATA.

Key Features:

- **Signaling**:

Uses single-ended signaling (not differential signaling like SATA).

Voltage levels: 5V (older devices) or 3.3V (newer devices) for logic states (high = 1, low = 0).

Susceptible to noise and crosstalk due to parallel transmission over multiple wires.

- **Cabling**:

40-pin ribbon cable: Original standard with 40 wires (16 data lines + control/ground lines).

80-conductor cable: Introduced for Ultra ATA/66 and later to reduce crosstalk (40 pins, but 80 wires with alternating ground lines).

Maximum cable length: 18 inches (45 cm).

- **Connectors**:

40-pin IDC (Insulation Displacement Connector) for host (motherboard) and device (hard drive).

Master/Slave configuration via jumpers on the device.

- **Timing**:

Synchronized using strobe signals (e.g., DIOR# [Read Strobe] and DIOW# [Write Strobe]).

Data transfer rates range from 16.6 MB/s (ATA-1) to 133 MB/s (ATA-7).

2. Data Link Layer

The data link layer manages data framing, error detection, and flow control between the host and the device.

Key Functions:

- **Data Framing**:

Data is transferred in 16-bit parallel chunks (with additional control signals).

Uses block transfers (sectors of 512 bytes) for read/write operations.

- **Error Detection**:

Cyclic Redundancy Check (CRC): Used to verify data integrity during transfers.

Parity Checking: Optional in older implementations (not widely used).

- **Flow Control**:

Handled via IORDY (I/O Channel Ready) signal. The device can assert IORDY to pause the host if it needs more time to process data.

- **Protocol Commands**:

Basic commands like Identify Device, Read Sector, and Write Sector are exchanged here.

3. **Transaction Layer (Command Layer)**

The transaction layer manages command execution, data transfers, and device coordination.

Key Functions:

- **Command Execution**:

The host sends ATA commands (e.g., read, write, flush cache) to the device via Task File Registers (a set of I/O ports).

Commands include parameters like sector count, LBA (Logical Block Address), and operation type.

- **Data Transfer Modes**:

PIO (Programmed Input/Output): CPU-managed transfers (slower, uses host CPU cycles).

DMA (Direct Memory Access): Device transfers data directly to memory (faster, offloads the CPU).

Ultra DMA (UDMA): Enhanced DMA with CRC for error detection (used in ATA/33 and later).

- **Task File Registers**:

A set of registers (e.g., Data Register, Sector Count, LBA Low/High) used to configure and execute commands.

Example: To read a sector, the host writes the LBA address to the registers and triggers a Read Sector command.

- **Master/Slave Arbitration**:

Handles communication when two devices (master and slave) share the same cable.

5. Fundamental components of ATA

The following are the main elements of ATA:

- ATA controller: This is a motherboard chip or an external expansion card that regulates data transfer between the computer and the hard drive.
- ATA cable: This ribbon cable joins the ATA controller and the hard disc. Hard drive − This is the storage device that stores data and is connected to the ATA controller via the ATA cable.
- ATA BIOS − This is a program stored on the motherboard that initializes the ATA controller and detects the presence of connected ATA devices during the boot process.

- ATA commands − These are a set of standardized commands that the ATA controller can send to the hard drive to perform tasks such as reading or writing data, and controlling the speed and timing of data transfers.

6. PATA types

PATA comes in a variety of types. In this section, we'll explore the available types of PATA and their functions.

- **ATA-1**

This is the first type of PATA included in the DeskPro 386. It began the use of a master/slave configuration. ATA-1 is a PATA type that uses 40-pin or 44-pin connectors and cables and is based on a subset of the conventional 96-pin connector. For the 44-pin versions, those extra four pins helped supply power to a drive that didn't have a separate power connector.

Furthermore, ATA-1 included signal timing for input/output programming and direct memory access. This meant that the drive would send information directly to the memory, and the PIO facilitated the computer's CPU in managing the information transfer.

- **ATA-2**

ATA-2 was the second type of PATA released, and it increased the transfer rate from 4-16 megabytes each second to 16.67 megabytes per second. It was an upgrade from ATA-1, providing power management and removable device support. It is also called EIDE because it increased the hard drive support to 137.4 gigabytes.

- **ATA/ATAPI-4**

Another name for this kind of PATA is UDMA/33. This version of PATA added the ATA Packet Interface (ATAPI) to the standard. This way, it was now possible to support several other devices like CD-ROM, tape systems, etc. The data transfer rate rose dramatically to 33 megabytes per second with ATA-4. This PATA also provided support for 80-conductor, 40-pin ribbon cables.

The majority of people believe that ATA-4 is the best addition to the PATA standard. This is due to the fact that ATAPI was completely separate before this version.

- **ATA/ATAPI-6**

The data transfer rate was also raised to 100 megabytes per second. Because of this, a lot of people call them PATA/100 drives. Additionally, ATA-6 introduced automated acoustic management, which let drives modify the speed of access. This action also helped to reduce running noise.

7. PATA layout & Structure

The ATA interfaces have a 40-pin connector and can support up to two drives per interface. The chart below describes each of the pins on a 40-pin ATA interface.

Pin	Function	Pin	Function
1	**Reset**	**2**	**Ground**
3	Data 7	4	Data 8
5	Data 6	6	Data 9
7	Data 5	8	Data 10
9	Data 4	10	Data 11
11	Data 3	12	Data 12
13	Data 2	14	Data 13
15	Data 1	16	Data 14
17	Data 0	18	Data 15
19	Ground	20	Key
21	DDRQ	22	Ground
23	I/O Write	24	Ground
25	I/O Read	26	Ground
27	IOC HRDY	28	Cable Select
29	DDACK	30	Ground
31	IRQ (interrupt request)	32	No Connect
33	Addr 1	34	GPIO_DMA66_Detect

35	Addr 0	36	Addr 2
37	Chip Select 1P	38	Chip Select 3P
39	Activity	40	Ground

Below is a picture of the IDE connector on a hard drive, IDE cable, and the IDE channels on the motherboard.

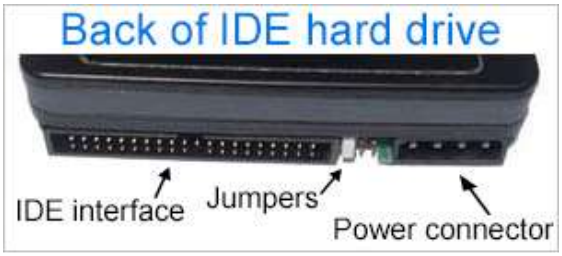

Figure 2 IDE connector

Figure 3 IDE cable

Figure 4 IDE channels on the motherboard

Figure 5 Two channels on a motherboard

The 40-pin PATA interface, commonly found on older motherboards, features a distinctive design with one pin intentionally omitted, resulting in a 39-pin configuration. This missing pin serves as a keying mechanism, ensuring that the cable can only be inserted in one specific orientation. In the past, it was standard for motherboards to include two such connectors. However, as technology evolved, this was typically reduced to a single connector. In modern motherboards, the PATA interface is rarely included, as it has been largely replaced by newer standards.

Figure 6 Back of IDE hard drive

PATA cables are generally keyed, with one pin modified to prevent incorrect connection. However, it is important to note that not all PATA cables possess this keying mechanism. Jumpers located on the drive itself allow for configuration settings. Power is typically provided to PATA drives using Molex connectors.

Figure 7 PATA cable

Upon examining the PATA cable, it is evident that the length of the cable between the middle connector and the end connectors varies. Typically, the connectors at either end of the cable are designated for device zero (also referred to as the master when using cable select to determine device roles). Consequently, the middle connector is generally assigned to device one (or the slave). However, this default configuration can be overridden by manually setting the storage device to operate as either device zero or device one, depending on the user's requirements.

8. PATA Dual-Drive Configurations

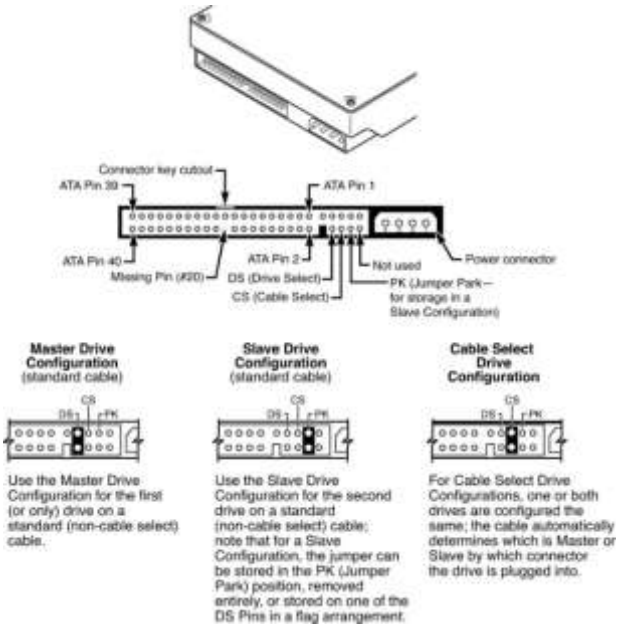

Figure 8 Dual configurations

In order for two storage devices to be supported on the one cable, one is designated as device zero and the other as device one. Originally, they were referred to as master and slave, so you may see these terms used. The master and slave terms were misleading as they tend to imply that one has priority over the other or that it requires the other to operate. This is generally not true. On very old equipment, like some of the earliest optical drives, you might find that they only work as device zero or device one, and sometimes only if a hard drive is installed as device zero. However, this was mostly an issue in the early days and isn't something you're likely to encounter now.

On the back of most PATA storage devices, near the connection, you'll usually find a set of jumpers. While the jumper settings can vary between devices, there are typically three common configurations: one for device zero, another for device one, and a third for cable select. If you use cable select, the drive will automatically configure itself as device zero or device one based on which connector it's plugged into on the cable.

Most devices have a sticker near the jumpers that explains what each setting does. If you're unsure, the default setting is usually cable select. In fact, if no jumpers are present at all, the drive will typically default to cable select.

Dual-drive PATA installations can be problematic because each drive has its own controller, and both controllers must function while being connected to the same bus. There has to be a way to ensure that only one of the two controllers responds to a command at a time.

The ATA standard provides the option of operating on the AT bus with two drives in a daisy-chained configuration. The primary drive (drive 0) is called the *master*, and the secondary drive (drive 1) is called the *slave*. You designate a drive as being master or slave by setting a jumper or switch on the drive or by using a special line in the interface called the *cable select (CS) pin* and setting the CS jumper on the drive.

When only one drive is installed, the controller responds to all commands from the system. When two drives (and, therefore, two controllers) are installed, both controllers receive all commands from the system. Each controller then must be set up to respond only to commands for itself. In this situation, one controller must be designated as the master and the other as the slave. When the system sends a command for a specific drive, the controller on the other drive must remain silent while the selected controller and drive are functioning. Setting the jumper to master or slave enables discrimination between the two controllers by setting a special bit (the DRV bit) in the drive/head register of a command block.

9. PATA and SATA

Figure 9 PATA cable (left) vs SATA cable (right)

People frequently mistake the two interface variants, PATA and SATA, for one another. But in a lot of respects, they're quite different. During the first introduction of the ATA interface, PATA was widely used. Serial Advanced Technology Attachment (SATA) is an improved version of PATA, and while ATA-6 stopped at 100 megabytes per second, the highest speed of SATA is 16GB. Nowadays, SATA is used by practically all computers to move data and information. Below is a simplified breakdown of the differences between both interfaces.

- **Transfer Speed**

Compared to PATA hard drives, SATA offers a faster transmission rate. This is due to the fact that the SATA interface enables data transfers in gb/s, but PATA only permits mb/s data transfers. This is a considerable distinction from PATA. This increased speed is useful when you need to transfer large documents. Additionally, if you want to play games, the fast SATA transfer rate guarantees a pleasant gaming experience.

- **Cable Length**

This is yet another important distinction between PATA and SATA. PATA has a maximum length of 46 centimeters, whereas SATA has a maximum length of one meter. In this way, SATA is more flexible for moving around your hard drive.

- **Performance**

Being an older version, PATA doesn't support hot-swapping. This means that you cannot change the part while using the computer. However, hot-swapping is fully supported by SATA. Furthermore, SATA cables are quite compact even though they are longer. This is to prevent the clogging of airflow in the computer. In this manner, SATA connections extend a computer's lifespan and guarantee improved performance.

- **Compatibility**

SATA cables are designed to support forward and backward compatibility. This means that even with future upgrades to the SATA standard, the system will still be able to accept input from future and past versions.

- **Versatility**

PATA typically offers greater versatility, even if SATA is the most modern version. This means it allows the connection of two devices to the cable simultaneously. One of the devices is identified as the primary device, or device 0, and the other is identified as the secondary device, or device 1. SATA, on the other hand, only provides two points of connection: one to the storage device and one to the motherboard.

10. IDE VS. PATA

The terms PATA (Parallel ATA) and IDE (Integrated Drive Electronics) are often used interchangeably to refer to the same type of hard drive interface, characterized by flat, ribbon-like cables. This terminology can be confusing, as there is no functional difference between the two.

Western Digital's introduction of the first drive integrating the controller onto the drive itself led to the term IDE. This interface was later standardized as ATA. To distinguish this parallel ATA standard from the subsequent serial SATA standard, the "P" was added, resulting in the term PATA. So, IDE is the term used to refer to the first hard drive generation that utilized the PATA interface.

11. References and Resources

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