Module 5

Electronic Appliances and Applications

Syllabus

Simple applications of Electronics-Loudspeaker principle, Permanent Magnet Speaker, Digital Set Top Box, Mobile Handset, Digital Camera System, Concept of Microwave Oven, Scanner: Barcode Scanner.

5. Mobile Handset:

5.1 Introduction to cellular mobile-basic concepts

Cellular system was developed to provide mobile telephony: telephone access "anytime, anywhere." Cellular telephony is a system-level concept, which replaces a single high power transmitter with a large number of low-power transmitters for communication between any two devices over a large geographic area. Primary goal of the cellular telephone network is to provide wireless communication between two moving devices, called mobile stations or between one mobile unit and a stationary unit, commonly referred to as land-line unit. To accommodate a large number of users over a large geographic area, the cellular telephone system uses a large number of low-power wireless transmitters to create cells. Variable power levels allow cells to be sized according to subscriber density and demand within a particular region.

5.2 History of wireless communication

5.2.1 Analog: 1G

The first cellular communications services (first generation, or 1G) were analog systems. Analog systems are based on frequency modulation (FM) using bandwidths of 25 kHz to 30 kHz. They use a constant phase variable frequency modulation technique to transmit analog signals. Among the most popular of analog wireless technologies is AMPS (Advanced Mobile Phone System), developed by Bell Labs in the 1970s.

A version of AMPS known as Narrowband AMPS (NAMPS) incorporates some digital technology, which allows the system to carry about three times as many calls as the original version. Though it uses digital technology, it is still considered analog. AMPS and NAMPS operate in the 800-MHz band only and do not offer features such as email.

5.2.2 Digital: 1G

Digital cell phones use analog radio technology, but they use it in a different way. Analog systems do not fully utilize the signal between the phone and the cellular network because analog signals cannot be compressed and manipulated as easily as digital. This is why many companies are switching to digital—they can fit more channels within a given bandwidth. and Web browsing.

Digital phones convert a voice into binary information (1s and 0s) and compress it. With this compression, between three and 10 digital cell phone calls occupy the space of a single analog call. Digital cellular telephony uses constant frequency variable phase modulation techniques to transmit its analog signals. With this technology digital cellular can handle up to six users at a time per channel compared to one user at a time with analog.

In the 1970s digital cellular research concentrated on narrow-band frequency division multiple access (FDMA) technology. In the early 1980s the focus switched to time division multiple access (TDMA) techniques. In 1987 narrow-band TDMA with 200 kHz channel spacing was adopted as the technology of choice for the pan-European GSM digital cellular standard. In 1989 the U.S. and Japan also adopted the narrow-band TDMA. More recently cellular networks are migrating to CDMA (code division multiple access) technology.

5.2.3 2G

Second-generation digital systems can provide voice/data/fax transfer as well as other value-added services. They are still evolving with ever-increasing data rates via new technologies such as HSCSD and GPRS. 2G systems include GSM, US-TDMA (IS_136), cdmaOne (IS-95), and PDC.US-TDMA/PDC have been structured atop existing 1G analog technology and are premised on compatibility and parallel operation with analog networks. GSM/IS-95, however, are based on an entirely new concept and are being increasingly adopted worldwide.

5.2.4 2.5G

2.5G technologies are those offering data rates higher than 14.4 Kb/s and less than 384 Kb/s. Though these cellular data services may seem like a steppingstone to things to come, they may be with us much longer than some cellular carriers want to believe.

2.5G technologies accommodate cellular nicely. First, they are packet-based as opposed to 2G data services, which were generally connection based. This allows for always-on services. And since no real connection needs to be established, latency in sending data is greatly reduced. Second, since 2.5G services don't require new spectrum or 3G licenses, the carrier's cost to deploy these services is modest. This might make them cheaper for consumers. Third, enabling handsets for 2.5G services are fairly inexpensive, typically adding less than $10 to the handset cost.

5.2.5 3G

3G (third generation) mobile communications systems include technologies such as cdma2000, UMTS, GPRS, WCDMA, and EDGE. The vision of a 3G cellular system was originally articulated by the International Telecommunications Union (ITU) in 1985. 3G combines high-speed mobile access with enhanced Internet Protocol (IP)-based services such as voice, text, and data. 3G will enable new ways to communicate access information, conduct business, and learn. 3G systems will integrate different service coverage zones including macrocell, microcell, and picocell terrestrial cellular systems.

In addition, they support cordless telephone systems, wireless access systems, and satellite systems. These systems are intended to be a global platform and provide the infrastructure necessary for the distribution of converged services. Examples Mobile or fixed communications, Voice or data, Telecommunications, Content, Computing.

5.2.6 4G

The fourth generation of mobile network technology, commonly known as 4G, represented a significant leap forward in wireless communication. 4G emerged in the late 2000s as the successor to 3G technology. It aimed to provide faster data transfer speeds and improved network reliability for mobile devices. The development of 4G was primarily focused on achieving higher data rates, lower latency, and better spectral efficiency compared to its predecessors. One of the key technologies that underpinned 4G was LTE. LTE technology significantly enhanced data speeds and network performance. It allowed for faster and more efficient use of the radio spectrum, enabling higher data transfer rates and better connectivity for users.

4G networks provided users with much-improved internet speeds, facilitating better streaming quality, faster downloads/uploads, and smoother online experiences on smartphones, tablets, and other connected devices. It became the foundation for various new applications, services, and technologies, including video streaming, online gaming, and the Internet of Things (IoT).

5.2.7 5G

5G is the 5th generation mobile network. It is a new global wireless standard after 1G, 2G, 3G, and 4G networks. 5G enables a new kind of network that is designed to connect virtually everyone and everything together including machines, objects, and devices.

5G wireless technology is meant to deliver higher multi-Gbps peak data speeds, ultra low latency, more reliability, massive network capacity, increased availability, and a more uniform user experience to more users. Higher performance and improved efficiency empower new user experiences and connects new industries.

5.3 Cell

A **cell** is a basic geographic unit of a cellular system. The term cellular comes from the honeycomb shape of the areas into which a coverage region is divided. Cells are base stations transmitting over small geographic areas that are represented as hexagons. As mobile users travel from cell to cell, their conversations are handed off between cells. Channels (frequencies) used in one cell can be reused in another cell some distance away, which allows communication by a large number stations using a limited number of radio frequencies. To summarize, the basic concept of reuse allows a fixed number of channels to serve an arbitrarily large number of users. A cluster is a group of cells and no channels are reused within a cluster.

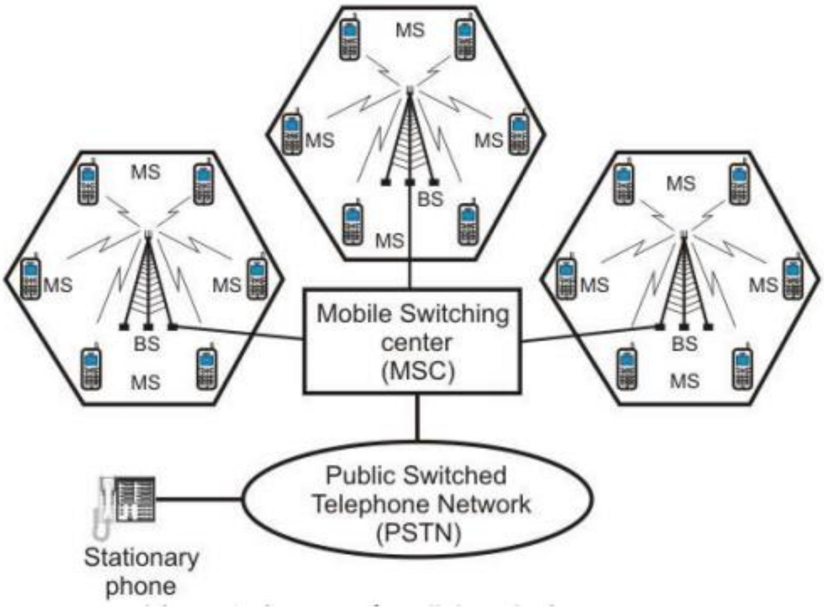

Fig 5.1 Schematic diagram of a cellular telephone system

As shown above, a cellular system comprises of the following basic components:

 Mobile Stations (MS): Mobile handsets, which is used by a user to communicate with another user

 Cell: Each cellular service area is divided into small regions called cell (5 to 20 Km)

 Base Stations (BS): Each cell contains an antenna, which is controlled by a small office.

 Mobile Switching Center (MSC): Each base station is controlled by a switching office, called mobile switching center

Frequency reuse is the process in which the same set of frequencies (channels) can be allocated to more than one cell, provided the cells are separated by sufficient distance. The figure shows a geographic cellular radio coverage area containing three groups of cells called clusters. Each cluster has seven cells in it, and all cells are assigned the same number of full-duplex cellular telephone channels. Cells with the same letter use the same set of channel frequencies. A, B, C, D, E, F and G denote the seven sets of frequencies.

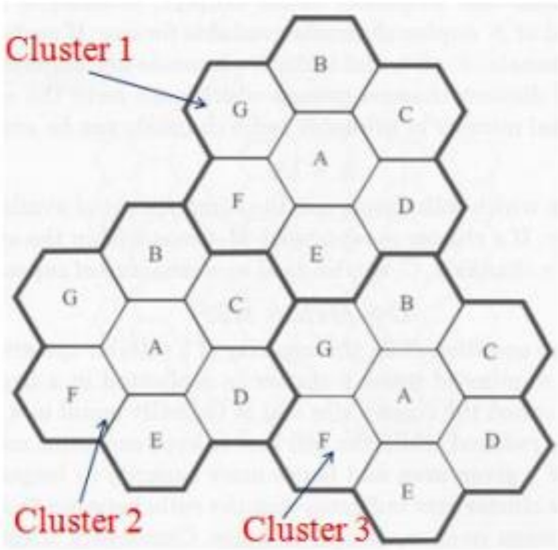

Fig 5.2 Frequency reuse

Handoff: At any instant, each mobile station is logically in a cell and under the control of the cell's base station. When a mobile station moves out of a cell, the base station notices the MS's signal fading away and requests all the neighboring BSs to report the strength they are receiving. The BS then transfers ownership to the cell getting the strongest signal and the MSC changes the channel carrying the call. The process is called handoff.

There are two types of handoff; **Hard Handoff** and **Soft Handoff**. In a hard **handoff**, which was used in the early systems, a MS communicates with one BS. As a MS moves from cell A to cell B, the communication between the MS and base station of cell A is first broken before communication is started between the MS and the base station of B. As a consequence, transition is not smooth. Hard handoff is often called as break before-make. Hard handoffs are intended to be instantaneous in order to minimize the disruption to the call. A hard handoff is perceived by network engineers as an event during the call. For smooth transition from one cell (say A) to another (say B), an MS continues to talk to both A and B. As the MS moves from cell A to cell B, at some point the communication is broken with the old base station of cell A. This is known as **soft handoff** (also called as make before break). A soft handoff may involve using connections to more than two cells, e.g. connections to three, four or more cells can be maintained by one phone at the same time. Softer handoffs are possible when the cells involved in the handoff have a single cell site.

5.3.1 Mobile Handset block description

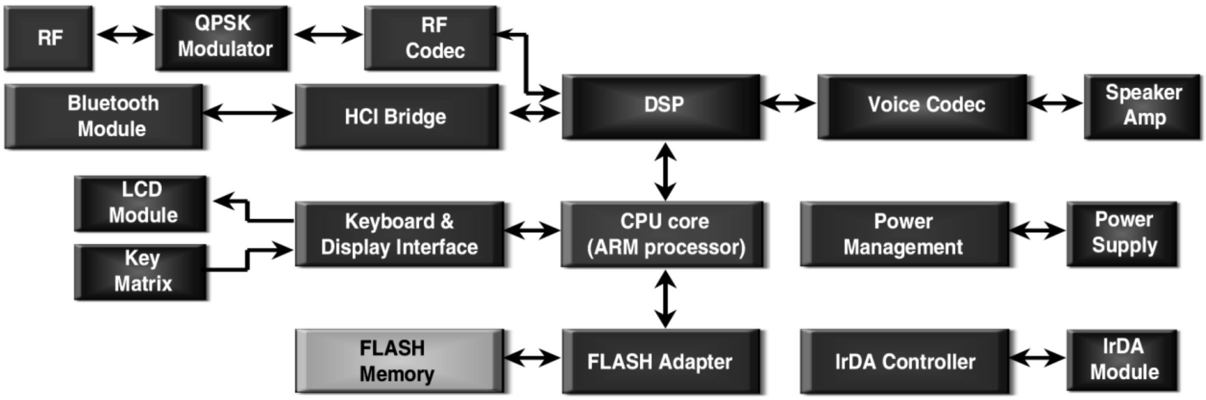

Fig 5.3 Mobile Handset Block Diagram

Cell phones are extremely intricate devices. Modern digital cell phones can process millions of calculations per second to compress and decompress the voice stream.

DSP/Baseband Processor and Analog codec subsection – The digital baseband and analog section includes:

- Channel and speech encoding/decoding
- Modulation/demodulation
- Clock
- D/A and A/D conversion
- Display
- RF interfacing.

This section performs high-speed encoding and decoding of the digital signal and manages the keypad and other system-level functions. The handset processor is responsible for functions such as keyboard entry, display updates, phonebook processing, setup functions, and time functions.

Memory – This includes SRAM, EEPROM and flash. Flash is a non-volatile memory that provides random access to large amounts of program information or code. There are two types of flash memories—NAND and NOR. NAND is better suited for serial access of large amounts of data. SRAM is much faster than flash and is used as low-power/low-density RAM for cache. ROM and flash memory provide storage for the phone's operating system and customizable features such as the phone directory.

RF section – The RF section includes the RF/IF transmitter and receiver ICs, RF power amplifiers, PLLs, synthesizers, and VCOs. These components receive and transmit signals through the antenna. RF functions include modulation, synthesis, up and down conversion, filtering, and power amplification.

The QPSK modulator plays a crucial role in encoding digital data into a format suitable for transmission through the communication channel, allowing for efficient and reliable communication over various mediums.

RF codec refers to a device or system that involves both the encoding (compression) and decoding (decompression) of digital audio signals for transmission over radio frequency (RF) channels.

A flash adapter, in the context of technology or computing, typically refers to a device or accessory that allows the connection or compatibility between different types or sizes of flash memory cards or storage devices.

Battery and/or power management - This section supplies and controls power distribution in the system since different components often operate at different voltages. The power management unit also controls power-down and stand-by modes within the handset and regulates the transmitter power of the handset's power amp.

Display – Cell phone displays can be color or monochrome. Some are backlit, some reflective, while others are organic electroluminescent displays.

Operating system – Several vendors have announced operating systems for the cell phones. Microsoft has introduced the PocketPC 2002 Phone Edition which is a PDA operating system based on Windows CE 3.0.

Keypad/keyboard

Microphone and speaker

5.4 Digital Imaging:

5.4.1 Introduction to digital Imaging

Camera technology is shifting from analog to digital. Most people have piles of photographs lying in the closet. While they bring back good memories, the storage and sharing of photos has always been an issue. With improvements in digital photography and the falling prices of hard disk drives and PCs, the digital camera is gaining in popularity. Digital cameras are replacing 35-mm cameras because of image quality, ease of use, compact size, and low cost. A digital camera is basically an extension of the PC. The photos can be viewed on the camera's built-in LCD screen or on a PC monitor if the camera is plugged into a computer. The photos can be edited (color adjustments, cropping, etc.) with a PC graphics application and sent to friends by e-mail, or printed.

Rapid technology changes in sensors, chipsets, and pixel resolution contributed to this progress. Advanced semiconductor products, such as CMOS sensors, helped improve digital imaging and overall camera performance. Meanwhile, the price of digital camera components—namely charged-coupled devices (CCDs)—continues to fall dramatically, reducing unit cost. Today, digital camera technology is transitioning from a niche market to mass consumer market. The unit price for some entry-level digital cameras has dropped below $50, giving the consumer greater choice in digital photography.

5.4.2 Digital Imaging Camera System

Digital camera is similar to a traditional film-based camera. There is a viewfinder to aim it, a lens to focus the image onto a light-sensitive device, and some means to store and remove images for later use. Digital photography uses a combination of advanced image sensor technology and memory storage. It allows images to be captured in a digital format that is available instantly—there is no need for a "development" process. Although the principle may be the same as a film camera, the inner workings of a digital camera are quite different. Once a picture is snapped, an embedded processor reads the light level of each pixel and processes it to produce a 24-bit-per-pixel color image. Soon after the picture is taken, the JPEG image is projected onto a LCD display on the back of the camera, or it may be compressed in non-volatile flash memory storage via software. Digital cameras provide speed and the convenience of instant development.

In the process of creating the pixels, an image is focused through a lens and onto an image sensor which is an array of light-sensitive diodes. The image sensor is either a charge-coupled device (CCD) or CMOS (complementary metal-oxide semiconductor) sensors. Each sensor element (chip) converts light into a voltage proportional to the brightness which is passed into an analog-to-digital converter (ADC). The ADC then translates the voltage fluctuations of the CCD into discrete binary code. It does this through a series of photodiodes—each containing red, green, and blue filters— which respond to different ranges of the optical spectrum. The sensor chip is typically housed on a daughter card along with numerous ADCs. The digital reproduction of the image from the ADC is sent to a DSP which adjusts contrast and detail, and compresses the image before sending it to the storage medium. The brighter the light, the higher the voltage and the brighter the resulting computer pixel. The more elements, the higher the resolution, and the greater the detail that can be captured.

Apart from the image sensors, the semiconductor content of a digital camera's bill-of-materials includes embedded micro-logic, flash memory, DRAM, analog, ADC, other logic, and discrete chips. By design, digital cameras require a considerable amount of image processing power. The five key elements of technology and design include:

■ a sensor

■ an image processing unit

■ a microprocessor

■ memory (DRAM)

■ digital film storage (flash memory)

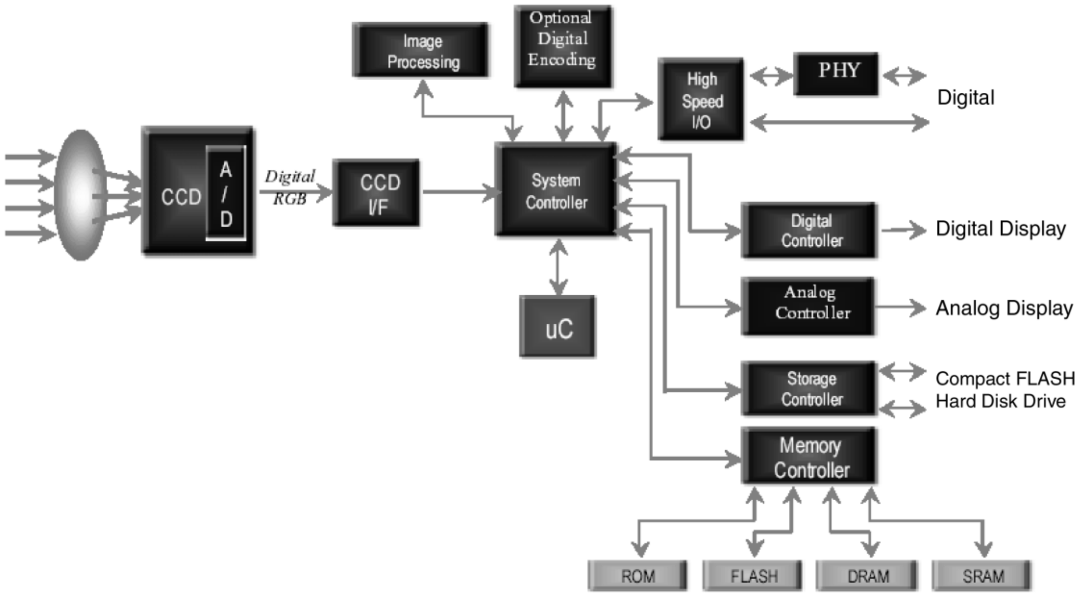

Fig5.4 Digital Camera System

5.4.3 Camera system on moving vehicles

Dashcam: In-vehicle camera systems are becoming more and more popular in today's world. The in-vehicle camera is a video recorder that records while the vehicle is in motion. It is also called a dashcam. It typically attaches to your windshield via a suction cup or clips onto your dashboard with an adhesive mount so it can record what happens on the road ahead of you continuously. Dashcams use a loop recording system, so when the memory card fills up from all of the driving footage, it automatically starts overwriting old videos to make room for new ones, which means there's never any worry about running out of space.

These devices are not only beneficial for catching lawbreakers but can also provide valuable information about road accidents. The camera captures footage that can be used as evidence to file an insurance claim or lawsuit against another driver. It is wise to invest in this technology now before you need it later.

360-degree camera: The 360-degree camera system in moving vehicles, especially in automobiles, is a game-changer for safety and convenience. These systems typically consist of multiple cameras strategically positioned around the vehicle to provide the driver with a complete view of the surroundings.

They offer various functionalities like:

Parkin**g Assistance:** Displaying a bird's-eye view or composite image of the car's surroundings, aiding in parking in tight spaces.

Collision Avoidance: Alerting drivers to obstacles or pedestrians in blind spots through visual and auditory cues.

Lane Departure Warning: Monitoring the vehicle's position in the lane and alerting the driver if the vehicle drifts out of its lane without signaling.

Adaptive Cruise Control: Assisting in maintaining a safe distance from vehicles ahead by adjusting speed accordingly.

These systems enhance driver awareness, improve safety, and simplify maneuvering in challenging situations. They've become increasingly common in modern vehicles, contributing significantly to driver assistance and overall safety on the road.

5.4.4 Technology requirements in the design of digital camera

The design of a digital camera involves several technological components and considerations to achieve optimal performance. Here are some key technology requirements:

Image Sensor: The image sensor captures light and converts it into digital signals. CCD (Charge-Coupled Device) and CMOS (Complementary Metal-Oxide Semiconductor) sensors are the two primary types. CMOS sensors are more common due to lower power consumption, better integration with other components, and faster readout speeds.

Resolution and Megapixels: The camera's resolution is determined by the number of pixels in the image sensor. Higher megapixel counts allow for greater detail and larger print sizes..

Lens Quality: A high-quality lens is crucial for sharp and clear images. Optical elements, coatings, and precision in construction are key factors in a camera's lens quality. Different lenses (prime, zoom, wide-angle, etc.) offer various shooting capabilities.

Image Processing and Signal Processing: Image processing chips handle tasks such as noise reduction, color accuracy, white balance, and compression. Advanced algorithms and processing power help improve image quality and enable features like high-speed continuous shooting and image stabilization.

Viewfinder and Display: Optical viewfinders or electronic viewfinders (EVFs) help users compose shots. LCD displays on the camera provide real-time previews, playback, and menu navigation. These screens require good resolution, color accuracy, and sometimes touch functionality for user convenience.

Autofocus Technology: Autofocus systems ensure sharp images by quickly and accurately focusing on subjects. Various autofocus technologies, such as phase detection and contrast detection, work in different ways to achieve this.

Connectivity: Modern digital cameras often include wireless connectivity (Wi-Fi, Bluetooth) for transferring images to other devices, remote control, or firmware updates. This connectivity enhances user convenience and workflow.

Battery Life and Power Management: Efficient power management systems are necessary to optimize battery life, ensuring the camera can operate for extended periods without frequent recharging.

Physical Design and Ergonomics: Comfortable handling, intuitive controls, and durability are essential for user satisfaction and the camera's longevity.

Storage: Cameras use various types of memory cards (SD, CFexpress, etc.) to store images and videos. The camera's design should support reliable and fast writing speeds to these cards

5.5 Barcode Scanner:

5.5.1 Bar codes

A bar code, shown in Fig, is a rectangular block of black and white lines often seen printed on cans of food, books and many other items. It is a method of coding consumer products by combinations of bars of varying thicknesses representing characters and numerals. The black lines and white spaces tell a computer what the item is and how much the item costs. The various codes, Universal Product Code (UPC), and others are designed to be read by optical wands or stationary in-counter readers.

Fig 5.5 Bar code

The most common format is called the **universal product code (UPC),** shown in Fig2, other formats called Interleave 2 of 5 and Code 39 are also used. Today the UPC has become a subset of the European Article Number (EAN). A typical UPC symbol shown in, Fig (a) usually has the UPC type represented by one character, the UPC manufacturer, or vendor ID number represented by five characters, the UPC item number represented by five characters, and finally, one character that is used as a check digit. Fig shows an example of a typical bar-code symbol.

Fig 5.6 Universal product code.

Another format for a bar code symbol is shown in fig 5.7 (b). This format is the **Automotive Industry Action Group (AIAG)**, which is used in the automotive industry to identify parts that are shipped between parts' manufacturer and the assembly plant. In this figure you can see that the format includes five separate bar-code symbols that are made up of numbers and letters. A wide variety of additional formats has been designed over the past few years for each special area of technology. These formats allow the bar-code symbols to represent information that is useful to these applications.

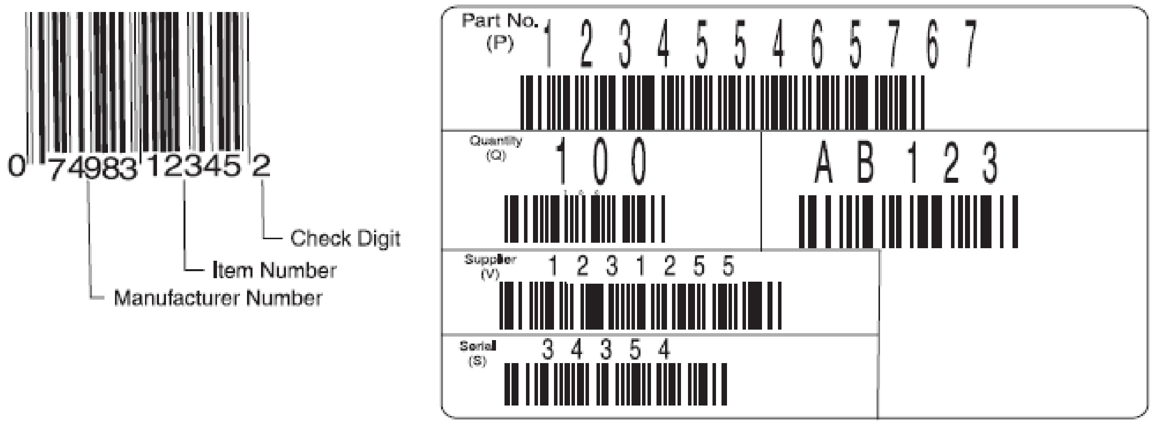

Fig 5.7 (a) Example of universal product code (UPC) format (b) Automative Industry Action Group (AIAG) format for bar codes

5.5.2 Block diagram of Barcode scanner and Decoder

Optical reading is a system based on the principle that the optical shape of each character on the input media is capable of being identified by a reading device.

A bar-code system is made up to two parts : the printer and the scanner/decoder. Printers are available to print labels or to print directly on products such as card board boxes and packages. The second part of the system consists of a scanner that reads the code symbols and a decoder that interprets the code.

Optical scanners, also referred to as digital scanners or bar-code readers, are special optical devices which scan patterns of incident light and generate analog/digital signals which are functions of the incident light synchronized with the scan, the primary purpose being to generate or read digital representation of printed or written data.

Fig shows the block diagram bar-code scanner and decoder. Here a light source is focused on the bar code. This light must be reflected back to the photo detector part of the scanner. Since the reflected light diffuses (spreads out), the window that receives the reflected light must be aligned correctly so that the scanner can read the code. After the signal is received it is amplified, conditioned, and then passed to the decoder section of the system. The decoder uses a microprocessor to decode the data and compare them to data in the database. The decoded data can be stored or displayed so that the humans using the system can read the data.

Bar-code optical scanners can read documents, encoded in a special bar code, at a hundred characters-per-second speed and are an element in the data station. The scanner opens up various system concepts for such tasks as billing, couponing, retail item control and other forms of returnable media. The scanner can read either lithographed or computer printed bar codes. As it scans it transfers the encoded data to a buffer for direct transmission or to printed paper tape and printer for pre-transmission editing (some systems).

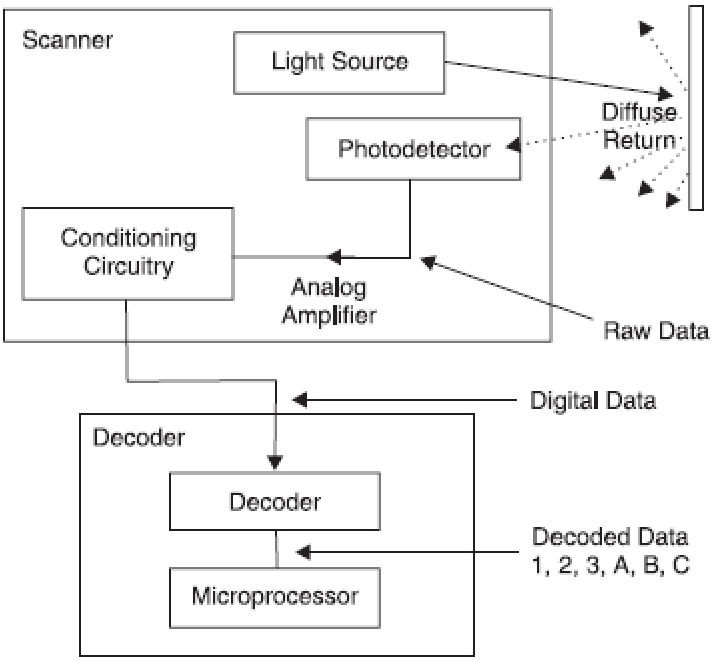

Fig 5.8 Block diagram of a bar-code scanner and decoder

References

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2. S. P. Bali. (2018) Consumer Electronics. (2018). Pearson Education.