Automated Storage Systems

- Suppose, the system are designed to reduce or eliminate the amount or human intervention required to operate it.
- There are less-automated systems, where a human operator is required in each storage/retrieval transaction and highly automated, where loads are entered or retrieved under computer control.
- Two general types:
  - Automated storage and retrieval systems
  - Carousel storage systems

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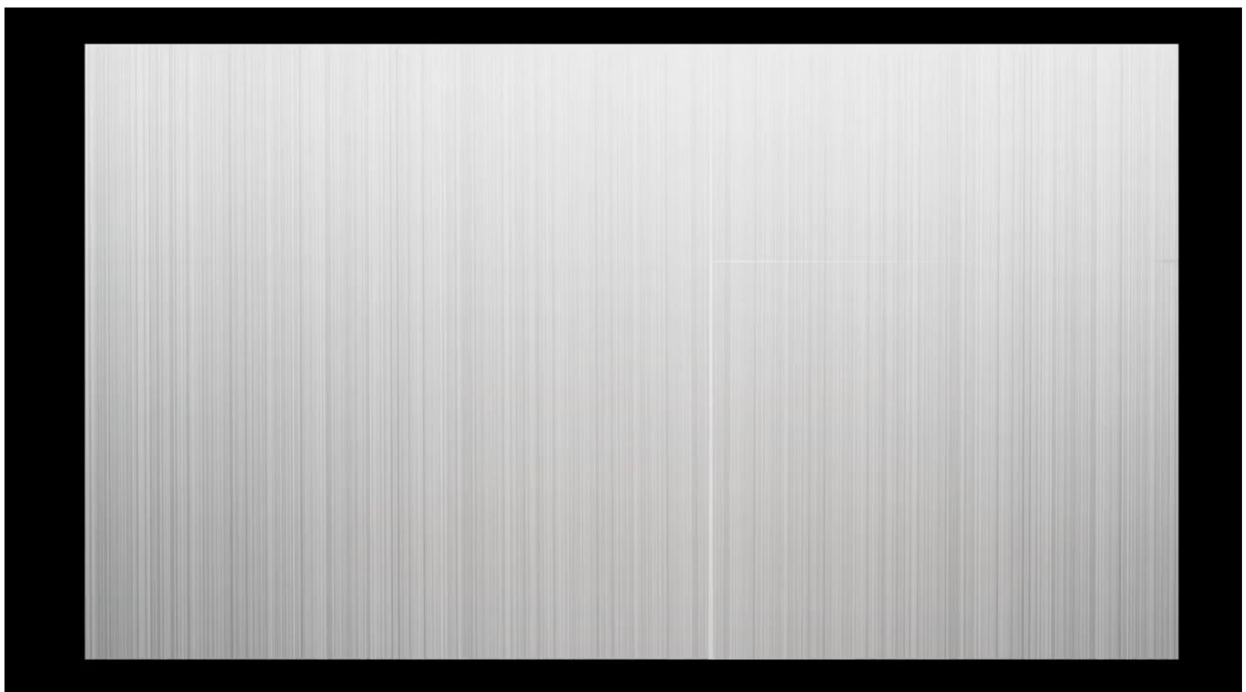


Automated Storage/Retrieval Systems

- A storage system that performs storage and retrieval operations with speed and accuracy under degree of automation.
- The basic system consists of a rack structure for storing loads and a storage/retrieval mechanism whose motions are linear (x-y-z motions). Also consists of one or more storage aisles that are each serviced by a storage/retrieval machine (sometime referred to as cranes).
- For each aisle has one or more input/output stations (called pickup-and-deposit stations).

AS/RS
-Objectives-

Possible Objectives for Automating a Company's Storage Operations

- To increase storage capacity
- To increase storage density
- To recover factory floor space presently used for storing work-in-process
- To improve security and reduce pilferage
- To reduce labor cost and/or increase labor productivity in storage operations
- To improve safety in the storage function
- To improve control over inventories
- To improve stock rotation
- To improve customer service
- To increase throughput

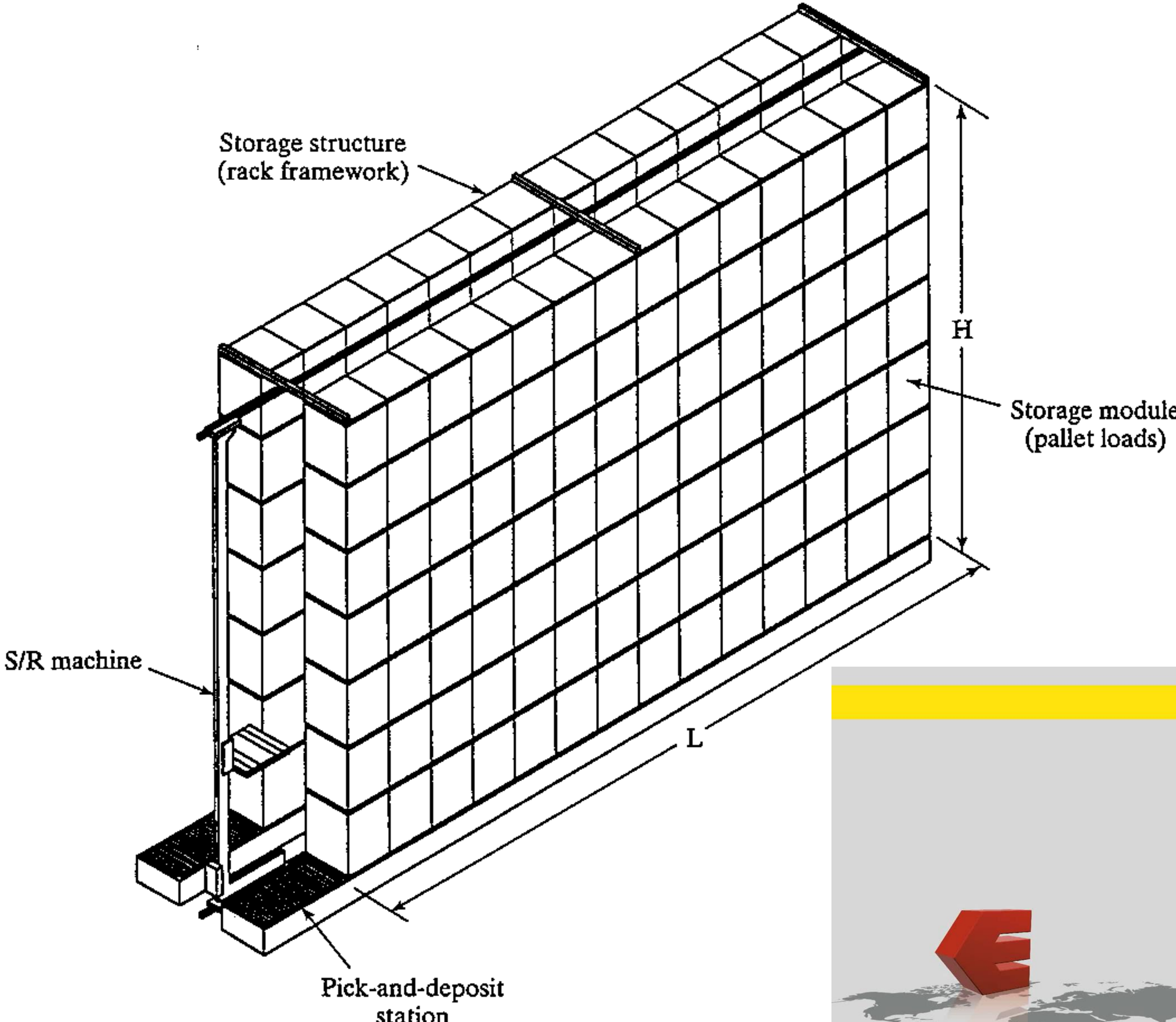
AS/RS
-Types and Application-

- Unit load AS/RS
- Deep lane AS/RS
- Miniload AS/RS
- Man-on-board AS/RS
- Automated item retrieval systems
- Vertical lift storage modules – the aisle is vertical

Unit load storage and retrieval applications

Order picking

Work-in process



A unit load automated storage/retrieval system

Components and Operating Features of AS/RS

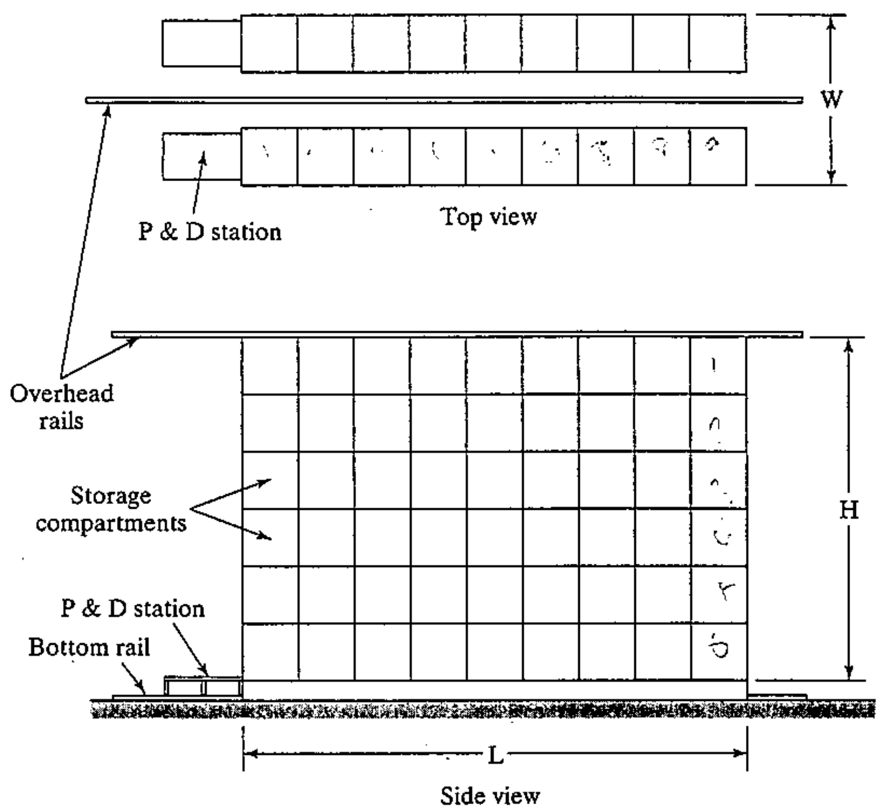
- Storage structure – rack framework, made of fabricated steel.
- S/R machine – to accomplish storage transactions, delivering loads from the input station into storage, and retrieving loads from storage and delivering them to the output system
- Storage module – the unit load containers of the stored material.
- The pick-and-deposit station – loads are transferred into and out of the AS/RS.

Eng. Analysis of Storage System

- This analysis only for AS/RS in sizing the AS/RS rack structure,

$$\text{Capacity per aisle} = 2\, n_y n_z \qquad (11.1)$$

Top and side view of a unit load AS/RS, with nine storage compartments horizontally (n_y = 9) and six compartments vertically (n_z = 6)



Number of load compartments along the length of the aisle, number of load compartments that make up the height of the aisle

Eng. Analysis of Storage System2

Let x and y the depth and width dimensions of a unit load, and z = the height of the unit load. The width, length and height of the rack structure of the AS/RS aisle are related to the unit load dimensions and number of compartments as follows:

$$W = 3(x + a) \quad (11.2a)$$

$$L = n_y(y + b) \quad (11.2b)$$

$$H = n_z(z + c) \quad (11.2c)$$

a, b and c are allowances designed into each storage compartment to provide clearance for the unit load and to account for the size of the supporting beams in the rack structure (MM, in). For an AS/RS with multiple aisles, W is simply multiplied by the number of aisles to obtain the overall width of the storage system.

Example[1]

Each aisle of a four-aisle AS/RS is to contain 60 storage compartments in the length direction and 12 compartments vertically. All storage compartments will be the same size to accommodate standard size pallets of dimensions: $x = 42$ in and $y = 48$ in. The height of a unit load $z = 36$ in. Using the allowances, $a = 6$ in, $b = 8$ in, and $c = 10$ in, determine: (a) how many unit loads can be stored in the AS/RS, and (b) the width, length, and height of the AS/RS.

Solution: (a) The storage capacity is given by Eq. (11.1):
Capacity per aisle = 2(60)(12) = 1440 unit loads.
With four aisles, the total capacity is:

$$\text{AS/RS capacity} = 4(1440) = 5760 \text{ unit loads}$$

(b) From Eqs. (11.2), we can compute the dimensions of the storage rack structure:

$$W = 3(42 + 6) = 144 \text{ in} = 12 \text{ ft/aisle}$$

$$\text{Overall width of the AS/RS} = 4(12) = 48 \text{ ft}$$

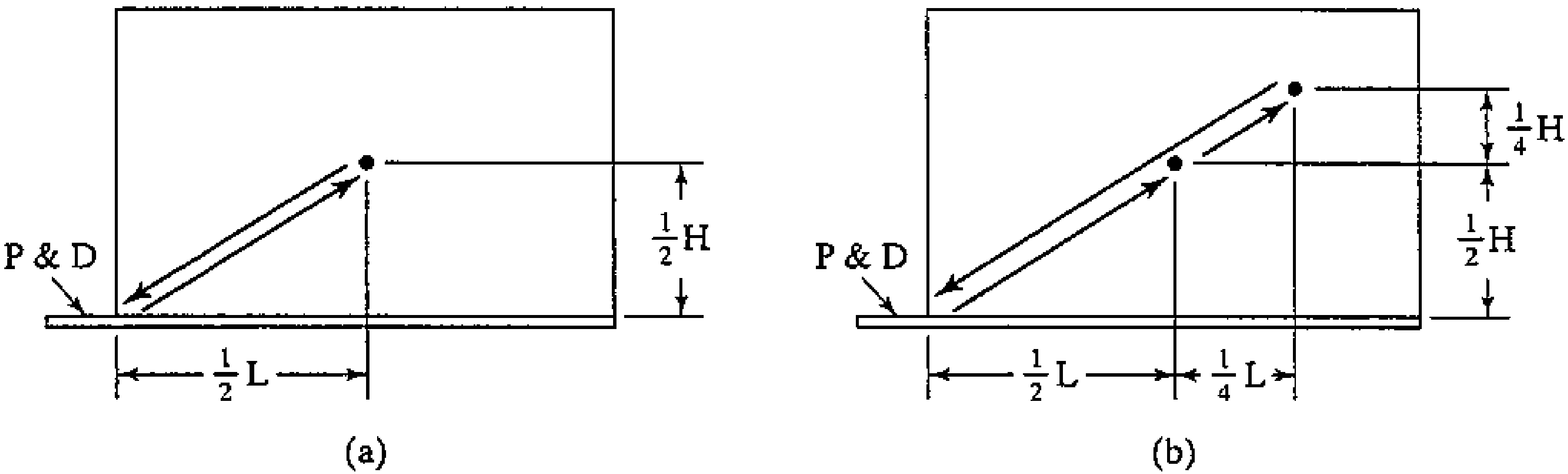
$$L = 60(48 + 8) = 3360 \text{ in} = 280 \text{ ft}$$

$$H = 12(36 + 10) = 552 \text{ in} = 46 \text{ ft}$$

Analysis of Storage System3

- Second analysis is an AS/RS Throughput. It is defined as the hourly rate of S/R transactions.
- For a single command cycle, the load to be entered or retrieved is assumed to be located at the center of the rack structure.
- Thus, the S/R machine must travel half the length and half the height of the AS/RS, and it must return the same distance.

Eng. Analysis of Storage System4



Assumed travel trajectory of the S/R machine for (a) single command cycle and (b) dual command cycle

Analysis of Storage System5

$$T_{cs} = 2\,\text{Max}\left\{\frac{0.5L}{v_y}, \frac{0.5H}{v_z}\right\} + 2T_{pd} = \text{Max}\left\{\frac{L}{v_y}, \frac{H}{v_z}\right\} + 2T_{pd} \quad (11.3a)$$

where T_{cs} = cycle time of a single command cycle (min/cycle), L = length of the AS/RS rack structure (m, ft), v_y = velocity of the S/R machine along the length of the AS/RS (m/min, ft/min), H = height of the rack structure (m, ft), v_z = velocity of the S/R machine in the vertical direction of the AS/RS (m/min, ft/min), and T_{pd} = pickup-and-deposit time (min). Two P&D times are required per cycle, representing load transfers to and from the S/R machine.

Analysis of Storage System[6]

- For a dual command cycle, the S/R machine is assumed to travel to the center of the rack structure to deposit a load, and then it travel to ¾ the length and height of the AS/RS to retrieve a load. Thus, the total distance traveled by the S/R machine is ¾ the length and ¾ the height of the rack structure, and back. In this case, cycle time is given by,

Analysis of Storage System7

$$T_{cd} = 2\,\text{Max}\left\{\frac{0.75L}{v_y}, \frac{0.75H}{v_z}\right\} + 4T_{pd} = \text{Max}\left\{\frac{1.5L}{v_y}, \frac{1.5H}{v_z}\right\} + 4T_{pd} \quad (11.3b)$$

cycle time for a dual command cycle (min/cycle)

System throughout depends on the relative numbers of single and dual command cycles performed by the system, Let R_{cs} = number of single command cycles performed per hour, and R_{cd} = number of dual command cycles per hour at a specified or assumed utilization level. An equation for the amount of time spent in performing single command and dual command cycles each hour:

Analysis of Storage System8

$$R_{cs} T_{cs} + R_{cd} T_{cd} = 60\ U \tag{11.4}$$

U = system utilization during the hour. Then the total hourly cycle rate is given by,

$$R_c = R_{cs} + R_{cd}$$

Where R_c = total S/R cycle rate (cycles/hr). Note that the total number of storage and retrieval transactions per hour will be greater than this value unless R_{cd} = 0, since there are two transactions accomplished in each dual command. Let R_t = the total number of transactions performed per hour, then

$$R_t = R_{cs} + 2R_{cd} \tag{11.6}$$

Example$_2$

Consider the AS/RS from previous example , in which an S/R machine is used for each aisle. The length of the storage aisle = 280 ft and its height = 46 ft. Suppose horizontal and vertical speeds of the S/R machine are 200 ft/min and 75 ft/min, respectively. The S/R machine requires 20 sec to accomplish a P&D operation. Find: (a) the single command and dual command cycle times per aisle, and (b) throughput per aisle under the assumptions that storage system utilization = 90% and the number of single command and dual command cycles are equal.

Solution: (a) We first compute the single and dual command cycle times by Eqs. (11.3):

$$T_{cs} = \text{Max}\{280/200, 46/75\} + 2(20/60) = 2.066 \text{ min/cycle}$$

$$T_{cd} = \text{Max}\{1.5 \times 280/200, 1.5 \times 46/75\} + 4(20/60) = 3.432 \text{ min/cycle}$$

(b) From Eq. (11.4), we can establish the single command and dual command activity levels each hour as follows:

$$2.066\ R_{cs} + 3.432\ R_{cd} = 60(0.90) = 54.0 \text{ min}$$

According to the problem statement, the number of single command cycles is equal to the number of dual command cycles. Thus, $R_{cs} = R_{cd}$.

Substituting this relation into the above equation, we have

$$2.066\ R_{cs} + 3.432\ R_{cs} = 54$$

$$5.498\ R_{cs} = 54$$

$$R_{cs} = 9.822 \text{ single command cycles/hr}$$

$$R_{cd} = R_{cs} = 9.822 \text{ dual command cycles/hr}$$

System throughput = the total number of S/R transactions per hour from Eq. (11.6):

$$R_t = R_{cs} + 2R_{cd} = 29.46 \text{ transactions/hr}$$

With four aisle, R_t for the AS/RS = 117.84 transactions/hr

Example 2

An automated storage/retrieval system for work-in-process has five aisles. The storage racks in each aisle are 10 m high and 50 m long. The S/R machine for each aisle travels at a horizontal speed of 2.0 m/s and a vertical speed of 0.4 m/s. Pick and deposit time = 15 s. Assume that the number of single command cycles per hour is equal to three times the number of dual command cycles per hour and that the system operates at 90% utilization. Determine the throughput rate (loads moved/hour) of the AS/RS.

Example 3

The length of one aisle in an AS/RS is 100 m and its height is 20 m. Horizontal travel speed is 4.0 m/s. The vertical speed is specified so that the storage system is "square in time," which means that $L/v_y = H/v_z$. The pick-and-deposit time is 12 s. Determine the expected throughput rate (transactions per hour) for the aisle if the expected ratio of the number of transactions performed under single-command cycles to the number of transactions performed under dual-command cycles is 2:1. The system operates continuously during the hour.

Automatic Data Capture

- A technology that provide direct entry of data into computer system for identifying product without using a keyboard.
- An alternative of manual data collection and entry due to errors, time factor and labor cost.
- There three main components: encoded data, machine reader or scanner and decoder.
- Category of bar codes are the leading ADC technologies but more than 250 different bar code schemes have been devised.

Six Categories of ADC Technologies

- Optical – a high-contrast symbols that can be interpreted by an optical scanner.
- Magnetic – encode data magnetically.
- Electromagnetic – operating in radio frequency identification (RFID).
- Smart card – chip card and integrated circuit card.
- Touch technique – touch screens.
- Biometric – are utilized to identify humans.

Bar Code

- Two basic types: (1) one-dimensional and (2)two-dimensional. The way how the reader machine read the code. The reader consists of the scanner and decoder.

(a) (b)

Figure 12.1 Two forms of linear bar codes: (a) width-modulated, exemplified here by the Universal Product Code; and (b) height-modulated, exemplified here by Postnet, used by the U.S. Postal Service.

Figure 12.2 The SOS distress signal in "Morse" bar codes.

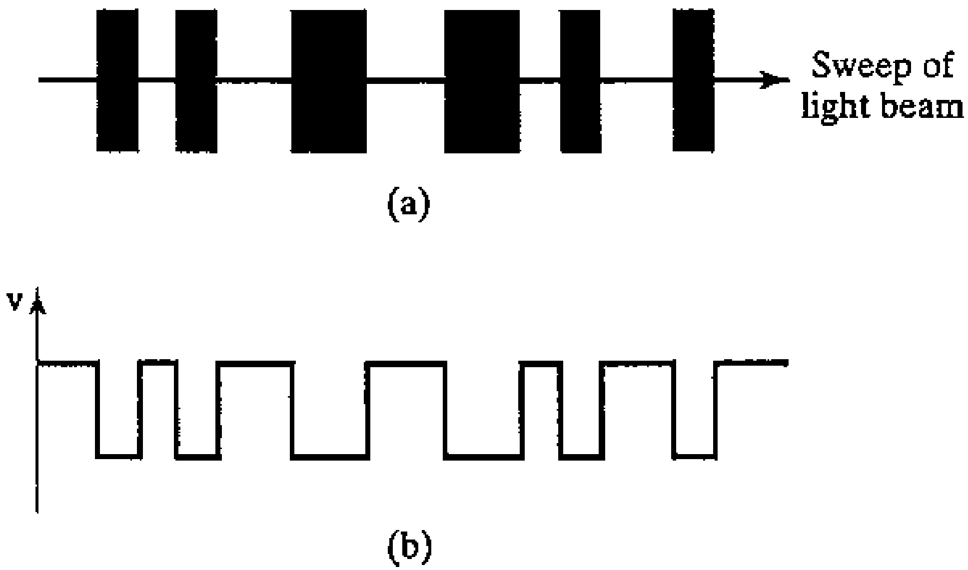


Figure 12.3 Conversion of bar code into a pulse train of electrical signals: (a) bar code and (b) corresponding electrical signal.

Light reflection are detected by a photodetector to convert the spaces and the bars to presence and absence of an electrical signal. The width of them are indicated the duration of the signal.

TABLE 12.2 Some Widely Used Linear Bar Codes

Bar Code	*Date*	*Description*	*Applications*
UPC*	1973	Numeric only, length = 12 digits	Widely used in U.S. and Canada grocery and other retail stores
Codabar	1972	Only 16 characters: 0–9, $, :, /, ., +, −	Used in libraries, blood banks, and some parcel freight applications
Code 39	1974	Alphanumeric. See text for description	Adopted by Dept. of Defense, automotive, and other manufacturing industries
Code 93	1982	Similar to Code 39 but higher density	Same applications as Code 39
Code 128	1981	Alphanumeric, but higher density	Substitutes in some Code 39 applications
Postnet	1980	Numeric only**	U.S. Postal Service code for ZIP code numbers

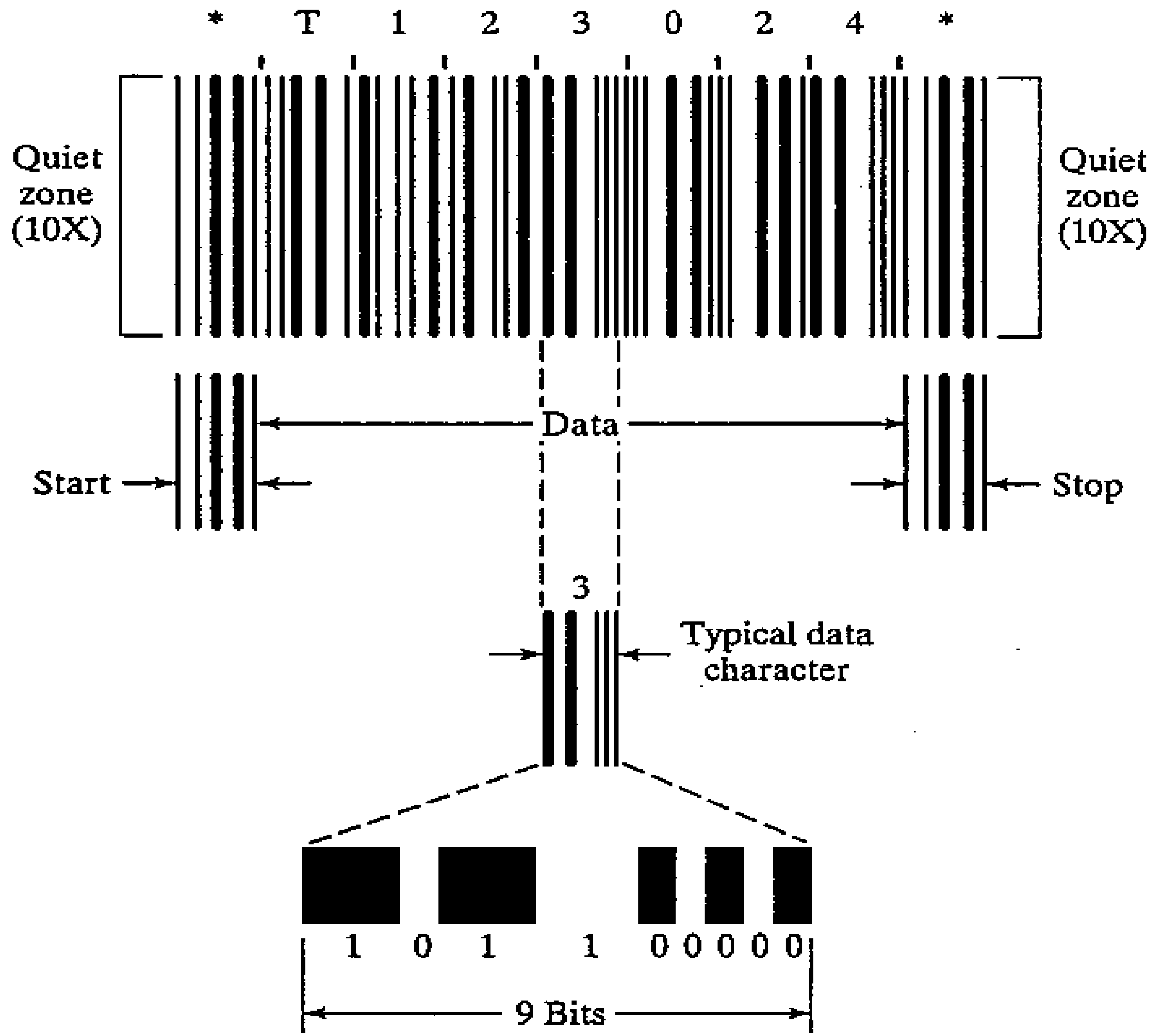


Figure 12.5 A typical grouping of characters to form a bar code in Code 39. (Reprinted from [4] by permission of Automatic Identification Manufacturers, Inc.)

2-D Bar Codes

Symbology	*Type*	*Date (Company or Inventor)*	*Relative Data Density**
Code 49	Stacked	1987 (Intermec)	5.8
Code 16K	Stacked	1988 (T. Williams)	5.8
PDF417	Stacked	1990 (Symbol Technology)	7.2
Code One	Matrix	1992 (T. Williams)	30
DataMatrix	Matrix	1989 (Priddy & Cymbalski)	21
MaxiCode	Matrix	1992 (UPS)	1.5

A 2-D stacked bar code. Shown is an example of a PDF417 symbol

A 2-D matrix bar code. Shown is an example the Data Matrix symbol

Next Assignment: Barcode reader using Your Mobile Phone

ML Kit   Guides   Reference   Samples   Case studies   Community   Search   English

Machine learning for mobile developers

ML Kit brings Google's machine learning expertise to mobile developers in a powerful and easy-to-use package. Make your iOS and Android apps more engaging, personalized, and helpful with solutions that are optimized to run on device.

Get started

Optimized for mobile

ML Kit's processing happens on-device. This makes it fast and unlocks real-time use cases like processing of camera input. It also works while offline and can be used for processing images and text that need to remain on the device.

Built with Google expertise

Take advantage of the machine learning technologies that power Google's own experiences on mobile.

Easy to use

We combine best-in-class machine learning models with advanced processing pipelines and offer these through easy-to-use APIs to enable powerful use cases in your apps.

Radio Frequency Identification (RFID)

- The concept is like bar code but with providing the communication link between remote bar code readers and some central terminal.
- An “identification tag” containing electronically coded data is attached to the subject item and communicates these data by RF to a reader as the item passes.

Magnetic Strips

- MS is a thin plastic film containing small magnetic particles to encode bits of data into the film. This strip is attached to the product or container. (bank access cards)
- It has large data storage capacity and the ability to alter the data contained.

Optical Character Recognition

- OCR is a 2-D symbology and scanning involves interpretation of both the vertical and horizontal features of each character during decoding.

Machine Vision

- Will be discussed detail in Chapter of Inspection Technology.
- The recognition task is accomplished without requiring a special identification code.
- The recognition by the machine is based on the inherent geometric features of the object.