DIGITAL SCANNER

CS/ECE/EEE/INSTR F241
Microprocessor Programming and Interfacing
Design Assignment

Submitted to Prof. K. R. Anupama
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Submitted by: Group 33

Group Members:
Vardaan Kakar (2020A7PS0969G)
Ananya Gupta (2020A7PS1693G)
Rajimwale Janhvi Manoj (2020A8PS1478G)
Harsure Khushi Nagendra (2020A7PS1271G)
Tanna Manav Riddhish (2020A7PS1689G)
Gurbaaz Singh Gill (2020A7PS1228G)

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PROBLEM STATEMENT

Design a microprocessor-based scanner that will scan a black and white image and store it as binary data.
The scanner has two stepper motors for motion along with two orthogonal coordinates. The rotational motion is converted into translational motion through a lead-screw mechanism.
Five paired LED photodiodes intended for B&W image scanning are placed 0.1 centimeters apart. The maximum size scannable is 10 cm X 10 cm.
The photodiode output is an analog signal (between 0 to 5 Volts) that is to be digitised.
Image information is stored sequentially in the RAM.
The user presses a switch labelled **Start Scan** when he wants the scanning process completed.
Once the scanning is completed, an LED labelled **Scan Complete** will glow.

USER REQUIREMENTS AND TECHNICAL SPECIFICATIONS

1. Our image scanner system's central processing unit is an Intel 8086 processor. Two Intel 8255 Programmable Peripheral Interfacing devices are used to connect two stepper motors to an ADC0808. ULC2803A connects each of the stepper motors to the 8255. The ADC0808 is used to connect the five paired photodiodes to the system.
2. Two 2716 ROM chips are used, an even bank and an odd bank. Two 6116 RAM chips, each with a capacity of 2 kilobytes, are utilised to store the image. One RAM chip operates as an even bank, while the other operates as an odd bank.
3. The address lines 00000H through 00FFFH are used to interface the two ROM chips, with a total memory capacity of 4 kilobytes. The RAM chips are addressed from 08000H to 08FFFH. The AD lines from the processor are demultiplexed using three 74LS373 octal latches. The AD lines originating from the processor are also demultiplexed using two 74LS245 bi-directional buffers. The RD', WR', and M/IO' signal lines are generated using OR and NOT gates.
4. The stepper motor has a step angle of 1.8 degrees. The lead-screw mechanism converts the rotational motion of the stepper motors to translational motion with a forward translation of 1mm after every revolution of the motor.
5. The design requires the user to scan a 10cm x 10cm image and store the image information in the RAM. The scanning is done pixel by pixel (1.25mm x 1.25mm). The user begins the scan using a “Start Scan” switch, and the end of the scan is marked by the glowing “Scan Complete” LED.
6. Photodiode-LED pairs are used to detect light in the visible spectrum. The photodiodes (FDS010) used in the design have a packaging diameter of 0.9 cm (standard TO-5 packaging) and an active area of diameter of 1 mm. There is a gap of 0.1cm between two photodiodes. Hence, there is a gap of 1cm (0.9cm + 0.1cm) between the centres of two adjacent photodiodes.

ASSUMPTIONS AND JUSTIFICATIONS

Assumptions:

1. While the system is running, there is no power outage.
2. Each pixel scanned by a photodiode has dimensions of 1.25mm x 1.25mm.
3. The top-left corner of the page is the beginning point. In the scanning process, the photodiodes would move from left to right and from top to bottom of a page.
4. The design always stores data for a 10cm X 10cm image, regardless of the actual size, because the microprocessor has no way of knowing.
5. To avoid interfering with the readings of the nearby photodiode, the LEDs must be surrounded by black cylinders.

Justifications:

1. One centimetre has eight gaps, each measuring 0.125 cm, and the pixels on the paper to be read are 0.125 cm apart. As a result, each row has 81 points to read, and each column has 81 points to move. In addition, the radiation sensitivity area of a photodiode has a diameter of 1mm. Because light will be incident at the active region, this area is sufficient to scan a 1.25mm X 1.25mm pixel.
2. If the image to be scanned is smaller than 10cm x 10cm, the additional region will be saved as white pixels in the RAM.

COMPONENTS USED

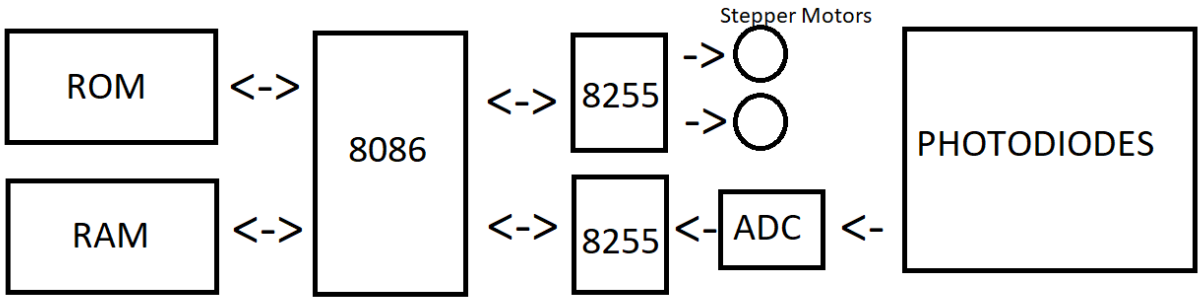
The following components are used in this project. The purpose and quantity of each component are mentioned alongside.

S no	Name of Component	Number of components used	Purpose of the component in the project
1	Intel 8086	1	All the devices are directly or indirectly controlled by the Intel 8086. It is the main processor of the scanner
2	ADC 0808	1	This Analog to Digital Converter is used to convert the analog signal generated from the photo diodes to digital signals. It is required to store the binary

			image in the RAM
3	Intel 8255A	2	The Intel 8255A interfaces the Analog to Digital Converter and stepper motors to the Intel 8086 processor
4	ULN2003A	2	This is a stepper motor driver which amplifies the current from 8255 is in order to drive the motors. There will be two chips; One for driving the horizontal motor and the other for the vertical stepper motor.
5	ROM2716	2	The Assembly Language Program, which is used to run the program is stored in the ROM.
6	RAM2716	2	The binary data of the scanned image is stored in these RAM chips
7	Photo-diodes	5	These paired photo-diodes are intended for black and white image scanning
8	74LS138	1	This decoder is used to interface the ROM and RAM chips
9	74LS245	2	This device provides bidirectional buffer for the data lines
10	74LS373	3	These are the octal latches for the Bus High Enable and the address lines
11	Stepper motors (NEMA 17)	2	The stepper motors are responsible for the movement along the X and Y directions

Besides these devices, simple hardwares like AND, OR and NOT gates are used for a variety of purposes which include the generation of IOR, IOW, MEMR, MEMW signals, to control RAM and ROM through 74LS138 and connecting address lines to the peripheral devices. The image sensor is made up of 5 paired photo-diodes.

BLOCK DIAGRAM



ADDRESS MAP

Memory Map:

Memory	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	Address Lines
ROM1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000H - 007FFH
	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	
ROM2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	00800H - 00FFFH
	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	
RAM1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	08000H - 087FFH
	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	
RAM2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	08800H - 08FFFH
	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	

Address lines A15, A12, A11 are used to decide the memory.

I/O Map:

Address lines A5-A3 are used to decide the peripheral device.

A7	A6	A5	A4		A3	A2	A1	A0	Address	Device
0	0	0	0		0	0	0	0	00H	8255(1)
0	0	0	0		0	1	1	0	06H	
0	0	0	0		1	0	0	0	08H	8255(2)
0	0	0	0		1	1	1	0	0EH	

Ports In 1st 8255A:

Ports in 1st 8255A	Address	Purpose
Port A	00H	Horizontal output port for stepper motors
Port B	02H	Vertical output port for stepper motors
Port C	04H	ADC lines are selected by lower C ports. The upper ports aren't used at all.
Control Register	06H	Initializing 1st 8255A port

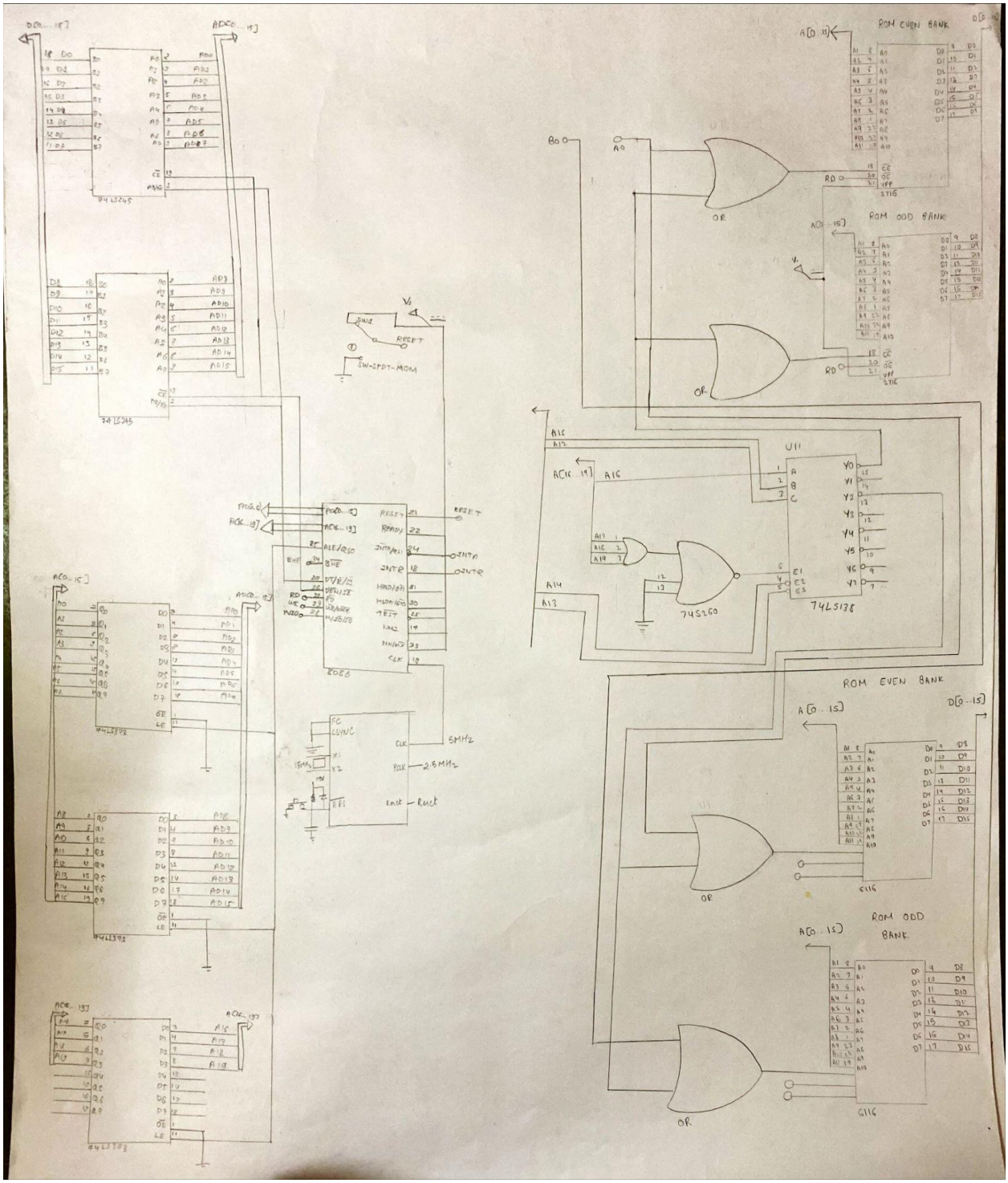
Ports in 2nd 8255A:

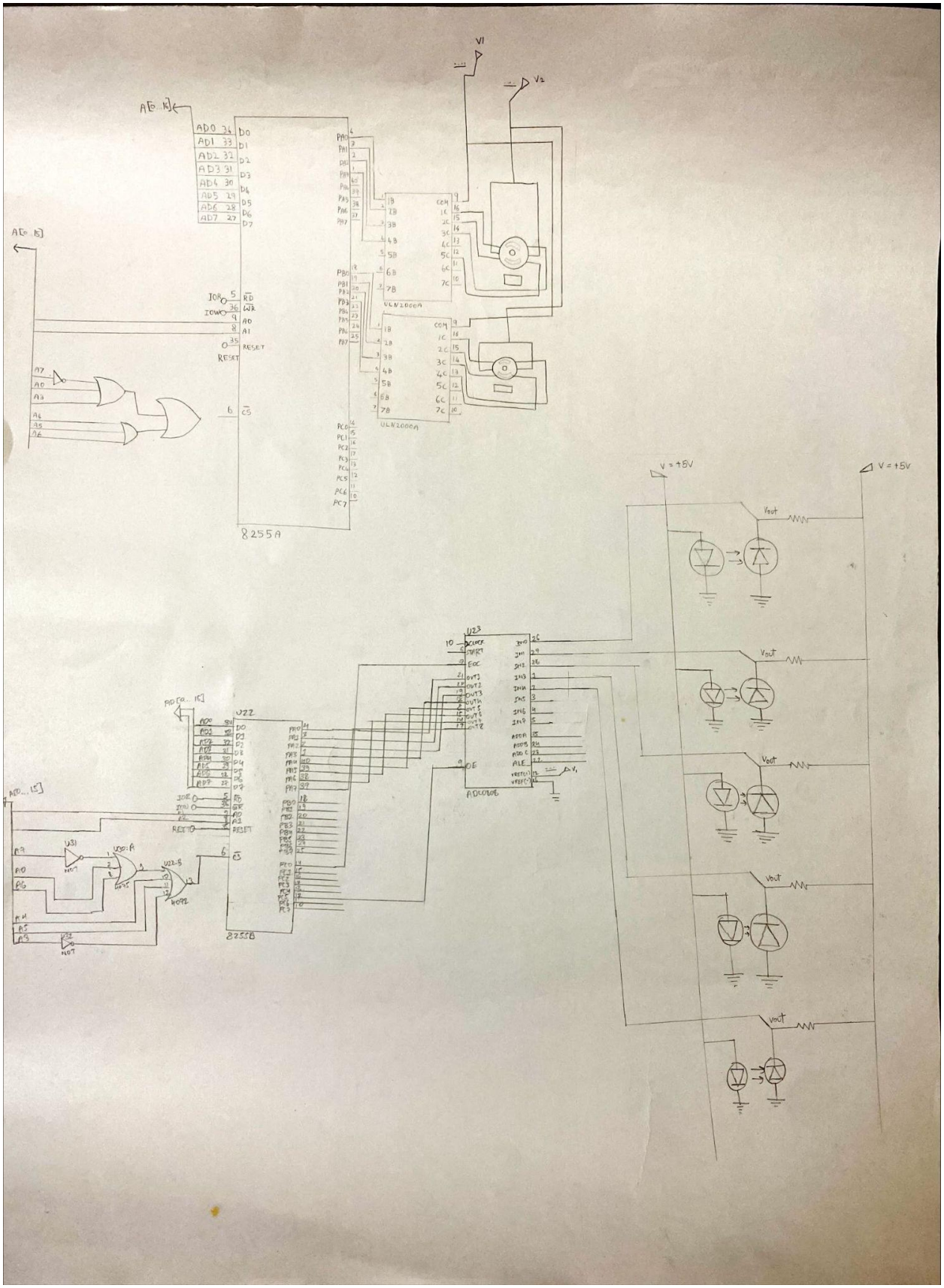
Ports in 2nd 8255A	Address	Purpose
Port A	08H	Connecting ADC input port
Port B	0AH	Initialized as output ports
Port C	0CH	Lower ports are used as input ports while the upper ports are used as output ports
Control Register	0EH	Initializing 2nd 8255A port

DESIGN

The complete process of scanning and storing the image in the RAM chips is described below.

1. The image to be scanned is procured and inserted. The 5 photo-diodes capture the intensity of light passed through the image and generate the corresponding current in analog signals. The light part of the image will generate a high analog signal and the dark part of the image will generate a low analog signal.
2. The paired photo-diodes are moved in the X and Y directions with the help of the NEMA 17 stepper motors to capture the complete image and produce the required analog signals.
3. The signals thus generated are fed into the analog to digital converter (ADC0808) which converts them into digital signals.
4. The digital signals produced are then sent to the Intel 8255.
5. The Intel 8255 feeds these digital signals to the Intel 8086.
6. The 8086 then stores them in the RAM.
7. The 10x10cm image into parts of 0.125 cm each, where each centimetre has 8 divisions, so that each part takes up one bit of a byte, the entire byte itself representing one centimetre. Here, within a centimetre, bit 0 would be the starting position and the 7th bit would be the last position.
8. The memory has already been initialised as all 0's. If a diode is read as 5V, then 1 would be written into the corresponding bit else no operation would be performed as already all bits have been initialized as 0.
9. In a row, the last point is read separately by choosing only the required photo-diode, and this bit is stored separately in the next byte. Therefore, any row would occupy 10+1 bytes.
10. The entire photodiode system is moved back horizontally to the left by 0.125cm and then vertically downwards by 0.125cm, and then the read operation resumes as from step 6.
11. Each row has 81 points to read, and each column has 81 points to move. Each row taking 11 bytes would imply that the entire page would take 11x81 = 891 bytes of memory for storing the image


ROM EVEN BANK
ROM ODD BANK
74LS245
74LS373
74LS138
74LS260
OR
RESET
SW-2PDT-MOM
5MHz
2.5MHz
ROM EVEN BANK
ROM ODD BANK


V1
V2
AD0
AD1
AD2
AD3
AD4
AD5
AD6
AD7
IOR
IOW
RESET
8255A
ULN2000A
ULN2000A
V = +5V
V = +5V
Vout
Vout
Vout
Vout
Vout
U23
ADC0808
U22
8255B
U31
U32-A
U32-B
U32
NOT
NOT
NOR2

FLOWCHART FOR THE MAIN PROGRAM