Batch No. 16

Batch Weighing Machine

Prepared in partial fulfilment of the requirements for the course - **Microprocessors and Interfacing (EEE F241)**

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Report

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Contents

1 Problem Statement

A microprocessor system is to be designed as a batch weighing machine. The system is interfaced to three load cells by means of an 8 bit A/D converter. The conditioned output of the load cells is given by the equation: Vout = 0.025 x weight (Kgs.) The system monitors the output of the load cells and finds out the total weight by taking the average of the three values that are sensed by each load cell. This value is displayed on a seven-segment display. When this value exceeds 99 kgs, an output port, which is connected to a relay, is switched on to sound an alarm. Design the necessary hardware and software for implementing the above-mentioned task. Once the objects are placed on the load cell user presses a switch labelled ***weigh***.

2 Design Specifications

The weight is sensed by the three load cells. The analog voltage output of the load cells are in the range of mili volts which is scaled to Volts range using an operational amplifier and then fed to an Analog to Digital Converter (ADC 0808). The ADC is connected with a Programmable Peripheral Interface (8255) and interfaced with the microprocessor (8086). A push button ***weigh*** switch is used to start the weighing process. When the ***weigh*** switch is pressed, the analog voltage value is converted to its 8 bit binary equivalent and stored in memory. This process is sequentially followed for each load cell. Once the three voltage values are obtained, they are converted into the corresponding weight using the ALP. The calculated weight is then averaged and compared with the limiting value of 99 Kg. If the weight is below this limiting value, it is displayed in the seven segment display which is interfaced to the 8255 using IC 7447. If the weight is more than 99 Kgs, an alarm is raised via a buzzer connected to a relay.

For the datasheets of all the peripherals please refer to Appendix A.

3 Assumptions

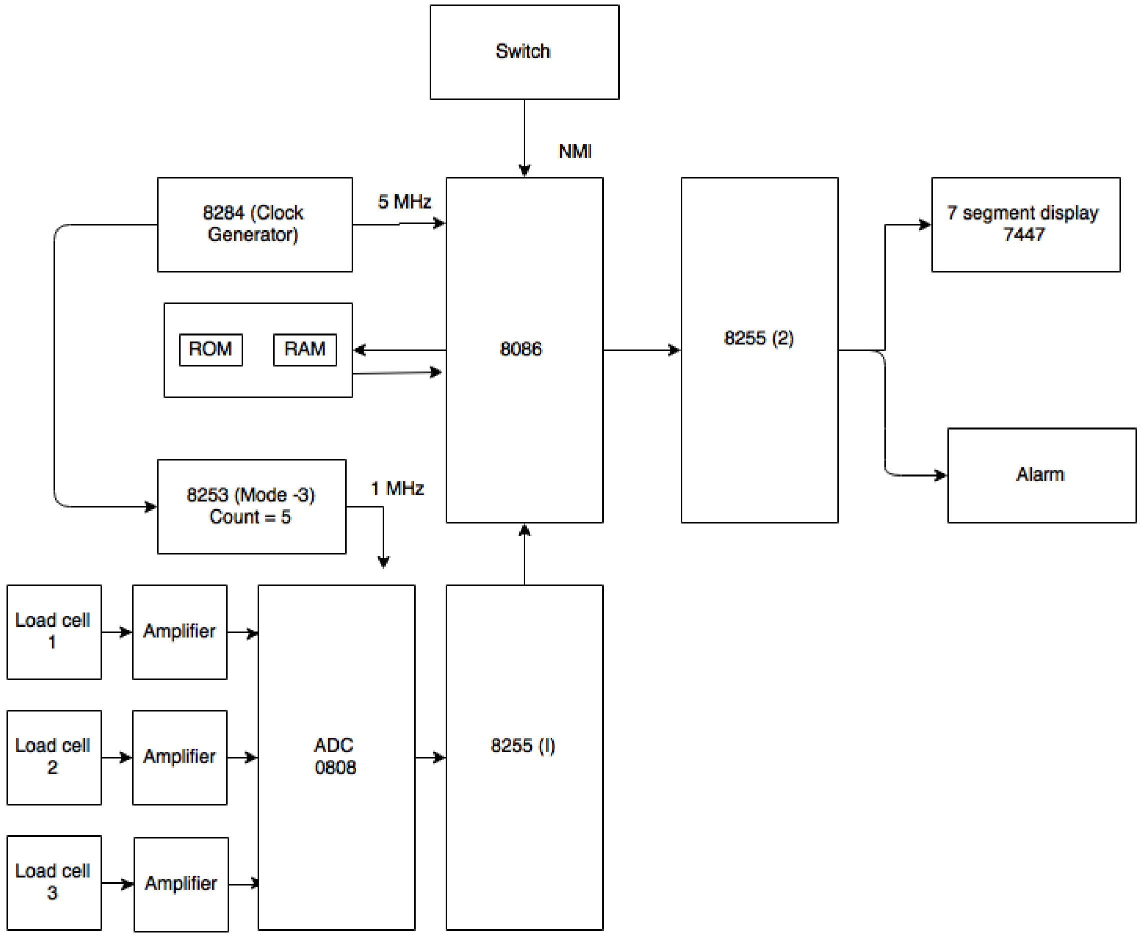
- Each load cell gives a voltage output in the range 0 - 1.8 mV which has to be amplified since the 0808 ADC works in the range of Volts.
- An operational amplifier amplifies the output voltage to get it in the range 0 - 7.5 Volts.
- The maximum capacity of weight that can be measured by each load cell is 300 Kgs. But the ADC can only measure upto 256 Kgs since we are using an 8 bit ADC.
- Once the user reloads the weights, he has to toggle the switch again to start measurement of the new weights.

4 Components used

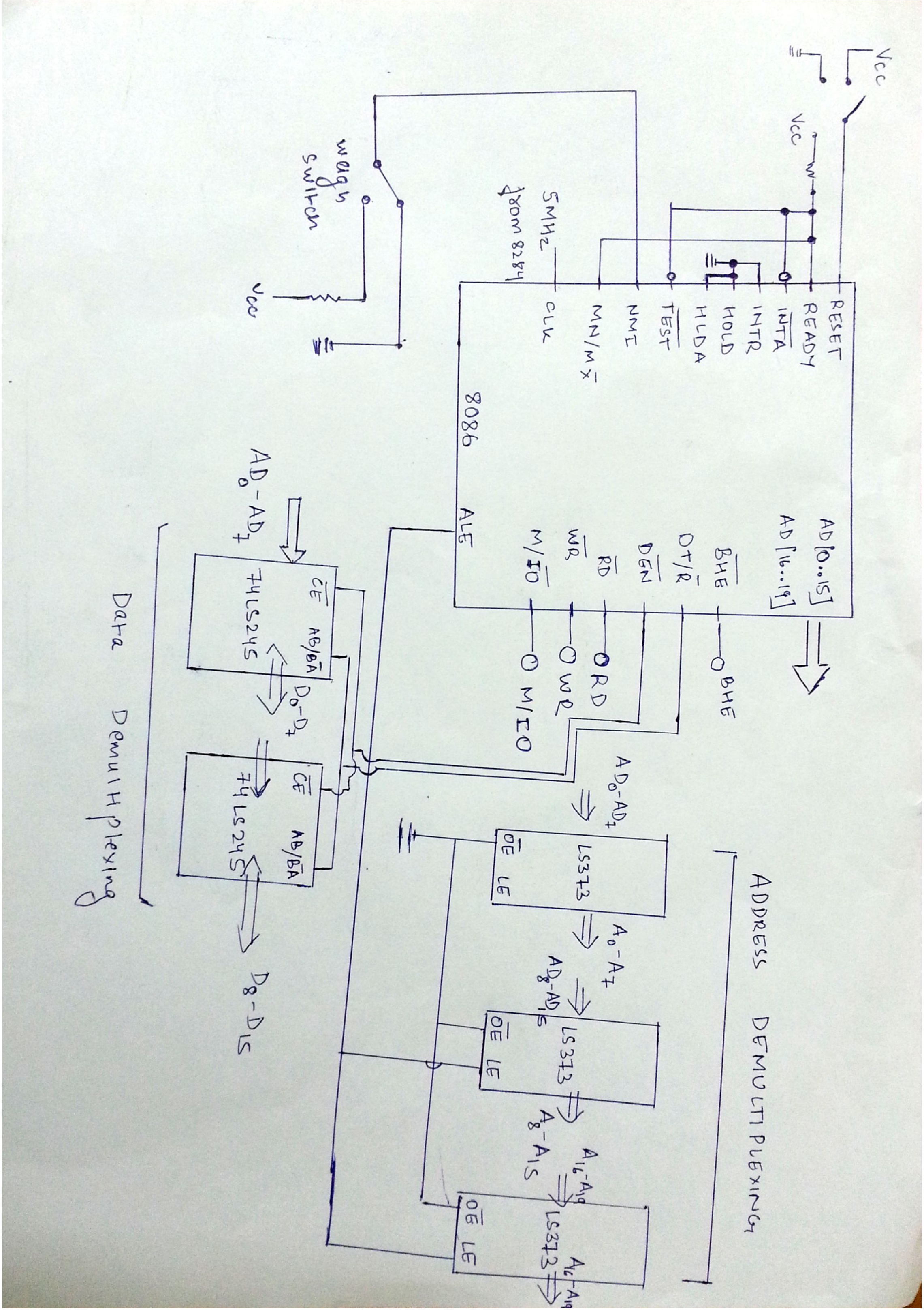
Description	Name	Quantity
Microprocessor	8086	1
Programmable Peripheral Interface	8255	2
Analog to Digital Converter	0808	1
Load Cell	Forsentek FC20	3
Relay	TE - RT1	1
Buzzer	Microbuzzer	1
Seven Segment Display	Common Cathode	5
BCD to 7 Segment convertor	7447	1
RAM	6116 (2K)	2
ROM	2732 (4K)	2
3 to 8 Line Decoder	74LS138	3
Clock Generator	8284	1
Timer	8253	1
Switch	Push button	2
Op-Amp	LM741	3

5 Hardware circuit diagram

5.1 Block diagram



5.2 Demultiplexing data lines in 8086



5.3 Memory interfacing

Two ROMs are used each of 8Kb memory. Each 8Kb ROM is divided into two banks (odd and even) of 4Kb each. One 4Kb RAM is also used which is divided into two 2K RAM banks(Odd and even). Thus in total we have 16Kb of ROM and 4Kb of RAM.

5.3.1 Memory organization

ROM1 (8k) is divided into ROM1 even (4k) and ROM2 odd (4k). ROM2 (8k) is divided into ROM2 even (4k) and ROM2 odd (4k). RAM1 (4k) is divided into RAM1 even (2k) and RAM1 odd (2k). So a total of four 2732 (4k ROM chips) and two 6116 (2k RAM chips) are required. The ROM2 is used because when the microprocessor starts, it starts from the address FFFF0H . Even and odd banks are distinguished using a decoding logic using a 3:8 decoder. Incremental addressing is used for sending chip select signals to the chips used.

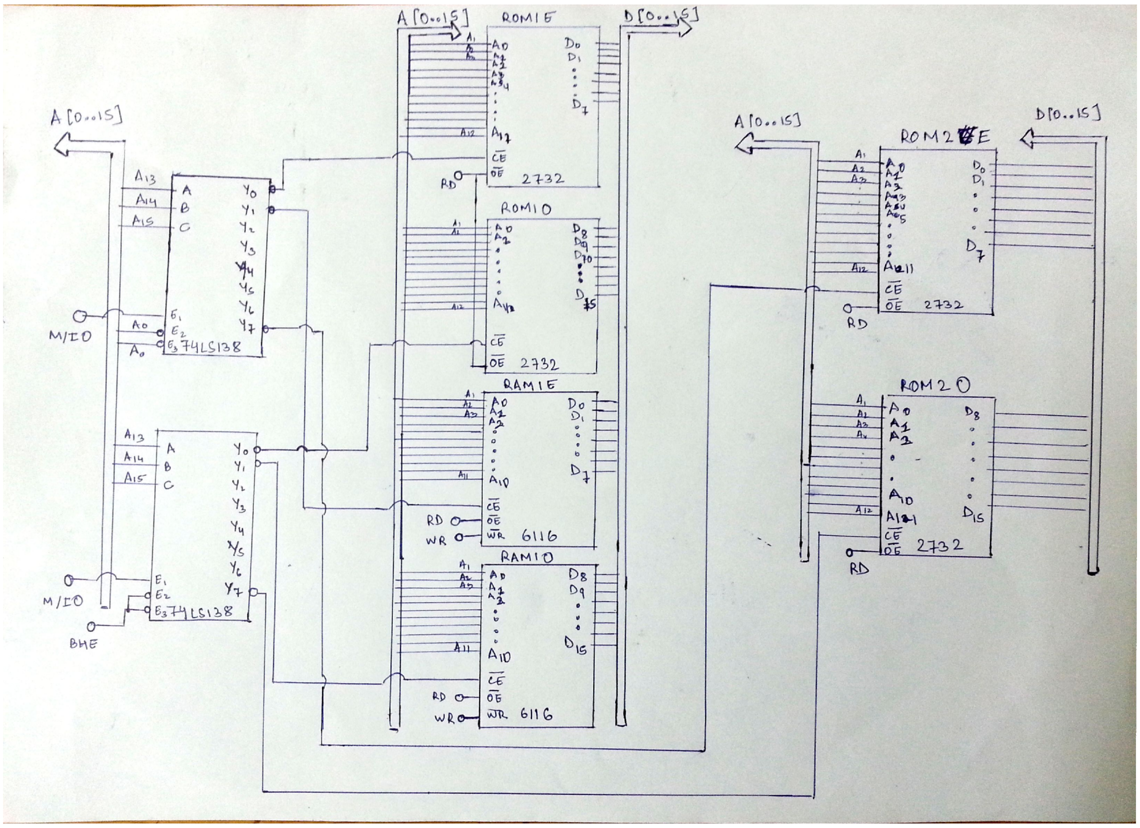
Memory	Size	Starting address	Ending address
ROM1	8K	00000H	01FFFH
RAM1	4K	02000 H	02FFFH
ROM2	8K	FE000H	FFFFFH

5.3.2 Memory decoding logic

		A19	A18	A17	A16	A15	A14	A13	A12
ROM1	Start	0	0	0	0	0	0	0	0
	End	0	0	0	0	0	0	0	1
RAM1	Start	0	0	0	0	0	0	1	0
	End	0	0	0	0	0	0	1	0
ROM2	Start	1	1	1	1	1	1	1	0
	End	1	1	1	1	1	1	1	1

The address lines A13, A14 and A15 can be used for the decoding logic to select between ROMs and RAM through a 3:8 decoder.

5.3.3 Memory decoding circuit



5.4 Sensor and ADC Interfacing

We are using three load cells for getting analog values of voltage which will be interfaced with a 0808 Analog to digital convertor. The voltage varies according to the weights and we will scale the values to match the resolution of the ADC using an operational amplifier. The load sensors used are Forsentek FC20 which give an output in the range 0 - 1.8 mV. In order to use the ADC we amplify this using an operational amplifier (LM741) such that the voltage gets amplified to the range 0 - 7.5 Volts.

5.4.1 Op-Amp gain calculation

We used a LM741 Operational amplifier to get a conversion factor of 0.025 as per the problem statement. The FC20 load sensor's output voltage range is 0 - 1.8 mV. We define a linear relationship between output voltage and weight as :

$$\frac{y}{w} = \frac{1.8*10^{-3}}{300}$$

According to the question the required relation is y = 0.025 x w . Hence, the value of required gain is $\frac{0.025}{\frac{1.8*10^{-3}}{300}} = 4166$. The formula for gain of Op-Amp is given by

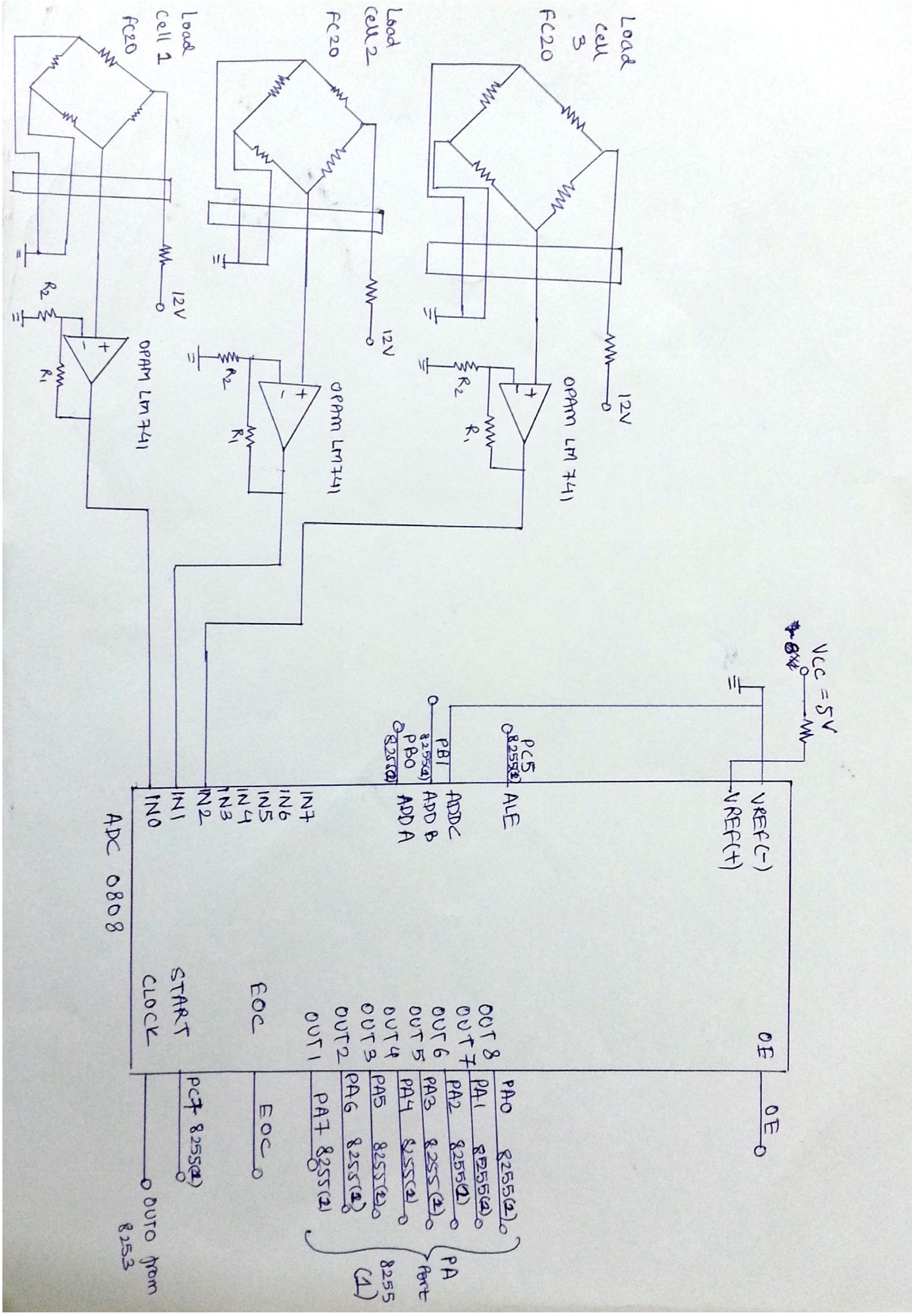
$$A_{\nu} = 1 + \frac{R_1}{R_2}$$

Using this relation we get the resistance ratio as $\frac{R_1}{R_2}$ as $\frac{24994}{6}$. Using the adjustment knob of Op-Amp we can set this resistance ratio to get the necessary gain.

5.4.2 Sensor Resolution vs ADC Resolution

We use a V_{ref} of 5 Volts which gives the resolution of our ADC (0808) as 0.0195 V calculated by taking a 8 volt reference and 8 address lines ($8V/2^8$). ADC resolution is 0.0195 V which is less than load cell resolution (0.025 V after amplification) hence the ADC will be able to sense the change.

5.4.3 ADC (0808) interfacing



5.5 Programmable Peripheral Interface (8255)

8255 (1)

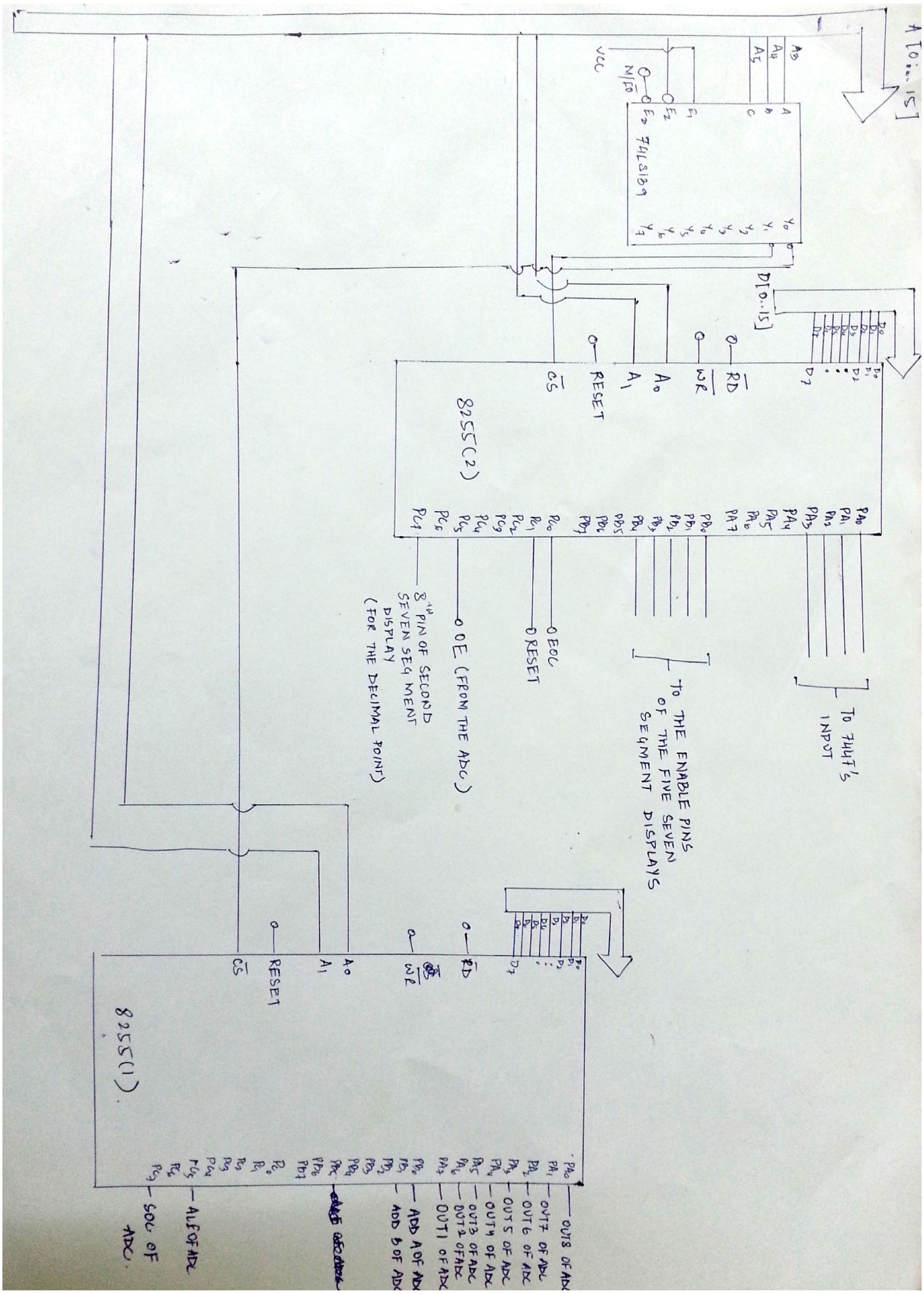
Port	**Address**	**Description**
Porta1	00H	Input from ADC (Out1 - Out8)
Portb1	02H	Output to ADC (ADD A - C)
Portc1(upper)	04H	Output to ADC (SOC, ALE)
Portc1(lower)	04H	Input (not used)
creg	06H	Control register

8255 (2)

Port	**Address**	**Description**
Porta2	08H	Output to 7447
Portb2	0AH	Output to 7 - segment
Portc2(upper)	0CH	Output to OE of ADC
Portc2(lower)	0CH	Input (EOC of ADC, Reset)
creg	0EH	Control register

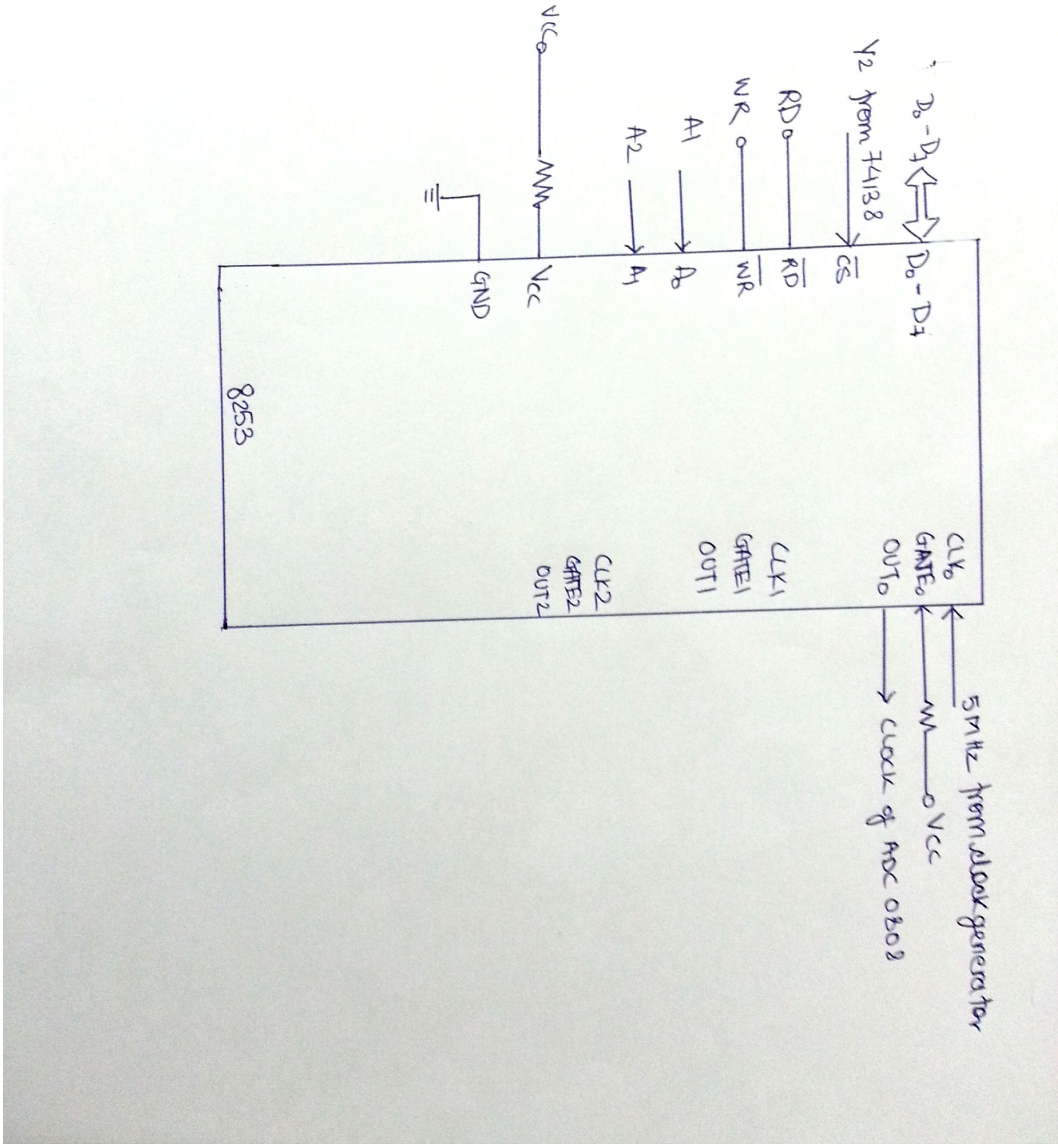
A7	A6	A5	A4	A3	A2	A1	A0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0
0	0	0	0	0	1	0	0
0	0	0	0	0	1	1	0
0	0	0	0	1	0	0	0
0	0	0	0	1	0	1	0
0	0	0	0	1	1	0	0
0	0	0	0	1	1	1	0

The address lines A3, A4 and A5 are used in decoding logic for the 8255's through a 3:8 decoder.

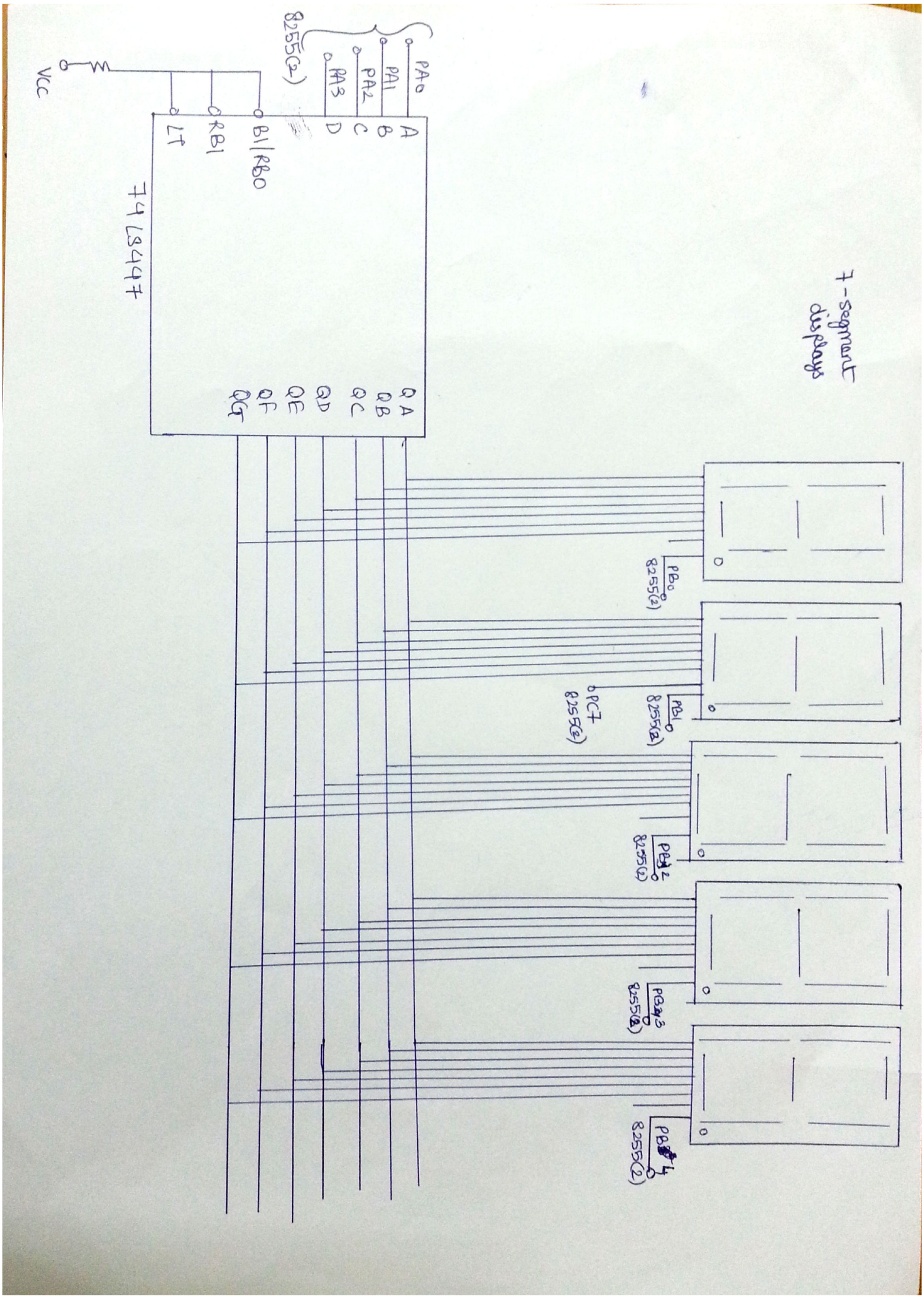

A [0... 15]
VCC
D[0..15]
8255(2)
RESET
EOC
OE (FROM THE ADC)
TO THE ENABLE PINS OF THE FIVE SEVEN SEGMENT DISPLAYS
8th PIN OF SECOND SEVEN SEGMENT DISPLAY (FOR THE DECIMAL POINT)
8255(1)
SOC OF ADC

5.6 Clock for ADC

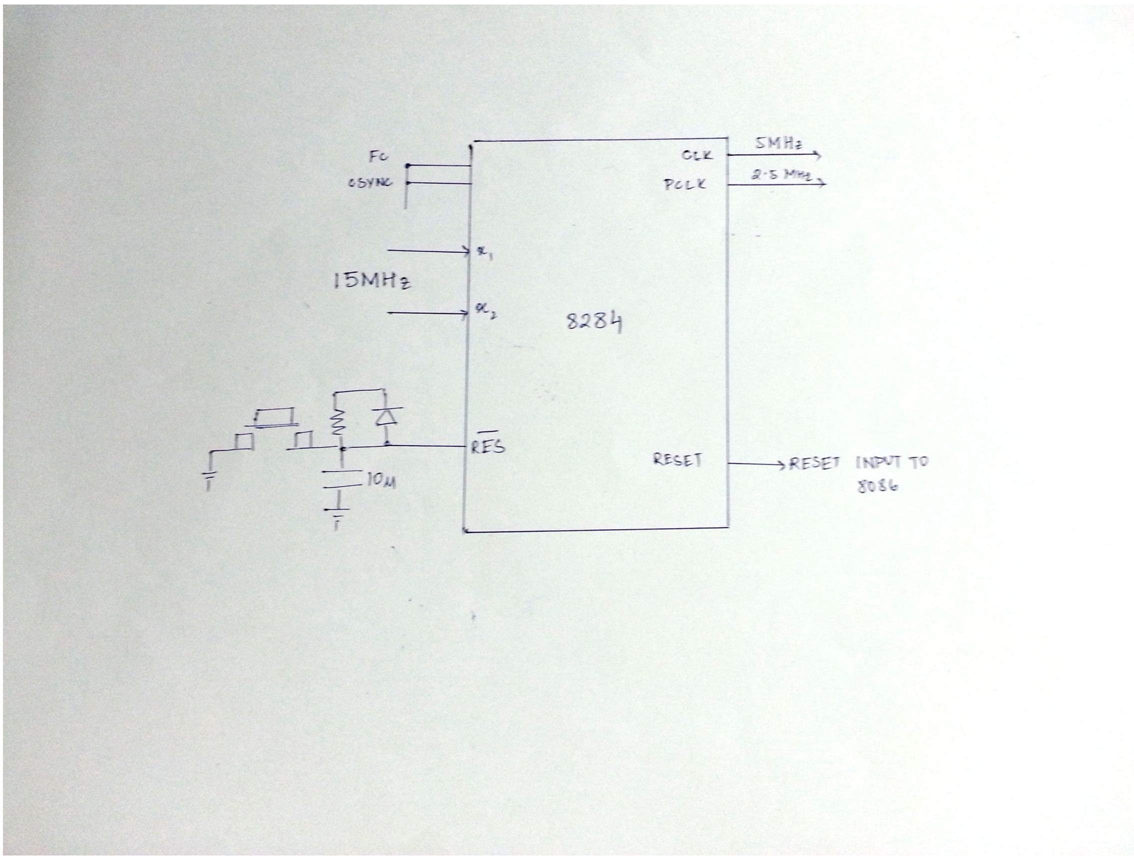
8254 is used as a timer to generate the clock of ADC in order to generate a frequency of 1 MHz. This is accomplished by loading a count of 5 in 8254 in mode 3 and thus diving the clock of 8086 (5 MHz) by 5 to get 1 MHz



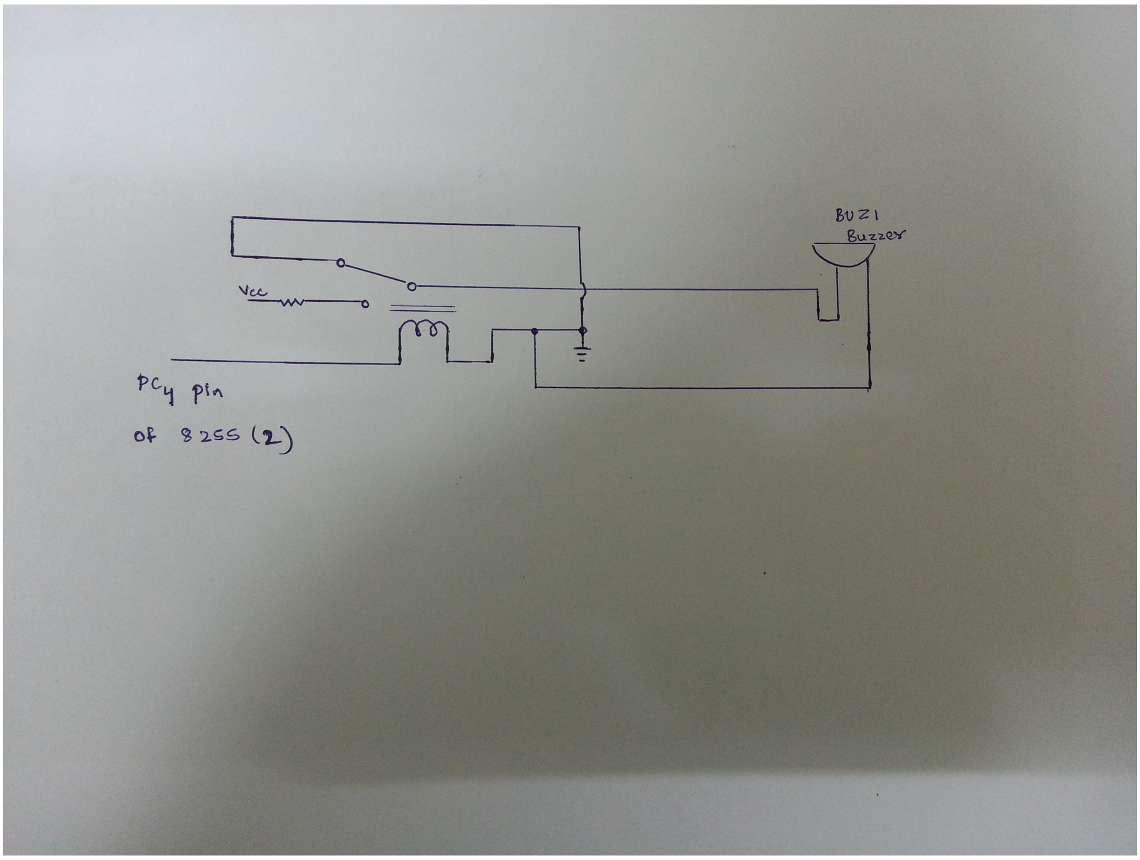
5.7 Interfacing the 7 segment display



5.8 Clock generator

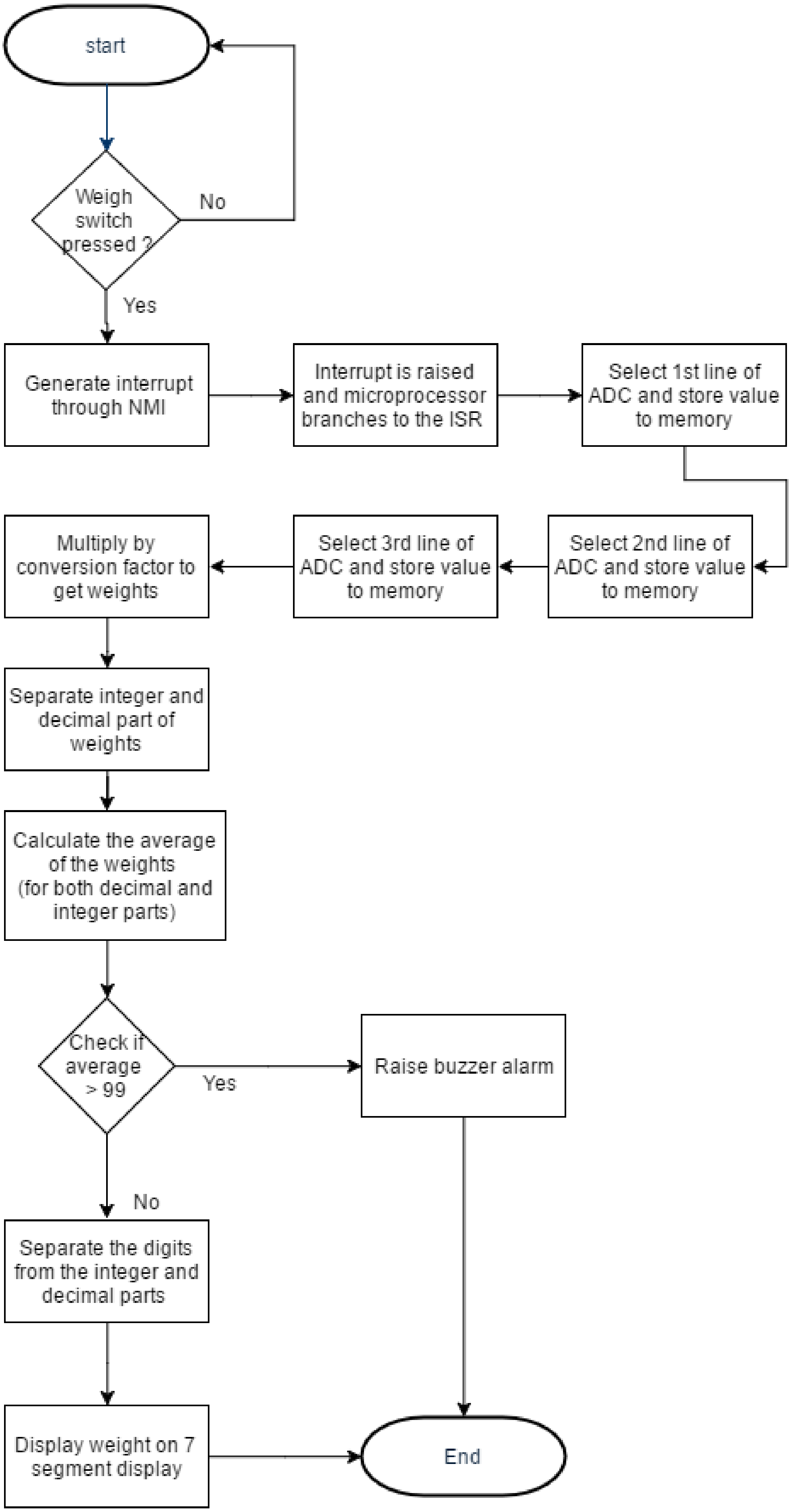


5.9 Interfacing Alarm



The buzzer alarm is connected via a relay device which gets the signal from the PC4 pin of 8255(2). We will be using a buzzer alarm to signal if the average weight is greater than 99 Kgs.

6 Flowchart


start
Weigh switch pressed ?
No
Yes
Generate interrupt through NMI
Interrupt is raised and microprocessor branches to the ISR
Select 1st line of ADC and store value to memory
Select 2nd line of ADC and store value to memory
Select 3rd line of ADC and store value to memory
Multiply by conversion factor to get weights
Separate integer and decimal part of weights
Calculate the average of the weights (for both decimal and integer parts)
Check if average > 99
Yes
Raise buzzer alarm
No
Separate the digits from the integer and decimal parts
Display weight on 7 segment display
End

7 Proteus simulation results

V1	V2	V3	Average weight displayed (Kgs)	Theoretical value (Kgs)	Error (Kgs)
1	1	1	39.831	40	0.42%
1	1.35	2	57.79	58	0.36%
4	5	1	Buzzer	133.33	0.42%
0	3	2	66.38	66.667	0.42%

Thus the error in the system is around 0.4 %.

8 Appendix A

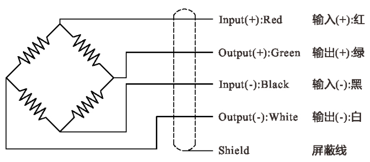
Load sensor

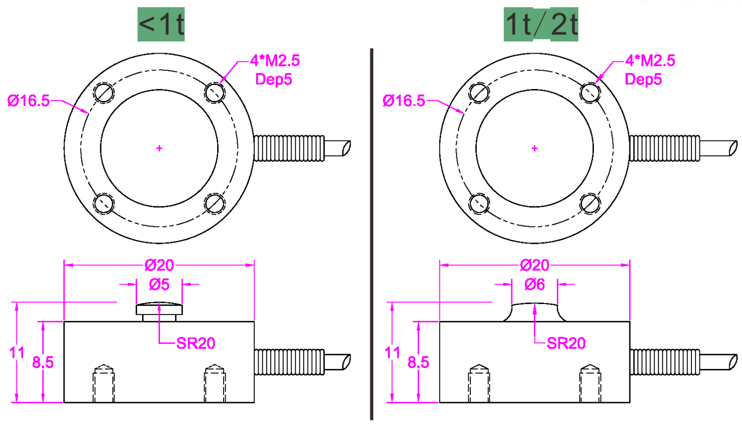
Measure it right
Forsentek

Weighing || Measuring || Controlling

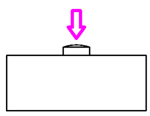
Model:FC20

Wiring Diagram/接线图





Load direction
加载方向



--- Specifications / 规格参数 ---

Capacity/量程	5/10/20/30/50/100/200/300/500/1000/2000kg		
Rated Output 额定输出	1.2~1.8mV/V	Compensated Temp. 温度补偿范围	-10...+40°C
Excitation 激励电压	5~12V	Operating Temp. 工作温度范围	-20...+60°C
Zero Balance 零点输出	±3% of R.O.	Temp. Shift Zero 零点温度漂移	±0.01% of R.O./°C
Nonlinearity 非线性	±0.5% of R.O.	Temp. Shift Span 灵敏度温度漂移	±0.01% of R.O./°C
Hysteresis 滞后	±0.5% of R.O.	Input Resistance 输入阻抗	350±30Ω
Nonrepeatability 非重复性	±0.2% of R.O.	Output Resistance 输出阻抗	350±3Ω
Creep(30min) 蠕变	±0.2% of R.O.	Insulation Resistance 绝缘阻抗	>5000MΩ(50V)
Safe Overload 安全过载	150% of F.S.	Ingress Protection 防护等级	IP65
Ultimate Overload 极限过载	200% of F.S.	Material of Element 弹性体材料	Stainless steel 不锈钢
Cable 导线	Ø3*1000mm 4-core shielded cable Ø3*1000mm 4芯屏蔽线		
R.O.=Rated Output/额定输出 F.S.=Full Scale/满量程			

• Subject to change without notice / 如有更改,不另行通知

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Buzzer

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ROHS Info

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MICRO BUZZER 5V DC / 20mA PCB TYPE - SEALED

Order Code: SV4/5-S

Features

- sealed: yes
- operating power: 3-6V DC / 25mA
- extremely compact, ultrathin construction
- no electrical noise
- low current consumption yet high sound pressure level

Specifications

- tone type: single
- operating voltage: 3-6V DC
- rated voltage: 5V DC
- current consumption: 25mA
- osc. frequency: 3.2kHz
- sound level: 87dB
- connector type: pcb
- body color: gray
- weight: 0.056oz

More...

Stock Info

Relay

RELAY PRODUCTS

General Purpose Relays
PCB Relays

SCHRACK

Power PCB Relay RT1 bistable

- 1 pole 16A, 1 form C (CO) or 1 form A (NO) contact
- Polarized bistable version with 1 or 2 coils
- 5kV/10mm coil-contact
- Reinforced insulation

Typical applications
Battery powered equipment or applications with "memory function"

Approvals

VDE Cert. No. 40007571, UL E214025, cCSAus 1142018
Technical data of approved types on request

Contact Data

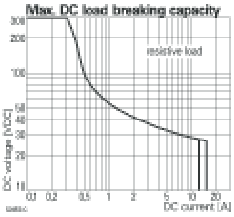
Contact arrangement	1 form C (CO) or 1 form A (NO)
Rated voltage	250VAC
Max. switching voltage	400VAC
Rated current	16A
Limiting continuous current	16A, UL: 20A
Limiting making current, max. 4s, duty factor 10%	30A
Breaking capacity max.	4000VA
Contact material	AgNi 90/10
Frequency of operation, with/without load	360/72000h^{-1}
Operate/Reset time max.	10/10ms
Bounce time max., form A/form B	3/6ms

Contact ratings

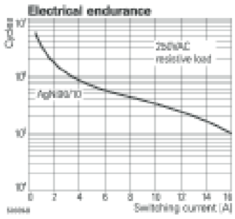
Type	Contact	Load	Cycles
IEC 61810			
RT314	A (NO)	16A, 250VAC resistive, 85°C	$30x10^3$
RT314	C (CO)	16A, 250VAC resistive, 85°C	$10x10^3$
UL 508			
RT314	A/B (NO/NC)	20A, 250VAC, general purpose, 85°C	$6x10^3$
RT334	A (NO)	16A, 250VAC, general purpose, 85°C	$50x10^3$
RT314	A (NO)	1hp, 240VAC, 40°C	$1x10^3$

Mechanical endurance	$>5x10^6$ operations

Max. DC load breaking capacity



Electrical endurance



Coil Data, bistable coils

Coil Data, bistable coils	1 coil	2 coils
Magnetic system	polarized, bistable	
Coil voltage range	3 to 24VDC	
Operative range, IEC 61810	2	
Limiting voltage, % of rated coil voltage	120%	150%
Min./Max. energization duration	30ms/1min at <10% duty factor	
Coil insulation system according UL 1446	class F	

Coil versions, bistable coil

Coil code	Rated voltage VDC	Set voltage VDC	Reset voltage VDC	Coil resistance Ω±10%	Rated coil power mW
bistable 1 coil					
A03	3	2.1	1.7	21	429
A05	5	3.5	2.8	62	403
A06	6	4.2	3.3	90	400
A12	12	8.4	6.6	360	400
A24	24	16.8	13.2	1440	400
bistable 2 coils					
F03	3	2.1	1.7	15	600
F05	5	3.5	2.8	42	595
F06	6	4.2	3.3	55	655
F12	12	8.4	6.6	240	600
F24	24	16.8	13.2	886	650

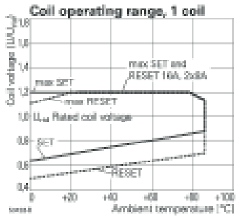
All figures are given for coil without pre-energization, at ambient temperature +23°C.
Other coil voltages on request.

Bistable coils - operation

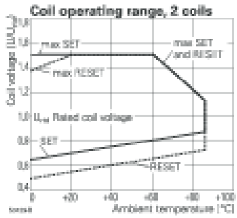
Version	1 coil		2 coils		
Coil terminals	A1	A2	A1	A3	A2
Operate	+	-		+	-
Reset	-	+	-	+	

Contact position not defined at delivery

Coil operating range, 1 coil



Coil operating range, 2 coils



10-2014, Rev. 1014
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Datasheets and product specification according to IEC 61810-1 and to be used only together with the 'Definitions' section.

Datasheets and product data is subject to the terms of the disclaimer and all chapters of the 'Definitions' section, available at http://relays.te.com/definitions

Datasheets, product data, 'Definitions' section, application notes and all specifications are subject to change.

Op-Amp

Product Folder | Sample & Buy | Technical Documents | Tools & Software | Support & Community

TEXAS INSTRUMENTS
LM741
SNOSC25D – MAY 1998 – REVISED OCTOBER 2015

LM741 Operational Amplifier

1 Features

- Overload Protection on the Input and Output
- No Latch-Up When the Common-Mode Range is Exceeded

2 Applications

- Comparators
- Multivibrators
- DC Amplifiers
- Summing Amplifiers
- Integrator or Differentiators
- Active Filters

3 Description

The LM741 series are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common-mode range is exceeded, as well as freedom from oscillations.

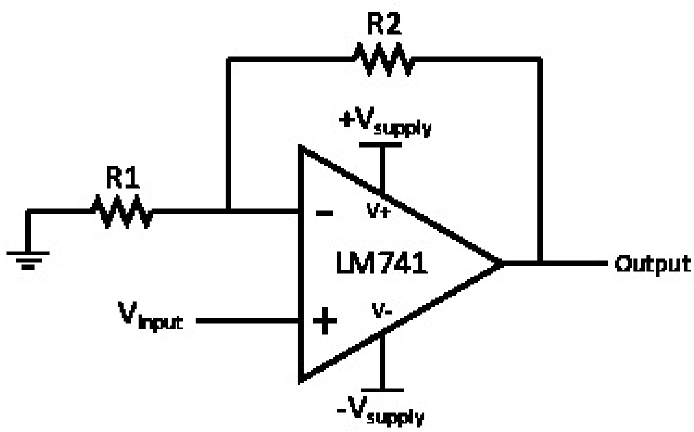
The LM741C is identical to the LM741 and LM741A except that the LM741C has their performance ensured over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM741	TO-99 (8)	9.08 mm × 9.08 mm
	CDIP (8)	10.16 mm × 6.502 mm
	PDIP (8)	9.81 mm × 6.35 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical Application



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