BATCH WEIGHING MACHINE

GROUP NO. 5

QUESTION NO. 14

Prepared in partial fulfilment of

Microprocessors and Interfacing

CS/ECE/EEE/INSTR F241

Under the guidance of

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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: V_{out} = 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 buzzer, 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.

DESIGN SPECIFICATION

The weight is sensed by three load cells, which gives output in the form of analog voltage signals in millivolts (mV). These signals are amplified with the help of an operational amplifier (op-Amp) which converts the signals to the required voltages, which are then fed on to the 0808 Analog-to-Digital Controller (ADC). This ADC is connected to a Programmable Peripheral Interface (8255) and is interfaced with the microprocessor (8086). We use the ***weigh*** switch to start the weighing process. When this switch is closed, an interrupt is raised by the microprocessor, and branches out to the Interrupt Service Routine (ISR) (using 8259 Priority Resolver) where the process of weighing happens. The three weights are recorded and stored in memory, followed by taking their average. This average is converted using a conversion factor which converts the voltage signal into weight to be displayed. This value is shown up to 2 decimal places. This weight is displayed on 4 7-segment displays using a 7447 IC. In case the weight value detected was more than 99 kg, then an Interrupt is triggered which sets the Buzzer on. We use a ***switch*** to stop the buzzer.

The clock is generated using a 8284 clock generator, for generating a clock of 5 MHz for the 8086 microprocessor and 8254 Programmable Interval Timer, in Mode 3 to generate a 1 MHz square wave clock input for ADC 0808.

Datasheets have been attached in the end.

ASSUMPTIONS

1. The weight result is displayed up to 2 decimal places.
2. Buzzer alarm is set by an interrupt acknowledged by the microprocessor and switched off using a switch when pressed.
3. The load cell we have used can sense a maximum of 200 kg load. Our design will raise an interrupt when the load crosses 99 kg and buzzer will be set.
4. When one load cell is activated, all the weight is sensed by this load cell, and the other load cells are deactivated for the mean time.

COMPONENTS

Sr. No.	Description	Chip	Quantity
1.	Microprocessor	8086	1
2.	Programmable Peripheral Interface	8255	2
3.	Analog-to-Digital Converter	0808	1
4.	Load Cell	Phidgets 3137_0 CZL204E	3
5.	Buzzer	Micro buzzer	1
6.	7-Segment Display	Common Anode	4
7.	BCD to 7-Segment Display	7447	4
8.	RAM chips	6116	2
9.	ROM chips	2716	4
10.	3-to-8 Decoder	74LS138	2
11.	Clock Generator	8284	1
12.	15 MHz Crystal	------	1
13.	Buffers	74LS373	3
		74LS254	2
14.	Op-Amp	LM741	1

MEMORY MAPPING

Sr. No.	Memory Block	Start Address	End Address
1.	ROM1 (2k per chip)	00000_h	$00FFF_h$
2.	RAM1 (2k per chip)	01000_h	$01FFF_h$
3.	ROM2 (2k per chip)	$FF000_h$	$FFFFF_h$

IO MAPPING

Sr. No.	IO Device	Start Address
1.	8259	00_h
2.	8255 (1)	10_h
3.	8255 (2)	20_h
4.	8254	30_h

PROGRAMMABLE PERIPHERAL INTERFACE (8255)

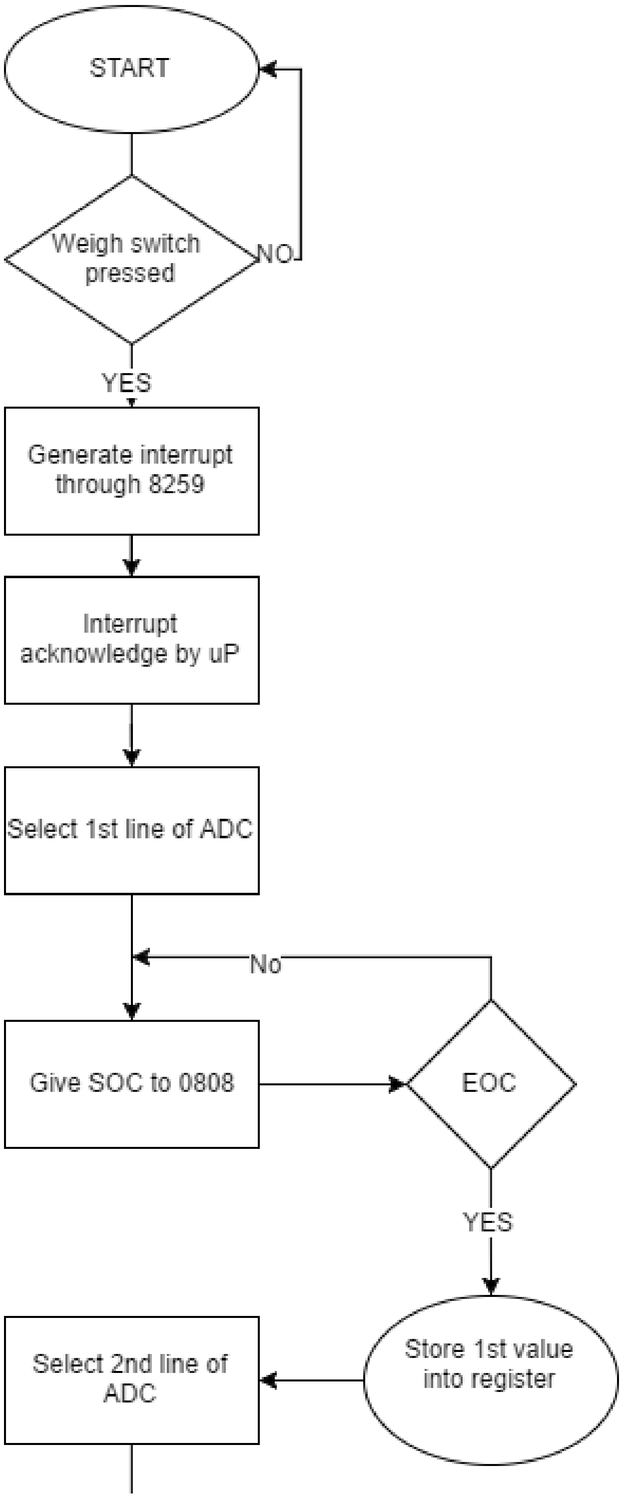
8255 (1)

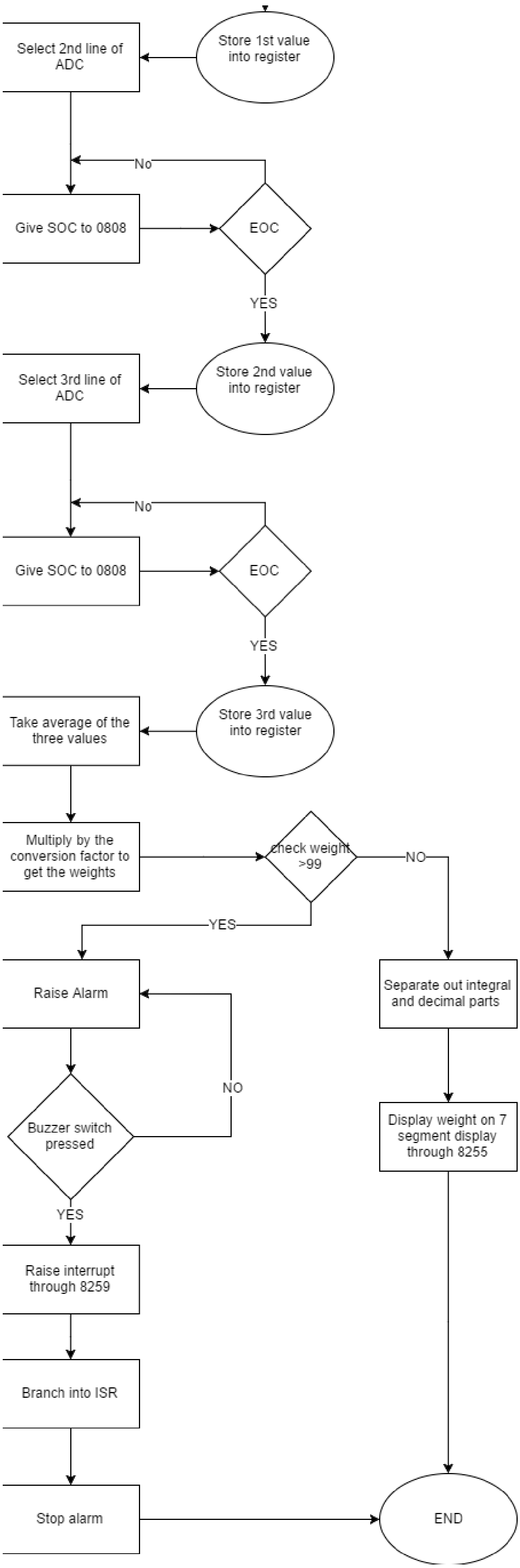
Port	**Address**	**Description**
PORTA1	10_h	Connected to 7447
PORTB1	12_h	Connected to 7447
PORTC1	14_h	Controlling ADC 0808 and Buzzer
CREG1	16_h	Control Register

8255 (2)

Port	**Address**	**Description**
PORTA2	20_h	-------------
PORTB2	22_h	Output from ADC
PORTC2	24_h	EOC from ADC
CREG2	26_h	Control Register

FLOWCHART


START
Weigh switch pressed
NO
YES
Generate interrupt through 8259
Interrupt acknowledge by uP
Select 1st line of ADC
No
Give SOC to 0808
EOC
YES
Store 1st value into register
Select 2nd line of ADC


Store 1st value into register
Select 2nd line of ADC
No
Give SOC to 0808
EOC
YES
Store 2nd value into register
Select 3rd line of ADC
No
Give SOC to 0808
EOC
YES
Store 3rd value into register
Take average of the three values
Multiply by the conversion factor to get the weights
check weight >99
NO
YES
Raise Alarm
NO
Buzzer switch pressed
YES
Raise interrupt through 8259
Branch into ISR
Stop alarm
Separate out integral and decimal parts
Display weight on 7 segment display through 8255
END

REFERENCES

1. Microprocessors and Interfacing, https://edge.edx.org/courses/course-v1:BITSX+CS-ECE-EEE-INSTR-F241+2016_Sem-II/info
2. Buzzer, http://www.electroncomponents.com/Piezo-buzzer-5v-pcb-mount
3. Texas Instruments, LM741 Op-Amp, http://www.ti.com/product/LM741
4. 3137_0 - Button Load Cell (0-200kg) - CZL204E http://www.phidgets.com/products.php?product_id=3137
5. Load Cell Primer, http://www.phidgets.com/docs/Load_Cell_Primer

APPENDIX

CODE

```
#make_bin#

#LOAD_SEGMENT=FFFFh#
#LOAD_OFFSET=0000h#

#CS=0000h#
#IP=0000h#

#DS=0000h#
#ES=0000h#

#SS=0000h#
#SP=FFFEh#

#AX=0000h#
#BX=0000h#
#CX=0000h#
#DX=0000h#
#SI=0000h#
#DI=0000h#
#BP=0000h#


porta1  equ 10h
portb1    equ  12h
portc1    equ  14h
```

```
creg1     equ  16h

porta2    equ  20h
portb2    equ  22h
portc2    equ  24h
creg2equ  26h

icw1 equ  00h
icw2 equ  02h
icw4 equ  02h

ocw1 equ  02h
ocw2 equ  00h

;add your code here

        jmp         st1
        db      5 dup(0)
        dw      nmi  ;interrupt for main switch
        dw      0000h
        db      1012 dup(0)

;main program

        st1:
        cli
        sti
```

```
;intialize ds, es,ss to start of RAM
        mov     ax,02000h

        mov     es,ax
        mov     ss,ax
        mov         sp,05ffh



        mov         ax,00h
        mov         ds,ax

        mov     al,10000000b
        out         creg1,al

        mov         al,10011011b
        out     creg2,al



        ;mov        al,00010011b
        ;out        icw1,al

        ;mov        al,01010000b
        ;out        icw2,al

        ;mov        al,00000011b
        ;out        icw4,al

        ;mov        al,11111100b
```

```
        ;out        ocw1,al


        ;mov        al,01100000b
        ;out        ocw2,al

        ;mov        al,01100001b
        ;out        ocw2,al



      x10:
        jmp x10
nmi:
    ;initializing value 0 in all register
    mov         ax,00h
    mov         bx,00h
    mov         cx,00h



    ;enabling input for first weights
    mov         al,0h
     out         portc1,al

     mov         al,00000001b
     out         portc1,al

     mov         al,00001001b
```

```
 out          portc1,al

 mov          al,00001000b
 out        portc1,al

 mov        al,00000000b
 out        portc1,al

pol_EOC1:
    in           al,portc2
 and        al,00000001b

 jz         pol_EOC1



 ;oe enable
mov         al,00010000b
 out        portc1,al

;taking input from portb2
 in           al,portb2



 ;making ah = 0
 mov          ah,00h
;moving value to register bx
add          bx,ax
```

```
;output enable off
mov         al,00000000b
 out        portc1,al

;enabling input for second weight
mov          al,00000010b
out          portc1,al



mov          al,00000011b
out          portc1,al

mov          al,00001011b
out          portc1,al

mov          al,00001010b
out          portc1,al

mov          al,00000010b
out          portc1,al



pol_EOC2:
    in           al,portc2
 and        al,00000001b
```

```
 jz         pol_EOC2
;oe enable
mov         al,00010010b
 out        portc1,al

;taking input from portb2
 in           al,portb2



;making ah = 0
 mov          ah,00h
;moving value to register bx
add          bx,ax

;output enable off
mov         al,00000010b
 out        portc1,al

 ;enabling input for third weight
mov          al,00000100b
out          portc1,al



mov          al,00000101b
out          portc1,al

mov          al,00001101b
out          portc1,al
```

```
mov         al,00001100b
out         portc1,al

mov         al,00000100b
out         portc1,al


pol_EOC3:
    in          al,portc2
 and       al,00000001b

 jz        pol_EOC3




;oe enable
mov        al,00010100b
 out       portc1,al

;taking input from portb2
 in          al,portb2




;making ah = 0
 mov         ah,00h
;moving value to register bx
```

```
add          bx,ax




;output enable off
mov         al,00000010b
 out        portc1,al

 mov          ax,bx

 mov          cl,3
 div          cl

 ;127d is the adc output for 99kg
 cmp          al,127d
 ja           buzzer



 ;making ah = 0 because weight is less than 99kg
 mov          ah,00h
 mov          cl,78
 mul          cl

 call         bcd
 mov          ax,bx
 cmp          ax,9900h
 ja           buzzer
```

```
;ax is the decimal value for the weight
and         ax,00ffh

out         portb1,ax

;bx is the integral value for the weight
sub         bx,ax

mov         ax,bx
mov         al,ah
out         porta1,al
jmp         toIret

buzzer:

;setting buzzer
mov         al,00100000b
out         portc1,al

;setting display to zero
mov         al,00000000b
out         porta1,al

mov         al,00000000b
out         portb1,al
```

```
;polling for buzzer switch
buzzerswitch:
in          al,portc1
and         al,01000000b
cmp         al,00h
jz          buzzerswitch

mov         al,00000000b
out         portc1,al



jmp         toIret



bcd      proc near
        pushf
        push cx
        push dx
        mov bx, 0000
        mov dh, 0
l9:     cmp ax, 10000
        jb l2
        sub ax, 10000
        inc dh
        jmp l9
l2:     cmp ax, 1000
        jb l4
```

```
        sub ax, 1000
        add bx, 1000h
        jmp l2
l4:     cmp ax, 100
        jb l6
        sub ax, 100
        add bx, 100h
        jmp l4
l6:     cmp ax, 10
        jb l8
        sub ax, 10
        add bx, 10h
        jmp l6
l8:     add bx, ax
        pop dx
        pop cx
        popf
        ret
bcd     endp

 toIret:

 iret
```

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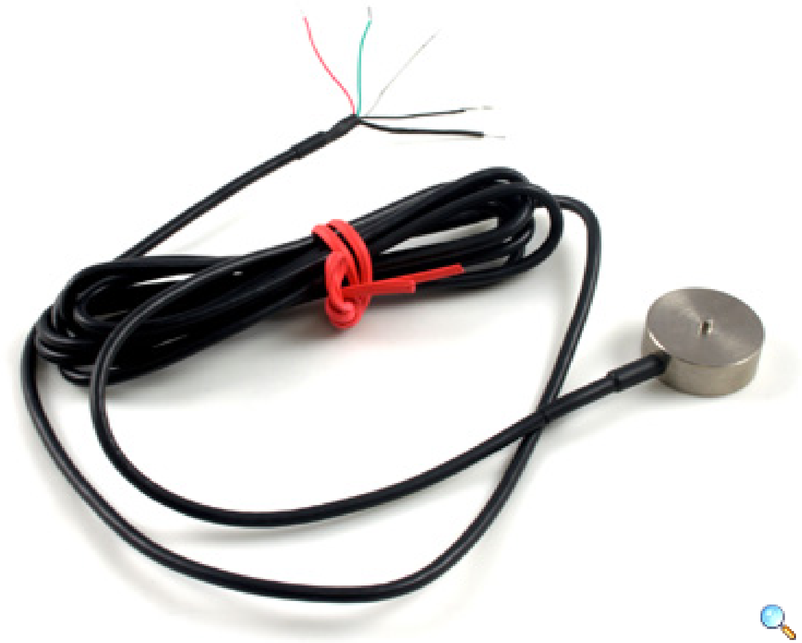
3137_0 - Button Load Cell (0-200kg) - CZL204E



Quantity	Price
1	**$45.00**
5	$43.20
10	$41.85
25	$40.50
100	$39.15

In Stock
Qty: 344

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1

RoHS compliant

Product Features

This load cell measures compressive forces of up to 200kg and connects to a bridge input.

Product Description

A load cell is a force sensing module - a carefully designed metal structure, with small elements called strain gauges mounted in precise locations on the structure. Load cells are designed to measure a specific force, and ignore other forces being applied. The electrical signal output by the load cell is very small and requires specialized amplification. Fortunately, the 1046 PhidgetBridge will perform all the amplification and measurement of the electrical output.

This Button Load Cell is used in applications that require a thin form factor. The bottom of the load cell is bolted, and force applied to the button on the top. By loading only the button, which is slightly rounded, the load cell is less sensitive to errors resulting from the load not pushing down exactly straight on the load cell.

Warning

Make sure to calibrate your load cell before using it. You can find information on how to calibrate the cell in the Load Cell Primer. You should also look at the 1046 - PhidgetBridge User Guide.

Connection

The 3137 connects to a bridge on the 1046 – PhidgetBridge 4-Input

Stepper Controllers
Stepper Motors
Hardware

Cables
USB
Wire
Multi-Conductor
Connectors

T-Slot
PG20
PG30
PG40

Linear Motion
8mm
12mm
16mm
25mm

Transmission
Belt Drive
Chain Drive
Gearboxes
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Relays
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Remote Control
LCD Displays
Adapters
LEDs
Switches
Fuses/Protection
USB Hubs
Power Supplies
Kits
Enclosures

Clearance Sale
Discontinued

Product Specifications

Sensor Properties

Sensor Type	Compression Load Cell
Weight Capacity Max	200 kg
Maximum Overload	240 kg
Creep	* 40 g/hr
Zero Balance	* ± 2 kg
Cell Repeatability Error Max	* ± 200 g
Cell Non-Linearity Max	* 400 g
Temperature Effect on Span	* 10 g/°C
Temperature Effect on Zero	* 10 g/°C

Electrical Properties

Rated Output	* 1 mV/V
Rated Output Error Max	40 μV/V
Output Impedance	350 Ω
Supply Voltage Min	5 V DC
Supply Voltage Max	12 V DC

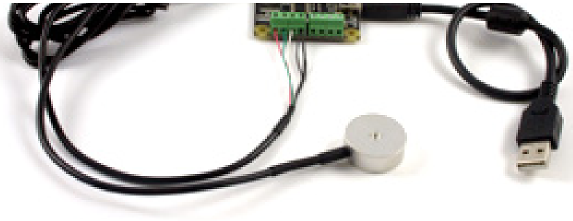
Physical Properties

Compensated Temperature Min	-10 °C
Compensated Temperature Max	40 °C
Operating Temperature Min	-20 °C
Operating Temperature Max	55 °C
Cable Length	3 m
Cable Gauge	30 AWG
Material	Aluminium Alloy & Alloy Steel
Screw Thread Size	M3x0.5

*Accuracy specifications may vary from cell to cell. See the included calibration sheet for precise values for your load cell.

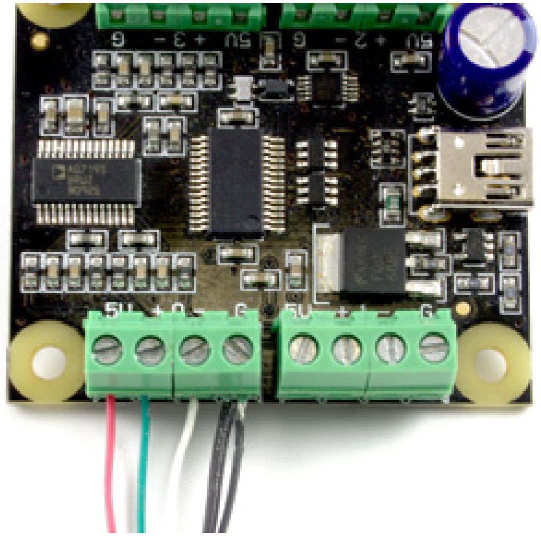
Resources

The Data Sheet below has a comprehensive glossary that describes



The following table shows how to connect the Load Cell Wires to the bridge connectors.

Wire Color	Red	Green	White	Black/Yellow
Bridge Connector	5V	+	-	GND



Related Products

- 3122 - Button Load Cell (0 - 50 lbs)
- 3123 - Button Load Cell (0 - 100 lbs)

- 3136 - Button Load Cell (0 - 50kg)
- 3141 - Button Load Cell (0 - 1000kg)

More Load Cells

in practical terms the meaning and usefulness of the specifications.

- Load Cell Primer
- Mechanical Drawing
- Download 3D Step File

Home » Electromagnetic Buzzer - 5v (active buzzer / Piezo Buzzer) (operational range 2V - 5 V)

Electromagnetic Buzzer - 5v (active buzzer / Piezo Buzzer) (operational range 2V - 5 V)

Product Code: SB_PB5
Reward Points: 5
In Stock

International shipping through Fedex (3-7 days priority delivery) OR
Shop in USD($)

Price (Inclusive of Taxes): Rs.14.00
Price in reward points: 90

10 or more Rs.13.50
25 or more Rs.13.00
50 or more Rs.12.75

Qty: 1 Add to Cart - OR - Add to Wish List
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Description | **Reviews (0)**

Buzzer (Electromagnetic) 5 volt - Active Buzzer : Piezo Buzzer (PCB mountable)

General Description
Good performance, general purpose piezo buzzer used commonly in alerting / alarming circuits. This is a PCB mountable buzzer can be easily soldered to PCB boad. Most commonly used in at 5v. Long life, stable performance, High Quality with SOT plastic package

Specification

- Voltage : 2 - 5VDC
- Maximum current : 30mA/5VDC
- Decibel : > 85db/10cm
- Resonant frequency : 2500Hz (+/- 300 HZ)
- Operating Temperature : -20 to 70 C

*Image shown is a representation only.

Related Products

Electromagnetic Buzzer - 3v - 12v (passive buzzer / AC) (operational range 3V - 12V)
Rs.15.00

Solder Wire Pack - 50Gm (High Quality)

~~Rs.90.00~~ Rs.79.00

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8 Channel Relay Board - 12V

~~Rs.335.00~~ Rs.320.00

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Tags: buzzer 5v, Audio, Piezo Buzzer, Alarm, Piezzo Buzzer 5v,

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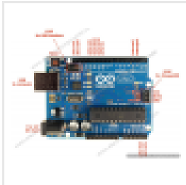

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LM741 Operational Amplifier

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

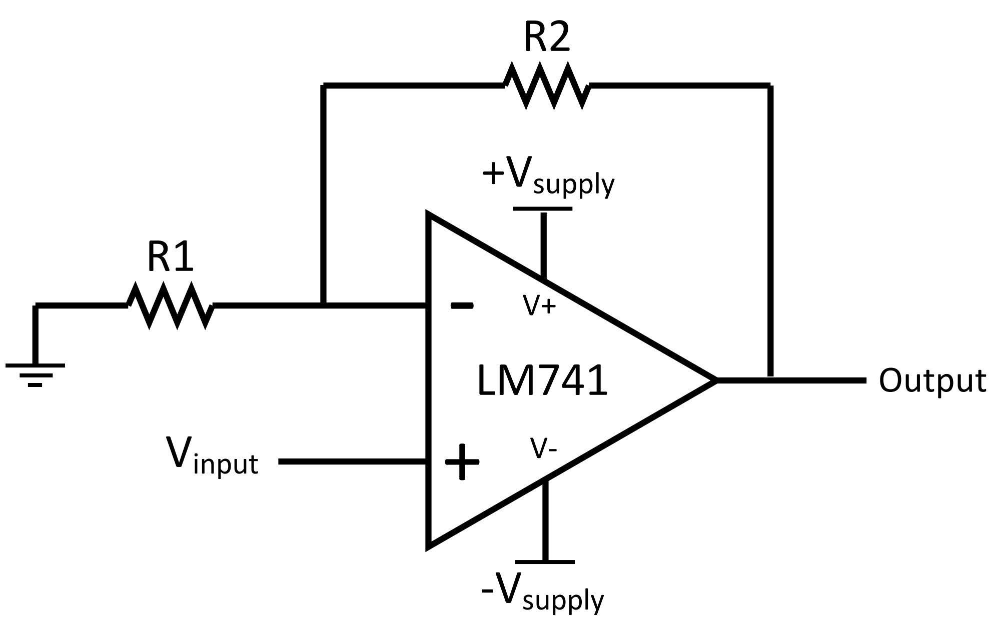


Table of Contents

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision C (October 2004) to Revision D **Page**

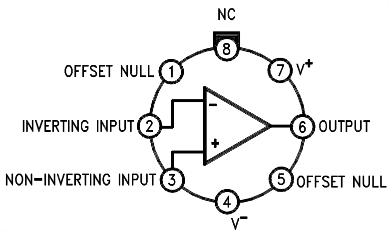
- Added *Applications* section, *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1
- Removed NAD 10-Pin CLGA pinout 3
- Removed obselete M (S0-8) package from the data sheet 4
- Added recommended operating supply voltage spec 4
- Added recommended operating temperature spec 4

Changes from Revision C (March 2013) to Revision D **Page**

- Added *Applications* section, *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1
- Removed NAD 10-Pin CLGA pinout 3
- Removed obselete M (S0-8) package from the data sheet 4
- Added recommended operating supply voltage spec 4
- Added recommended operating temperature spec 4

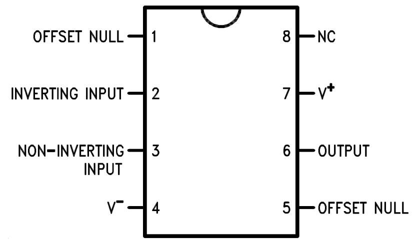
5 Pin Configuration and Functions

LMC Package
8-Pin TO-99
Top View



LM741H is available per JM38510/10101

NAB Package
8-Pin CDIP or PDIP
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
INVERTING INPUT	2	I	Inverting signal input
NC	8	N/A	No Connect, should be left floating
NONINVERTING INPUT	3	I	Noninverting signal input
OFFSET NULL	1, 5	I	Offset null pin used to eliminate the offset voltage and balance the input voltages.
OFFSET NULL			
OUTPUT	6	O	Amplified signal output
V+	7	I	Positive supply voltage
V–	4	I	Negative supply voltage

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)(2)(3)

		MIN	MAX	UNIT
Supply voltage	LM741, LM741A		±22	V
	LM741C		±18	
Power dissipation (4)			500	mW
Differential input voltage			±30	V
Input voltage (5)			±15	V
Output short circuit duration		Continuous		
Operating temperature	LM741, LM741A	–50	125	°C
	LM741C	0	70	
Junction temperature	LM741, LM741A		150	°C
	LM741C		100	
Soldering information	PDIP package (10 seconds)		260	°C
	CDIP or TO-99 package (10 seconds)		300	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) For military specifications see RETS741X for LM741 and RETS741AX for LM741A.
(3) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(4) For operation at elevated temperatures, these devices must be derated based on thermal resistance, and T_j max. (listed under “Absolute Maximum Ratings”). $T_j = T_A + (\theta_{jA} P_D)$.
(5) For supply voltages less than ±15 V, the absolute maximum input voltage is equal to the supply voltage.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±400	V

(1) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
Supply voltage (VDD-GND)	LM741, LM741A	±10	±15	±22	V
	LM741C	±10	±15	±18	
Temperature	LM741, LM741A	–55		125	°C
	LM741C	0		70	

6.4 Thermal Information

THERMAL METRIC (1)		LM741			UNIT
		LMC (TO-99)	NAB (CDIP)	P (PDIP)	
		8 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	170	100	100	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	25	—	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics, LM741[1]

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage	$R_S \le 10$ kΩ	$T_A = 25°C$		1	5	mV
		$T_{AMIN} \le T_A \le T_{AMAX}$			6	mV
Input offset voltage adjustment range	$T_A = 25°C$, $V_S = ±20$ V			±15		mV
Input offset current	$T_A = 25°C$			20	200	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$			85	500	
Input bias current	$T_A = 25°C$			80	500	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$				1.5	µA
Input resistance	$T_A = 25°C$, $V_S = ±20$ V		0.3	2		MΩ
Input voltage range	$T_{AMIN} \le T_A \le T_{AMAX}$		±12	±13		V
Large signal voltage gain	$V_S = ±15$ V, $V_O = ±10$ V, $R_L \ge 2$ kΩ	$T_A = 25°C$	50	200		V/mV
		$T_{AMIN} \le T_A \le T_{AMAX}$	25			
Output voltage swing	$V_S = ±15$ V	$R_L \ge 10$ kΩ	±12	±14		V
		$R_L \ge 2$ kΩ	±10	±13		
Output short circuit current	$T_A = 25°C$			25		mA
Common-mode rejection ratio	$R_S \le 10$ Ω, $V_{CM} = ±12$ V, $T_{AMIN} \le T_A \le T_{AMAX}$		80	95		dB
Supply voltage rejection ratio	$V_S = ±20$ V to $V_S = ±5$ V, $R_S \le 10$ Ω, $T_{AMIN} \le T_A \le T_{AMAX}$		86	96		dB
Transient response: Rise time	$T_A = 25°C$, unity gain			0.3		µs
Transient response: Overshoot				5%		
Slew rate	$T_A = 25°C$, unity gain			0.5		V/µs
Supply current	$T_A = 25°C$			1.7	2.8	mA
Power consumption	$V_S = ±15$ V	$T_A = 25°C$		50	85	mW
		$T_A = T_{AMIN}$		60	100	
		$T_A = T_{AMAX}$		45	75	

(1) Unless otherwise specified, these specifications apply for $V_S = ±15$ V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

6.6 Electrical Characteristics, LM741A[1]

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage	$R_S \le 50$ Ω	$T_A = 25°C$		0.8	3	mV
		$T_{AMIN} \le T_A \le T_{AMAX}$			4	mV
Average input offset voltage drift					15	µV/°C
Input offset voltage adjustment range	$T_A = 25°C$, $V_S = ±20$ V		±10			mV
Input offset current	$T_A = 25°C$			3	30	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$				70	
Average input offset current drift					0.5	nA/°C
Input bias current	$T_A = 25°C$			30	80	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$				0.21	µA
Input resistance	$T_A = 25°C$, $V_S = ±20$ V		1	6		MΩ
	$T_{AMIN} \le T_A \le T_{AMAX}$, $V_S = ±20$ V		0.5			
Large signal voltage gain	$V_S = ±20$ V, $V_O = ±15$ V, $R_L \ge 2$ kΩ	$T_A = 25°C$	50			V/mV
		$T_{AMIN} \le T_A \le T_{AMAX}$	32			
	$V_S = ±5$ V, $V_O = ±2$ V, $R_L \ge 2$ kΩ, $T_{AMIN} \le T_A \le T_{AMAX}$		10			

(1) Unless otherwise specified, these specifications apply for $V_S = ±15$ V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

Electrical Characteristics, LM741A[1] (continued)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Output voltage swing		V_S = ±20 V	R_L ≥ 10 kΩ	±16			V
			R_L ≥ 2 kΩ	±15			
Output short circuit current		T_A = 25°C		10	25	35	mA
		T_{AMIN} ≤ T_A ≤ T_{AMAX}		10		40	
Common-mode rejection ratio		R_S ≤ 50 Ω, V_{CM} = ±12 V, T_{AMIN} ≤ T_A ≤ T_{AMAX}		80	95		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, R_S ≤ 50 Ω, T_{AMIN} ≤ T_A ≤ T_{AMAX}		86	96		dB
Transient response	Rise time	T_A = 25°C, unity gain			0.25	0.8	μs
	Overshoot				6%	20%	
Bandwidth [2]		T_A = 25°C		0.437	1.5		MHz
Slew rate		T_A = 25°C, unity gain		0.3	0.7		V/μs
Power consumption		V_S = ±20 V	T_A = 25°C		80	150	mW
			T_A = T_{AMIN}			165	
			T_A = T_{AMAX}			135	

(2) Calculated value from: BW (MHz) = 0.35/Rise Time (μs).

6.7 Electrical Characteristics, LM741C[1]

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		R_S ≤ 10 kΩ	T_A = 25°C		2	6	mV
			T_{AMIN} ≤ T_A ≤ T_{AMAX}			7.5	mV
Input offset voltage adjustment range		T_A = 25°C, V_S = ±20 V			±15		mV
Input offset current		T_A = 25°C			20	200	nA
		T_{AMIN} ≤ T_A ≤ T_{AMAX}				300	
Input bias current		T_A = 25°C			80	500	nA
		T_{AMIN} ≤ T_A ≤ T_{AMAX}				0.8	μA
Input resistance		T_A = 25°C, V_S = ±20 V		0.3	2		MΩ
Input voltage range		T_A = 25°C		±12	±13		V
Large signal voltage gain		V_S = ±15 V, V_O = ±10 V, R_L ≥ 2 kΩ	T_A = 25°C	20	200		V/mV
			T_{AMIN} ≤ T_A ≤ T_{AMAX}	15			
Output voltage swing		V_S = ±15 V	R_L ≥ 10 kΩ	±12	±14		V
			R_L ≥ 2 kΩ	±10	±13		
Output short circuit current		T_A = 25°C			25		mA
Common-mode rejection ratio		R_S ≤ 10 kΩ, V_{CM} = ±12 V, T_{AMIN} ≤ T_A ≤ T_{AMAX}		70	90		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, R_S ≤ 10 Ω, T_{AMIN} ≤ T_A ≤ T_{AMAX}		77	96		dB
Transient response	Rise time	T_A = 25°C, Unity Gain			0.3		μs
	Overshoot				5%		
Slew rate		T_A = 25°C, Unity Gain			0.5		V/μs
Supply current		T_A = 25°C			1.7	2.8	mA
Power consumption		V_S = ±15 V, T_A = 25°C			50	85	mW

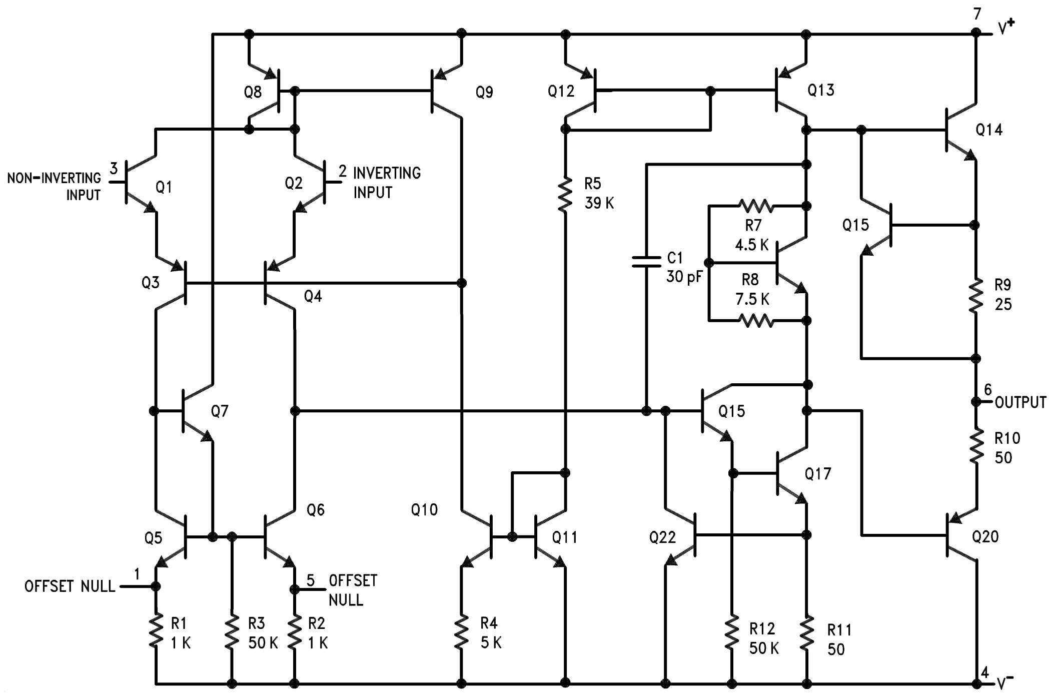
(1) Unless otherwise specified, these specifications apply for V_S = ±15 V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

7 Detailed Description

7.1 Overview

The LM74 devices are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. It is intended for a wide range of analog applications. The high gain and wide range of operating voltage provide superior performance in integrator, summing amplifier, and general feedback applications. The LM741 can operate with a single or dual power supply voltage. The LM741 devices are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Overload Protection

The LM741 features overload protection circuitry on the input and output. This prevents possible circuit damage to the device.

7.3.2 Latch-up Prevention

The LM741 is designed so that there is no latch-up occurrence when the common-mode range is exceeded. This allows the device to function properly without having to power cycle the device.

7.3.3 Pin-to-Pin Capability

The LM741 is pin-to-pin direct replacements for the LM709C, LM201, MC1439, and LM748 in most applications. Direct replacement capabilities allows flexibility in design for replacing obsolete parts.

7.4 Device Functional Modes

7.4.1 Open-Loop Amplifier

The LM741 can be operated in an open-loop configuration. The magnitude of the open-loop gain is typically large thus for a small difference between the noninverting and inverting input terminals, the amplifier output will be driven near the supply voltage. Without negative feedback, the LM741 can act as a comparator. If the inverting input is held at 0 V, and the input voltage applied to the noninverting input is positive, the output will be positive. If the input voltage applied to the noninverting input is negative, the output will be negative.

7.4.2 Closed-Loop Amplifier

In a closed-loop configuration, negative feedback is used by applying a portion of the output voltage to the inverting input. Unlike the open-loop configuration, closed loop feedback reduces the gain of the circuit. The overall gain and response of the circuit is determined by the feedback network rather than the operational amplifier characteristics. The response of the operational amplifier circuit is characterized by the transfer function.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LM741 is a general-purpose amplifier than can be used in a variety of applications and configurations. One common configuration is in a noninverting amplifier configuration. In this configuration, the output signal is in phase with the input (not inverted as in the inverting amplifier configuration), the input impedance of the amplifier is high, and the output impedance is low. The characteristics of the input and output impedance is beneficial for applications that require isolation between the input and output. No significant loading will occur from the previous stage before the amplifier. The gain of the system is set accordingly so the output signal is a factor larger than the input signal.

8.2 Typical Application

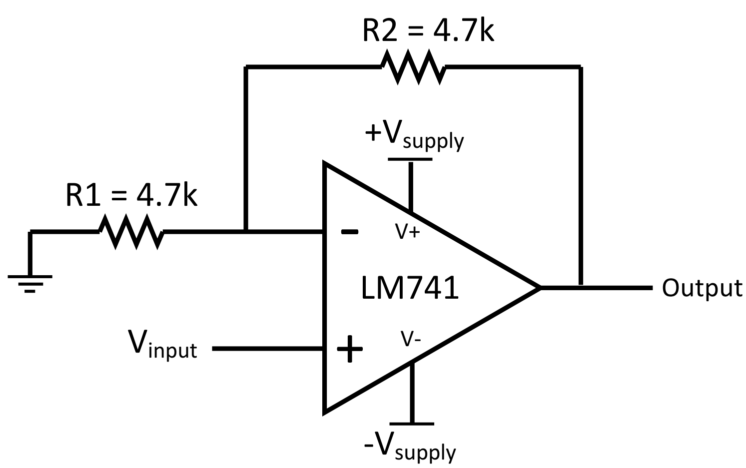


Figure 1. LM741 Noninverting Amplifier Circuit

8.2.1 Design Requirements

As shown in Figure 1, the signal is applied to the noninverting input of the LM741. The gain of the system is determined by the feedback resistor and input resistor connected to the inverting input. The gain can be calculated by Equation 1:

$$\text{Gain} = 1 + (R2/R1) \quad (1)$$

The gain is set to 2 for this application. R1 and R2 are 4.7-k resistors with 5% tolerance.

8.2.2 Detailed Design Procedure

The LM741 can be operated in either single supply or dual supply. This application is configured for dual supply with the supply rails at ±15 V. The input signal is connected to a function generator. A 1-Vpp, 10-kHz sine wave was used as the signal input. 5% tolerance resistors were used, but if the application requires an accurate gain response, use 1% tolerance resistors.

Typical Application (continued)

8.2.3 Application Curve

The waveforms in Figure 2 show the input and output signals of the LM741 non-inverting amplifier circuit. The blue waveform (top) shows the input signal, while the red waveform (bottom) shows the output signal. The input signal is 1.06 Vpp and the output signal is 1.94 Vpp. With the 4.7-kΩ resistors, the theoretical gain of the system is 2. Due to the 5% tolerance, the gain of the system including the tolerance is 1.992. The gain of the system when measured from the mean amplitude values on the oscilloscope was 1.83.

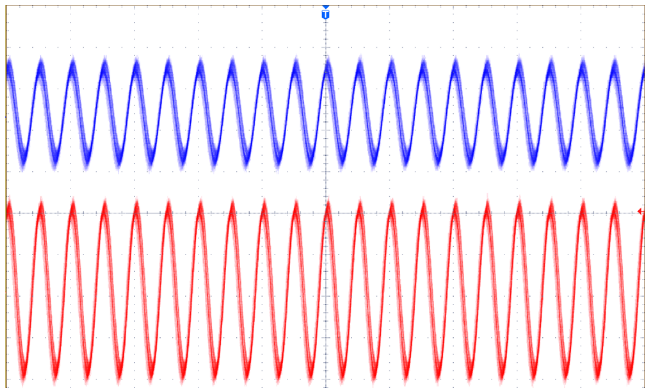


Figure 2. Waveforms for LM741 Noninverting Amplifier Circuit

9 Power Supply Recommendations

For proper operation, the power supplies must be properly decoupled. For decoupling the supply lines, a 0.1-µF capacitor is recommended and should be placed as close as possible to the LM741 power supply pins.

10 Layout

10.1 Layout Guidelines

As with most amplifiers, take care with lead dress, component placement, and supply decoupling in order to ensure stability. For example, resistors from the output to an input should be placed with the body close to the input to minimize pick-up and maximize the frequency of the feedback pole by minimizing the capacitance from the input to ground. As shown in Figure 3, the feedback resistors and the decoupling capacitors are located close to the device to ensure maximum stability and noise performance of the system.

10.2 Layout Example

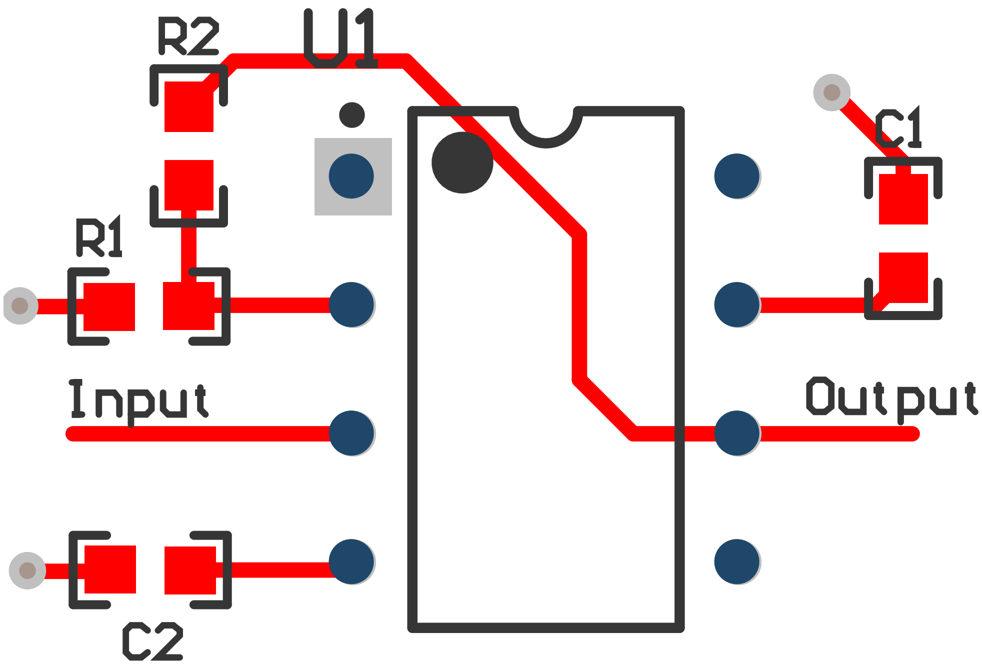


Figure 3. LM741 Layout

11 Device and Documentation Support

11.1 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.2 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.3 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.4 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM741C-MWC	ACTIVE	WAFERSALE	YS	0	1	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-40 to 85		Samples
LM741CH	ACTIVE	TO-99	LMC	8	500	TBD	Call TI	Call TI	0 to 70	(LM741CH ~ LM741CH)	Samples
LM741CH/NOPB	ACTIVE	TO-99	LMC	8	500	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	0 to 70	(LM741CH ~ LM741CH)	Samples
LM741CN/NOPB	ACTIVE	PDIP	P	8	40	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	LM 741CN	Samples
LM741H	ACTIVE	TO-99	LMC	8	500	TBD	Call TI	Call TI	-55 to 125	(LM741H ~ LM741H)	Samples
LM741H/NOPB	ACTIVE	TO-99	LMC	8	500	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125	(LM741H ~ LM741H)	Samples
LM741J	ACTIVE	CDIP	NAB	8	40	TBD	Call TI	Call TI	-55 to 125	LM741J	Samples
U5B7741312	ACTIVE	TO-99	LMC	8	500	TBD	Call TI	Call TI	-55 to 125	(LM741H ~ LM741H)	Samples
U5B7741393	ACTIVE	TO-99	LMC	8	500	TBD	Call TI	Call TI	0 to 70	(LM741CH ~ LM741CH)	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

[4] There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

[5] Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

[6] Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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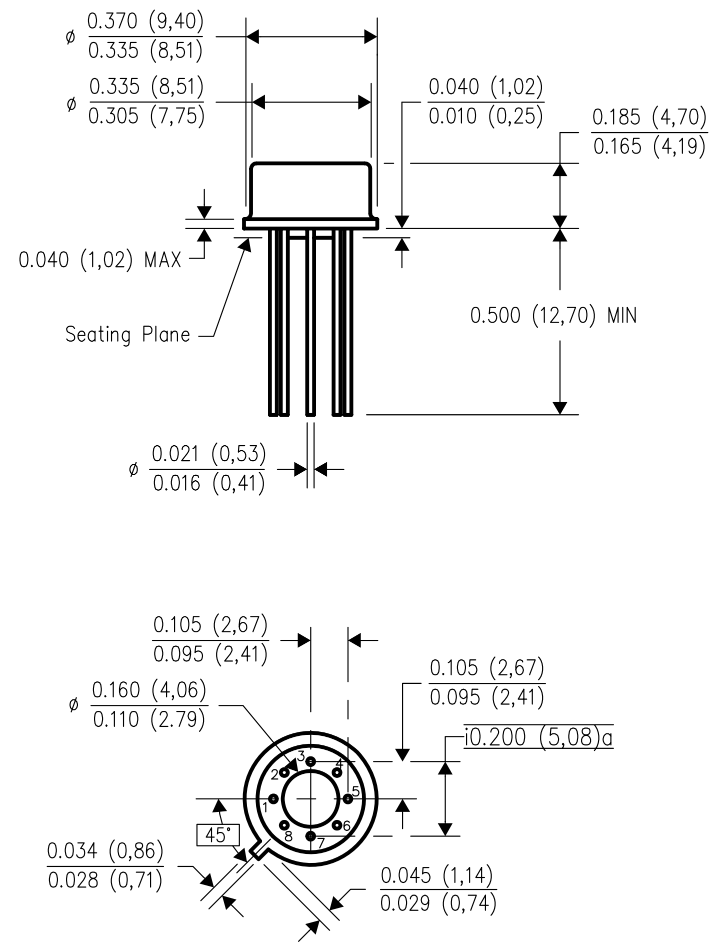
LMC (O-MBCY-W8) METAL CYLINDRICAL PACKAGE



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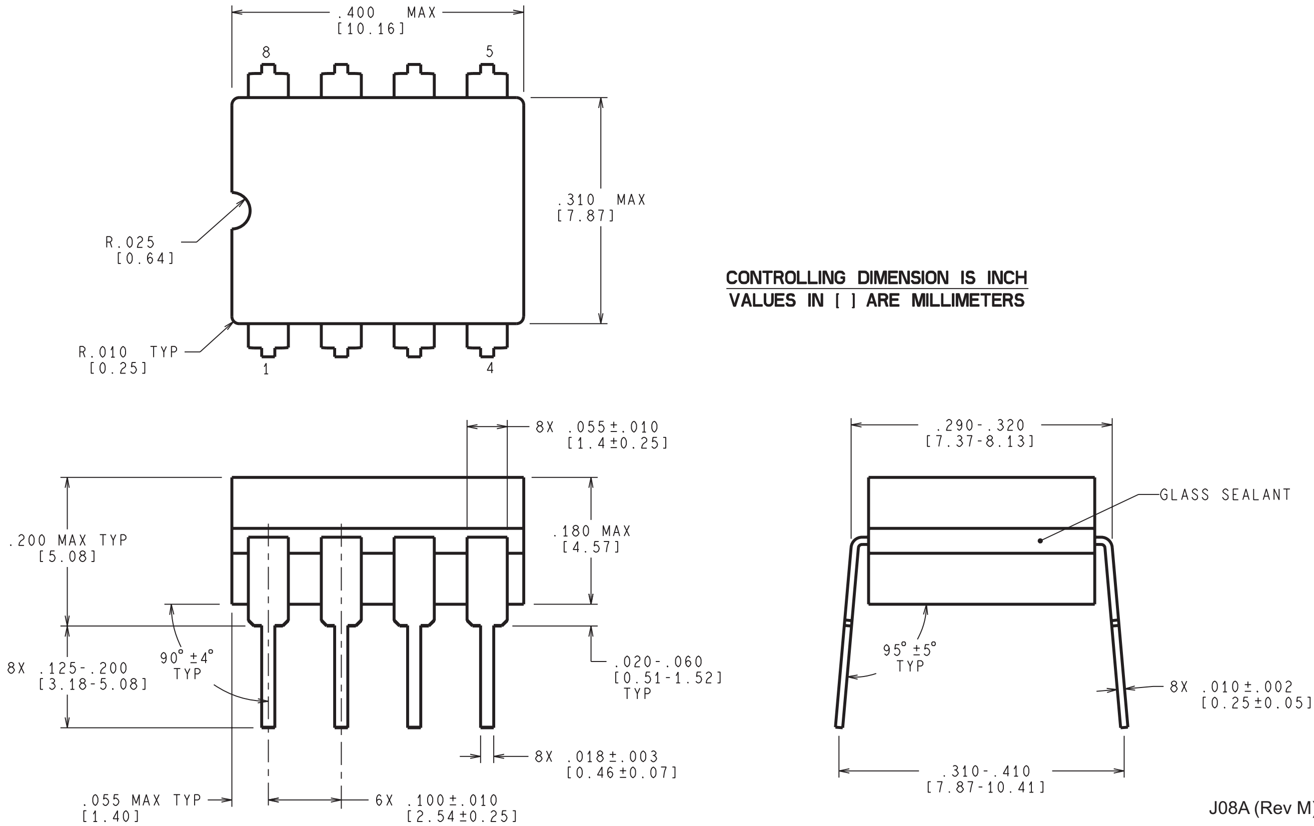
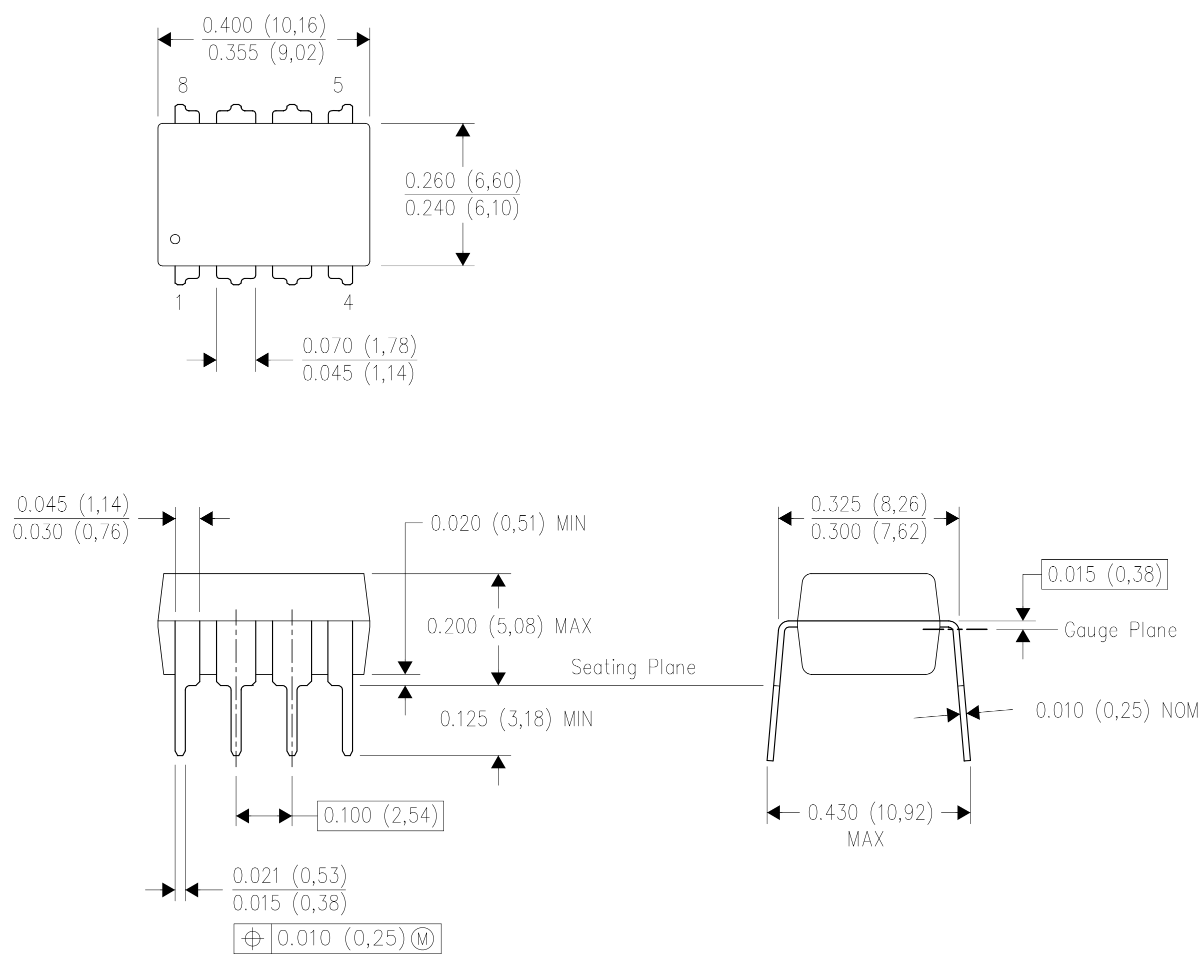
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
- D. Pin numbers shown for reference only. Numbers may not be marked on package.
- E. Falls within JEDEC MO-002/TO-99.

NAB0008A



J08A (Rev M)

P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE



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- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Falls within JEDEC MS-001 variation BA.

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