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DATASHEET Kit version 1.0



# xL741 Discrete Operational Amplifier

Re-create one of the most classic, popular, and all-around useful chips of all time.

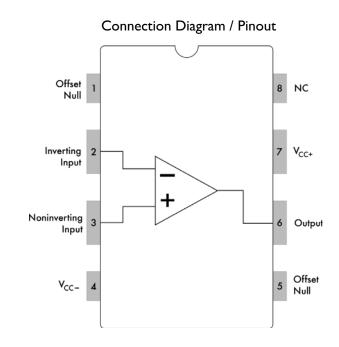
The XL741 Discrete Operational Amplifier is a faithful and functional transistor-scale replica of the classic µa741 op-amp integrated circuit.

Designed by Eric Schlaepfer (tubetime.us), in collaboration with Evil Mad Scientist Laboratories.

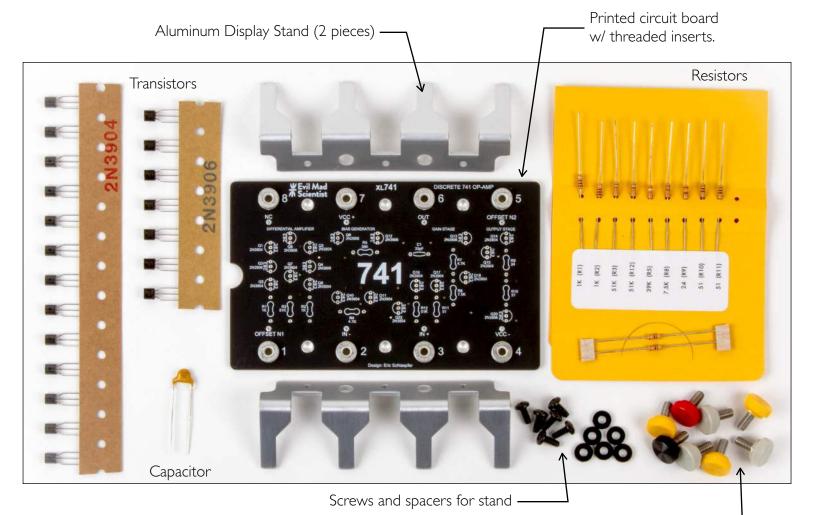
The latest version of this document and additional resources about 741 op-amps are available at: http://wiki.evilmadscientist.com/XL741

#### Main Specifications

- Kit type: Through-hole soldering kit
- · Assembly instructions: Printed, included with kit
- Assembly time: 30-60 minutes (typical)
- Function: Equivalent circuit to µa741 IC.
   Some performance characteristics differ; Refer to Abs.
   Maximum ratings and Electrical Characteristics
- RoHS compliance: All kit components are RoHS compliant (lead free)
- Connection methods: Terminal posts (bare wire, lug, or alligator clip) or solder



#### Kit Contents



Thumbscrew terminal posts (color coded red, black, yellow, and gray)

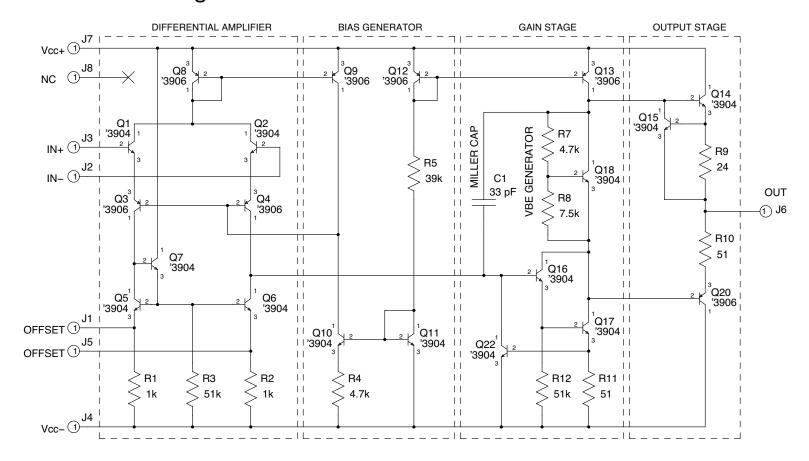
#### Contents of the xL741 kit:

- The xL741 printed circuit board (extra thick 0.100"), pre-fitted with eight 8-32 threaded inserts
- The transistors, resistors, and capacitor required to assemble the kit
- Eight thumbscrews (terminal posts) with color-coded caps (1 red, 1 black, 3 yellow, 3 gray)
- Two-piece "IC Legs" stand, anodized aluminum
- Mounting screws and spacers for attaching the "IC Legs" stand
- Printed assembly instructions (not shown)

#### Tools and materials required for assembly (not included with kit):

- Soldering iron
- Solder
- Wire clippers
- Phillips head screwdriver (#2 size recommended).

# Schematic Diagram



# **Electrical Components**

| Reference                 | Qty | Туре            | Value  |
|---------------------------|-----|-----------------|--------|
| Q1,2,5,6,7,10,11,14-18,22 | 13  | NPN Transistor  | 2N3904 |
| Q3,4,8,9,12,13,20         | 7   | PNP Transistor  | 2N3906 |
| RI,R2                     | 2   | Resistor, 1/4 W | IkΩ    |
| R3,R12                    | 2   | Resistor, 1/4 W | 51 kΩ  |
| R4,R7                     | 2   | Resistor, 1/4 W | 4.7 kΩ |
| R5                        | I   | Resistor, 1/4 W | 39 kΩ  |
| R8                        | I   | Resistor, 1/4 W | 7.5 kΩ |
| R9                        | I   | Resistor, 1/4 W | 24 Ω   |
| RIO,RII                   | 2   | Resistor, 1/4 W | 51 Ω   |
| CI                        | 13  | Cap., Ceramic   | 33 pF  |

# Absolute Maximum Ratings<sup>1</sup>

| Parameter                                 | Symbol            | Value                            | Unit |
|---|-------------------|----------------------------------|------|
| Supply Voltage, Positive <sup>2</sup>     | V <sub>CC+</sub>  | +18                              | V    |
| Supply Voltage, Negative                  | V <sub>CC</sub> - | -18                              | V    |
| Differential Input Voltage <sup>3,4</sup> | V <sub>ID</sub>   | ±11                              | V    |
| Input Voltage (any input) 5               | V <sub>IN</sub>   | Lesser of V <sub>CC</sub> or ±15 | V    |

#### Notes:

- 1. Exceeding Absolute Maximum Ratings may cause permanent damage to the device. Please refer to Electrical Characteristics for recommended operating parameters.
- 2. Input voltages are measured with respect to the midpoint between  $V_{\text{CC+}}$  and  $V_{\text{CC-}}$ .
- 3. Differential Input Voltage is the voltage at pin IN+ with respect to the voltage at pin IN-.
- 4. Note that this value differs significantly from the μA741 integrated circuit.
- 5. Input voltages must not exceed V<sub>cc</sub> nor 15 V in magnitude.



# **Electrical Characteristics**

At  $V_{CC} = \pm 15 \text{ V}$ ,  $T_A = 25 \,^{\circ}\text{C}$  (unless otherwise specified)

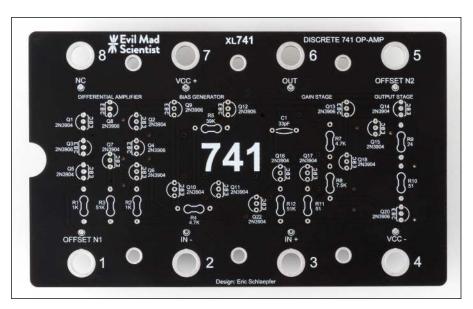
| Parameter                                | Symbol                        | Conditions  | Тур | Unit |
|--|-------------------------------|---|-----|------|
| Input Offset Voltage                     | V <sub>IO</sub>               | R <sub>S</sub> ≤ 10 kΩ                                  | 2.0 | mV   |
| Input Offset Current                     | l <sub>IO</sub>               |   | 20  | nA   |
| Input Bias Current                       | I <sub>IB</sub>               |   | 80  | nA   |
| Input Resistance                         | ri                            |   | 2.0 | ΜΩ   |
| Input Capacitance <sup>1</sup>           | Ci                            |   | 10  | pF   |
| Offset Voltage Adjustment Range          | $\Delta V_{IO(ADJ)}$          |   | ±15 | mV   |
| Input Voltage Range (Common Mode)        | V <sub>IR</sub>               |   | ±13 | V    |
| Common Mode Rejection Ratio <sup>1</sup> | CMRR                          | $R_S \le 10 \text{ k}\Omega$                            | 43  | dB   |
| Supply Voltage Sensitivity               | $\Delta V_{IO}/\Delta V_{CC}$ | $R_S \le 10 \text{ k}\Omega$                            | 30  | μV/V |
| Large-Signal Differential Voltage Gain   | A <sub>VD</sub>               | $R_L \ge 2 \text{ k}\Omega, V_{OUT} = \pm 10 \text{ V}$ | 200 | V/mV |
| Output Voltage Swing                     | V <sub>OM</sub>               | $R_L \ge 10 \text{ k}\Omega$                            | ±14 | V    |
|  |                               | $R_L \ge 2 k\Omega$                                     | ±13 | V    |
| Output Resistance                        | ro                            |   | 75  | Ω    |
| Output Short-Circuit Current             | los                           |   | 25  | mA   |
| Supply Current                           | Icc                           | V <sub>O</sub> = 0 V, No load                           | 1.7 | mA   |
| Power Consumption                        | P <sub>D</sub>                | V <sub>O</sub> = 0 V, No load                           | 50  | mW   |
| Transient Response (unity gain)          |                               | $V_{in}$ = 20 mV $R_L$ = 2 k $\Omega$ , $C_L$ ≤ 100 pF  |     |      |
| Risetime                                 | t <sub>r</sub>                | V <sub>CC</sub> = 5 V                                   | 0.3 | μs   |
| Overshoot                                |                               |   | 5   | %    |
| Slew Rate                                | SR                            | $R_L \ge 2 k\Omega$                                     | 0.5 | V/µs |

#### Notes:

1. Note that this value differs significantly from the  $\mu\text{A741}$  integrated circuit.

### Additional Photos

Bare PCB

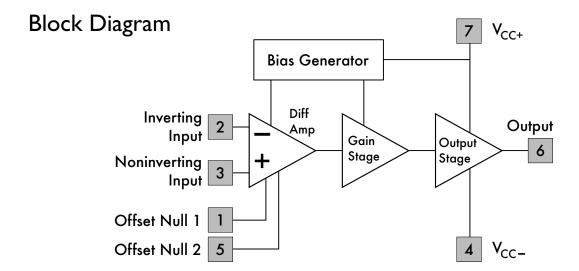




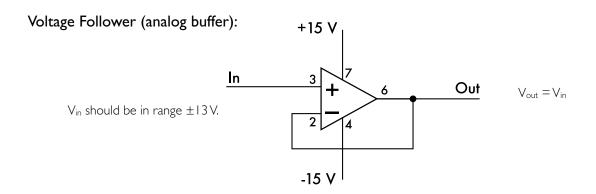
Assembled PCB with stand (Terminal posts removed)

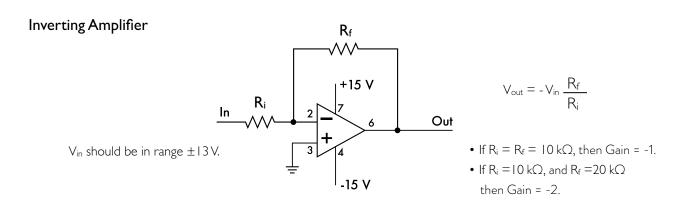
Assembled kit with stand and terminal posts (top view)



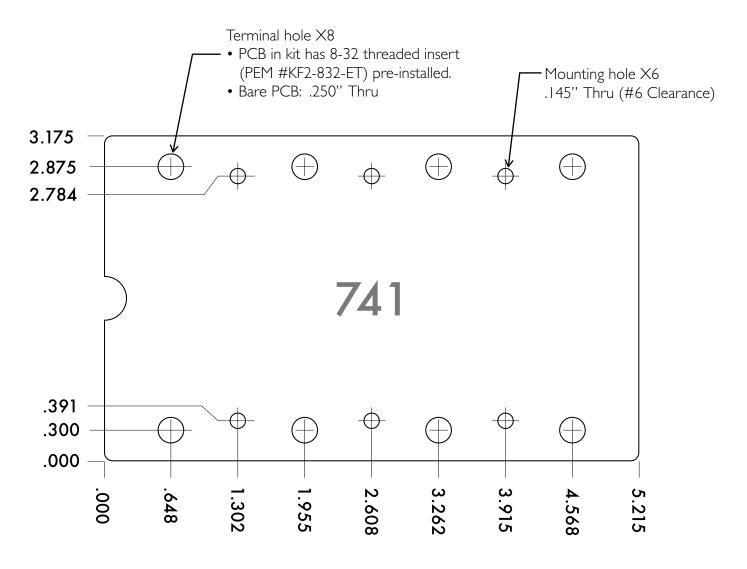


# **Example Circuits**





# Printed Circuit Board: Physical layout and mounting holes



Note: All dimensions are in INCHES.

#### Additional physical specifications:

- Printed Circuit Board size: 5.215 X 3.175 inches (13.25 X 8.06 cm) wide
- PCB thickness: 0.100" (2.54 mm) nominal, not including threaded inserts
- PCB thickness: 0.196" (4.98 mm) nominal, including threaded inserts
- Overall thickness: Allow 0.5" min. clearance above and below circuit board
- Mounting holes: Six #6 clearance holes provided. See drawing for locations.
- Nominal height of "IC legs" stand: 1.25 inches (3.175 cm), not including spacers
- Nominal height of "IC legs" stand: 1.31 inches (3.33 cm), including spacers, to bottom of PCB.