**AB51**
**Active Filters**
**Low Pass and High Pass**

**Operating Manual**

**Ver.1.1**

An ISO 9001 : 2000 company

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TÜV

# TÜV Rheinland Group

# CERTIFICATE

**The Certification Body for**
**Quality Management Systems**
**of TÜV Rheinland India Pvt. Ltd.**

certifies in accordance with
TÜV Rheinland Group procedures that

## Scientech Technologies Pvt. Ltd.

**Unit-1: 94-101, Electronics Complex, Pardeshi Pura,**
**Indore – 452 010, Madhya Pradesh, India**
**Unit-2: 90-91, Electronics Complex, Pardeshi Pura,**
**Indore – 452 010, Madhya Pradesh, India**

has established and applies a quality management system for

**Design, Manufacture of Electronic Test & Measuring Instruments, Training Products for Electrical & Electronics Education and Providing Technology Training**

An audit was performed, Report No. 07930

Proof has been furnished that the requirements according to

**DIN EN ISO 9001: 2000**

are fulfilled.

The certificate is valid until 2010-11-20

Certificate Registration No. **85 100 001 07930**

TÜV NABCB QMS 010

Bangalore, 2007-11-21

The certification Body of
TÜV Rheinland India Pvt. Ltd.

The validity of this certificate is subject to timely completion of Surveillance audits as agreed in the Contract. The Validity of the Certificate can be verified under WWW.tuv.com with the Identification No. 9105027653

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www.tuv.com

**Low Pass and High Pass Active Filters**

**AB51**

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**RoHS Compliance**

Scientech Products are RoHS Complied.

RoHS Directive concerns with the restrictive use of Hazardous substances (Pb, Cd, Cr, Hg, Br compounds) in electric and electronic equipments.

Scientech products are “Lead Free” and “Environment Friendly”.

It is mandatory that service engineers use lead free solder wire and use the soldering irons upto (25 W) that reach a temperature of 450°C at the tip as the melting temperature of the unleaded solder is higher than the leaded solder.

## Introduction

**AB51** is a compact, ready to use **Active Filters** experiment board. It incorporates Low pass filter and High pass filter on a single board and illustrates the functionality of Active filters at adjustable cutoff frequency. It can be used as stand alone unit with external power supply or can be used with **Scientech Analog lab ST2612** which has built in DC power supply, AC power supply, function generator, modulation generator, continuity tester, toggle switches and potentiometers.

**List of Boards :**

| Model | Name |
|---|---|
| **AB01** | Diode characteristics (Si, Zener, LED) |
| **AB02** | Transistor characteristics (CB NPN) |
| **AB03** | Transistor characteristics (CB PNP) |
| **AB04** | Transistor characteristics (CE NPN) |
| **AB05** | Transistor characteristics (CE PNP) |
| **AB06** | Transistor characteristics (CC NPN) |
| **AB07** | Transistor characteristics (CC PNP) |
| **AB08** | FET characteristics |
| **AB09** | Rectifier Circuits |
| **AB10** | Wheatstone Bridge |
| **AB11** | Maxwell’s Bridge |
| **AB12** | De Sauty’s Bridge |
| **AB13** | Schering Bridge |
| **AB15** | Common Emitter Amplifier |
| **AB14** | Darlington Pair |
| **AB16** | Common Collector Amplifier |
| **AB17** | Common Base Amplifier |
| **AB18** | Cascode Amplifier |
| **AB19** | RC-Coupled Amplifier |
| **AB20** | Direct Coupled Amplifier |
| **AB21** | Class A Amplifier |
| **AB22** | Class B Amplifier (push pull emitter follower) |
| **AB23** | Class C Tuned Amplifier |
| **AB25** | Phase Locked Loop (FM Demodulator & Frequency Divider / Multiplier) |
| **AB28** | Multivibrator ( Mono stable / Astable) |
| **AB29** | F-V and V-F Converter |
| **AB30** | V-I and I-V Converter |
| **AB31** | Zener Voltage Regulator |
| **AB32** | Transistor Series Voltage Regulator |
| **AB33** | Transistor Shunt Voltage Regulator |
| **AB35** | DC Ammeter |
| **AB39** | Instrumentation Amplifier |
| **AB41** | Differential Amplifier (Transistorized) |
| **AB42** | Operational Amplifier (Inverting / Non-inverting / Differentiator) |

| | |
|---|---|
| **AB43** | Operational Amplifier (Adder/Scalar) |
| **AB44** | Operational Amplifier (Integrator/ Differentiator) |
| **AB45** | Schmitt Trigger and Comparator |
| **AB49** | K Derived Filter |
| **AB52** | Active Band Pass Filter |
| **AB54** | Tschebyscheff Filter |
| **AB56** | Fiber Optic Analog Link |
| **AB57** | Owen’s Bridge |
| **AB58** | Anderson’s Bridge |
| **AB59** | Maxwell’s Inductance Bridge |
| **AB64** | RC – Coupled Amplifier with Feedback |
| **AB65** | Phase Shift Oscillator |
| **AB66** | Wien Bridge Oscillators |
| **AB67** | Colpitt Oscillator |
| **AB68** | Hartley Oscillator |
| **AB80** | RLC Series and RLC Parallel Resonance |
| **AB82** | Thevenin’s and Maximum power Transfer Theorem |
| **AB83** | Reciprocity and Superposition Theorem |
| **AB84** | Tellegen’s Theorem |
| **AB85** | Norton’s theorem |
| **AB88** | Diode Clipper |
| **AB89** | Diode Clampers |
| **AB90** | Two port network parameter |
| **AB91** | Optical Transducer (Photovoltaic cell) |
| **AB92** | Optical Transducer (Photoconductive cell/LDR) |
| **AB93** | Optical Transducer (Phototransistor) |
| **AB96** | Temperature Transducer (RTD & IC335) |
| **AB97** | Temperature Transducer (Thermocouple) |
| **AB101** | DSB Modulator and Demodulator |
| **AB102** | SSB Modulator and Demodulator |
| **AB106** | FM Modulator and Demodulator |

………… and many more

## Theory

An electric filter is a frequency selective circuit that passes electric signals of specific band of frequencies and attenuates signal of frequencies outside this band. Depending on the type of elements used in their construction filters may be classified as passive or active filters. Elements used in passive filters are resistors, capacitors and inductors. Active filter consists of active components such as Op-amp, transistors with passive elements.

Most commonly used filters are:

1. Low Pass Filter
2. High Pass Filter
3. Band Pass Filter

**Low Pass Filter :**

It is a frequency selective circuit, which passes signals of frequency below it's high cut off frequency ($f_h$) and attenuates signals of frequency above $f_h$.

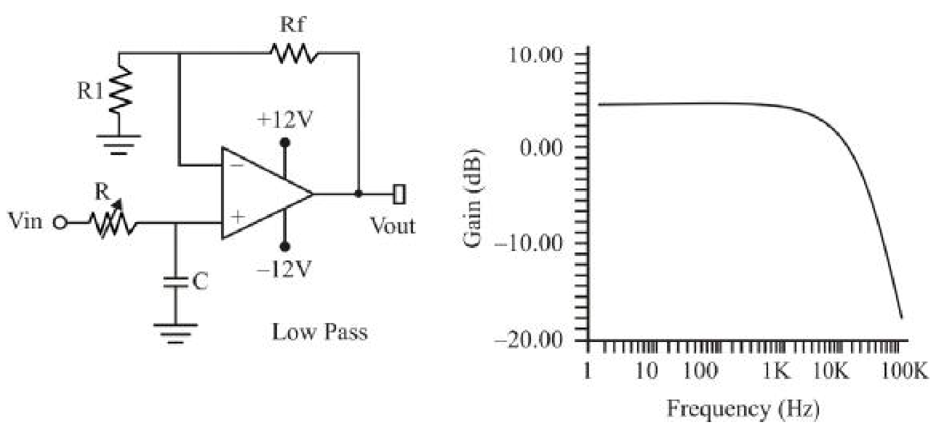



**Figure 1**

Equation of low pass filter is

$$\frac{Vout}{Vin} = \frac{AE}{1 + j(f/f_h)} \longrightarrow 1$$

$$\left|\frac{Vout}{Vin}\right| = \frac{A_F}{\{1 + (f/f_h)^2\}^{1/2}} \longrightarrow 2$$

Vin = Input signal Voltage
Vout = Output signal Voltage

$$\left|\frac{Vout}{Vin}\right| = \text{Gain of filter as a function of frequency}$$

AF = 1 + $R_F$ / R1 = pass band gain of filter

f = frequency of input signal

$f_H = 1/2\pi RC$ = high cut off frequency, 3-db frequency, corner frequency Operation of low pass filter using equation 2

a. at low frequencies $f < f_H$ $$\left|\frac{Vout}{Vin}\right| = A_F$$

b. at $f = f_H$ $$\left|\frac{Vout}{Vin}\right| = 0.707 * A_{F\,(approx)}$$

c. at $f > f_H$ $$\left|\frac{Vout}{Vin}\right| < A_F$$

The ideal low pass filter has a constant gain $A_F$ from 0 to high cut off frequency ($f_H$) at $f_H$ the gain is 0.707 * $A_f$. And after $f_H$ it decreases at a constant rate with an increase in frequency i.e. when input frequency is increased tenfold (one decade), the voltage gain is divided by 10.

$$\text{Gain (db)} = 20 \log |V_{out} / V_{in}|$$

i.e. Gain Roll off rate is –20db / decade.

**High Pass Filter :**

It is a frequency selective circuit, which passes signals of frequencies above it's low cut off frequency ($f_L$) and attenuates signals of frequencies below $f_L$.

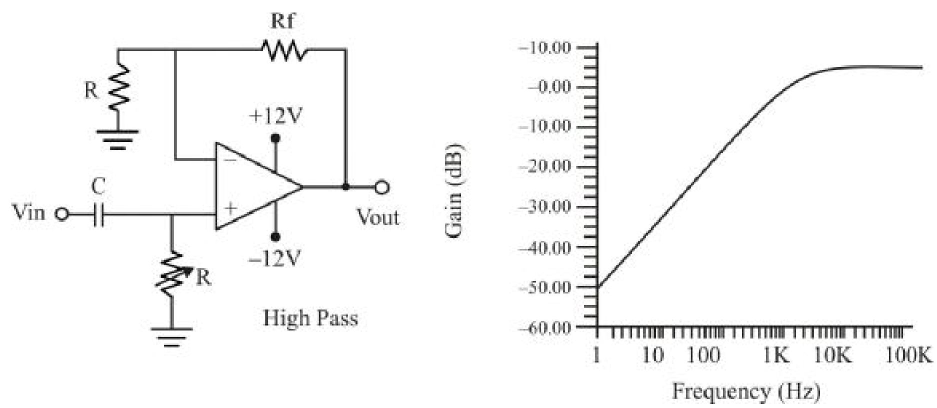



**Figure 2**

Equation of High pass filter is

$$\frac{Vout}{Vin} = \frac{A_F}{1 - j(f_L/f)} \longrightarrow 3$$

$$\left|\frac{Vout}{Vin}\right| = \frac{A_F}{\{1 + (f_L/f)^2\}^{1/2}} \longrightarrow 4$$

Vin = Input signal Voltage

Vout = Output signal Voltage

$$\left|\frac{Vout}{Vin}\right| = \text{Gain of filter as a function of frequency}$$

$A_F = 1 + R_F / R1$ = pass band gain of filter
f = frequency of input signal

$f_L = 1/2\,\pi\,RC$ = Low cut off frequency, 3-db frequency, corner frequency Operation of high pass filter using equation.

a. at low frequencies $f < f_L$ $\quad \left|\frac{Vout}{Vin}\right| < A_F$

b. at $f = f_L$ $\quad \left|\frac{Vout}{Vin}\right| = 0.707 * A_{F\,(approx)}$

c. at $f > f_L$ $\quad \left|\frac{Vout}{Vin}\right| < A_F$

In ideal high pass filter, when $f < f_L$ gain is increased at a constant rate has a constant rate with an increase in frequency. At $f_L$ the gain is $0.707*A_F$. And above $f_L$ it has constant gain of $A_F$. Below $f_L$ when input frequency is increased tenfold (one decade), the voltage gain is multiplied by 10.

Gain (db) = 20 log | Vout / Vin |

i.e. Gain Roll off rate is –20db / decade.

**Experiment 1**

**Objective :**

**Study of the Active Low Pass Filter and to Evaluate :**

- **High cutoff frequency of Low pass filter.**
- **Pass band gain of Low Pass Filter.**
- **Plot the frequency response of Low Pass Filter.**

**Equipments Needed :**

1. Analog board of **AB51.**
2. DC power supplies +12V, –12V from external source or **ST2612 Analog Lab**.
3. Function generator or **ST2612 Analog Lab**.
4. Oscilloscope
5. Digital Multimeter
6. 2 mm patch cords.

**Circuit diagram :**

Circuit used to study Active Low pass filter shown in figure 3.

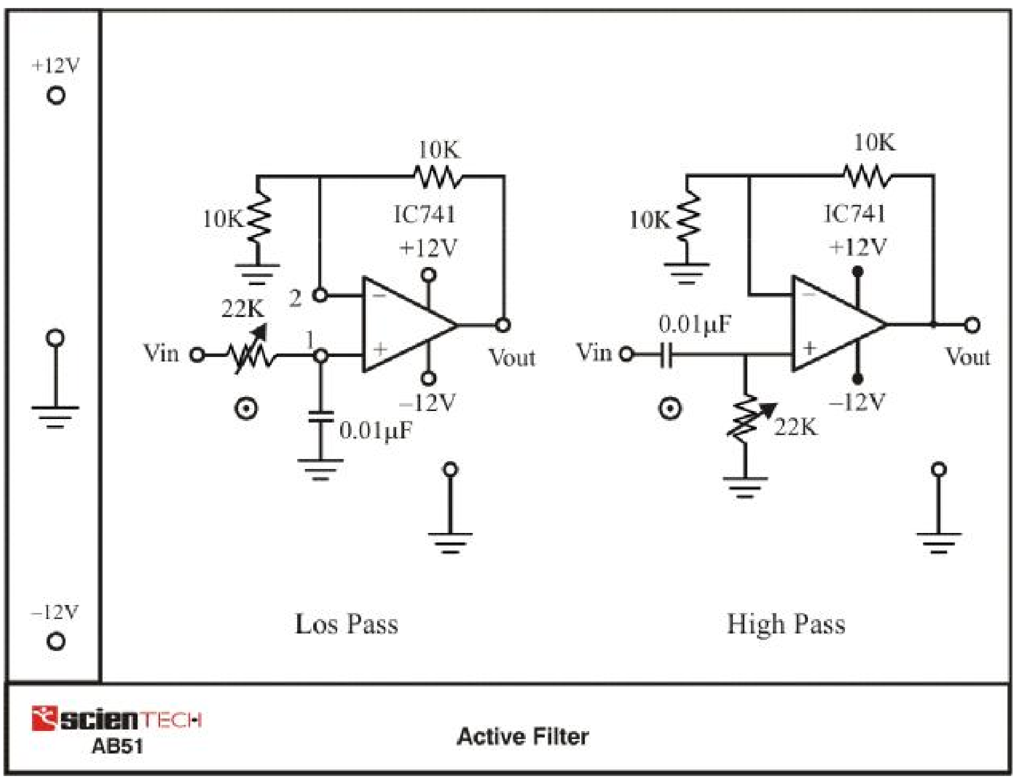



**Figure 3**

**Procedure :**

**1.** Connect Ohmmeter between Test point Vin and Test point 1. Adjust resistance value to 1.59K by varying the potentiometer 22K of Low pass filter to set the high cutoff frequency ($f_H$) at 10K.

**2.** Connect +12V and –12V DC power supplies at their indicated position from external source or **ST2612 Analog Lab**.

**3.** Switch 'On' the power supply.

**4.** Connect a sinusoidal signal of amplitude 1V (p-p) of frequency 1KHz to Vin of Low Pass Filter from external source or **ST2612 Analog Lab**.

**5.** Observe output on oscilloscope by connecting Test point Vout to oscilloscope.

**6.** Increase the frequency of input signal step by step and observe the effect on output Vout on oscilloscope.

**7.** Tabulate values of Vout, gain, gain (db) at different values of input frequency shown in observation Table.

**Observation Table :**

| Sr. No. | Input frequency (Hz) | Vout | \|Vout / Vin\| = gain | Gain(db) = 20 Log \|Vout / Vin\| |
|---|---|---|---|---|
| **1** | 500 | | | |
| **2** | 1 K | | | |
| **3** | 5 K | | | |
| **4** | 10 K ($f_H$) | | | |
| **5** | 15 K | | | |
| **6** | 20 K | | | |
| **7** | 30 K | | | |

**8.** Plot the frequency response of low pass filter using the data obtained at different input frequencies.

**9.** Perform the same procedure at different Cutoff frequencies as shown below:

| **Resistance (W)** | **Capacitance (uF)** | **$f_H$ high cutoff frequency (Hz)** |
|---|---|---|
| 800 | 0.01 | 20K |
| 1.59 K | 0.01 | 10K |
| 15.9 K | 0.01 | 1K |

**Theoretical Calculations :**

Calculate all the following values

**1.** Pass band gain of Low pass filter $A_F = 1 + R_F / R_1$

**2.** Pass band gain (db) = 20 log |Vout / Vin|

**3.** 3 db frequency $f_H = 1/2\pi RC$

**4.** Gain at 3 db frequency $f_H = 0.707 * A_F$

**5.** Gain (db) at 3 db frequency $f_H$ = 20 log |Vout / Vin| where Vout = $(2)^{1/2}$ * Vin

**6.** Roll off rate = –20db/decade

**Results :**

| | **Theoretical** | **Practical** |
|---|---|---|
| **Pass band gain($A_f$)** | | |
| **Pass band gain($A_f$) in db** | | |
| **3db frequency $f_H$** | | |
| **Gain at 3db frequency ($f_H$ ) in db** | | |

**Experiment 2**

**Objective :**

**Study of the Active High Pass Filter and to Evaluate :**

1. **Low cutoff frequency of Low pass filter.**
2. **Pass band gain of High pass filter.**
3. **Plot the frequency response of High pass filter.**

**Equipments Needed :**

1. Analog board of **AB51.**
2. DC power supplies +12V, **–**12V from external source or **ST2612 Analog Lab**.
3. Function generator or **ST2612 Analog Lab**.
4. Oscilloscope
5. Digital Multimeter
6. 2 mm patch cords.

**Circuit Diagram :**

Circuit used to study Active High pass filter shown in figure 4.

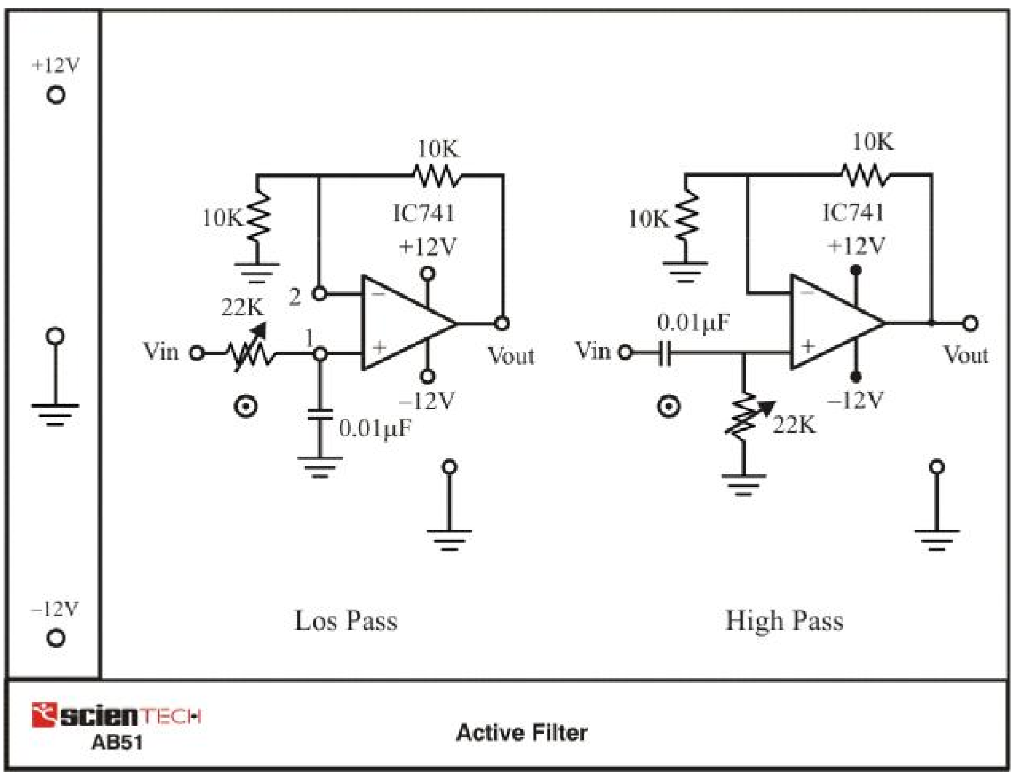



**Figure 4**

**Procedure :**

1. Connect Ohmmeter between Vin and Test point 3. Adjust resistance value to 15.9K by varying the potentiometer 22K of High pass filter to set the Low cutoff frequency ($f_L$) at 1K.
2. Connect +12V and –12V DC power supplies at their indicated position from external source or **ST2612 Analog Lab**.
3. Switch 'On' the power supply.
4. Connect a sinusoidal signal of amplitude 1V (p-p) of frequency 100 Hz to the Test point $V_{in}$ of high pass filter from external source or **ST2612 Analog Lab**.
5. Observe output on oscilloscope by connecting Test point Vout to oscilloscope.
6. Increase the frequency of input signal step by step and observe the effect on output Vout on oscilloscope.
7. Tabulate different values of Vout, gain, gain (db) at different values of input frequency shown in observation Table.

**Observation Table :**

| **Sr. No.** | **Input frequency (Hz)** | **Vout** | **\|Vout / Vin\| = gain** | **Gain(db) = 20 Log \|Vout / Vin\|** |
|---|---|---|---|---|
| **1** | 100 | | | |
| **2** | 200 | | | |
| **3** | 500 | | | |
| **4** | 1K($f_L$) | | | |
| **5** | 5 K | | | |
| **6** | 10 K | | | |
| **7** | 15 K | | | |
| **8** | 20 K | | | |

8. Plot the frequency response of high pass filter using the data obtained at different input frequencies.
9. Perform the same procedure at different Cutoff frequencies as shown below:

| **Resistance (W)** | **Capacitance (µF)** | **3 db frequency (Hz)** |
|---|---|---|
| 800 | 0.01 | 20K |
| 1.59 K | 0.01 | 10K |
| 15.9 K | 0.01 | 1K |

**Theoretical Calculations :**

Calculate all the following values

1. Pass band gain of Low pass filter $A_F = 1 + R_F / R_1$
2. Pass band gain (db) = 20 log |Vout / Vin|
3. Low cutoff frequency $f_L = 1/2\pi RC$
4. Gain at Low cutoff frequency $f_L = 0.707 * A_F$
5. Gain (db) at Low cutoff frequency $f_H$ = 20 log |Vout / Vin| where
   Vout = $(2)^{1/2}$ * Vin
6. Roll off rate = –20db/decade

**Results :**

| | **Theoretical** | **Practical** |
|---|---|---|
| **Pass band gain($A_f$)** | | |
| **Pass band gain($A_f$) in db** | | |
| **Low cutoff frequency ($f_L$)** | | |
| **Gain at 3db frequency ($f_L$ ) in db** | | |

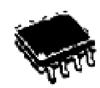
**Data Sheet**

# UA741

## GENERAL PURPOSE SINGLE OPERATIONAL AMPLIFIER

- LARGE INPUT VOLTAGE RANGE
- NO LATCH-UP
- HIGH GAIN
- SHORT-CIRCUIT PROTECTION
- NO FREQUENCY COMPENSATION
- REQUIRED
- SAME PIN CONFIGURATION AS THE UA709

**N**
**DIP8**
**(Plastic Package)**



**D**
**SO8**
**(Plastic Micropackage)**

### DESCRIPTION

The UA741 is a high performance monolithic operational amplifier constructed on a single silicon chip. It is intented for a wide range of analog applications.

- Summing amplifier
- Voltage follower
- Integrator
- Active filter
- Function generator

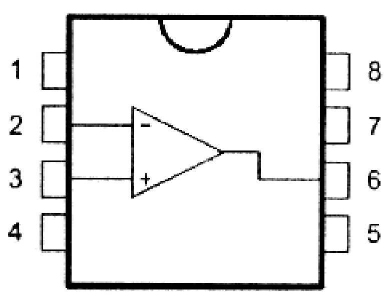
The high gain and wide range of operating voltages provide superior performances in integrator, summing amplifier and general feedback applications. The internal compensation network (6dB/octave) insures stability in closed loop circuits.

### ORDER CODE

| Part Number | Temperature Range | Package | |
|---|---|---|---|
| | | N | D |
| UA741C | 0°C, +70°C | • | • |
| UA741I | -40°C, +105°C | • | • |
| UA741M | -55°C, +125°C | • | • |
| **Example** : UA741CN | | | |

N = Dual in Line Package (DIP)
D = Small Outline Package (SO) - also available in Tape & Reel (DT)

**PIN CONNECTIONS** (top view)




1 - Offset null 1
2 - Inverting input
3 - Non-inverting input
4 - $V_{CC}^-$
5 - Offset null 2
6 - Output
7 - $V_{CC}^+$
8 - N.C.

November 2001 1/5

## Warranty

1. We guarantee the product against all manufacturing defects for 24 months from the date of sale by us or through our dealers. Consumables like dry cell etc. are not covered under warranty.
2. The guarantee will become void, if
   - **a)** The product is not operated as per the instruction given in the operating manual.
   - **b)** The agreed payment terms and other conditions of sale are not followed.
   - **c)** The customer resells the instrument to another party.
   - **d)** Any attempt is made to service and modify the instrument.
3. The non-working of the product is to be communicated to us immediately giving full details of the complaints and defects noticed specifically mentioning the type, serial number of the product and date of purchase etc.
4. The repair work will be carried out, provided the product is dispatched securely packed and insured. The transportation charges shall be borne by the customer.

For any Technical Problem Please Contact us at **service@scientech.bz**

## List of Accessories

1. 2mm Patch Cord (Red) 16" .................................................................. 2 Nos.
2. 2mm Patch Cord (Black) 16"................................................................ 2 Nos.
3. 2mm Patch Cord (Blue) 16" ................................................................. 3 Nos.
4. e-Manual.......................................................................................... 1 No.

Updated 26-06-2009