



FEATURES

- 1.0 to 5V DC supply voltage
- 70µA of analog current drain (typical)
- 6µA of memory current drain (typical)
- single or dual switch control
- touch plate compatible (for GT560 on 30MΩ typ impedance)
- typical 42dB range
- adjustable clock frequency increases or decreases time required to change diode impedance

CIRCUIT DESCRIPTION

The GT/LV560 is a low voltage transconductance block which can be used as an electronic volume control. The transconductance element consists of two diodes back-to-back, whose impedance is varied by changing the amount of current through the diodes.

The impedance of the diodes is controlled by digital circuitry which consists of:

- an oscillator with an external capacitor, C_T to set the ramp frequency f_c .

$$f_c = \frac{5 \times 10^{-7}}{C_T}$$

- logic interface, which senses the volume up-down controls
- a digital / analog converter
- the control logic/debounce logic
- synchronous up-down counter

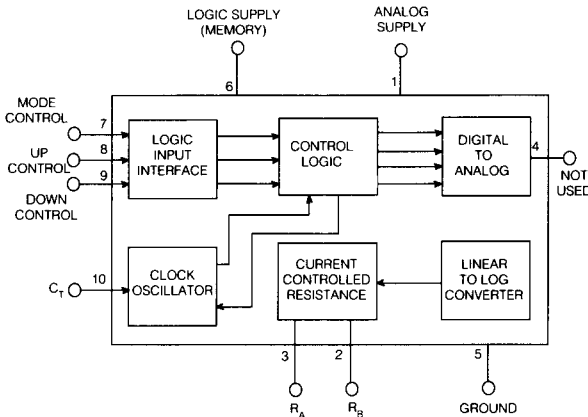
To increase or decrease the LV560 impedance, the switching mechanism can be touch sensitive contacts or a mechanical switch. In either configuration, the switches are connected from pin 8 to ground and pin 9 to ground. Any resistance, up to 6 MΩ from pin 8 or 9 to ground will activate the GT/LV560 control circuitry and the device will change impedance levels.

OPERATION

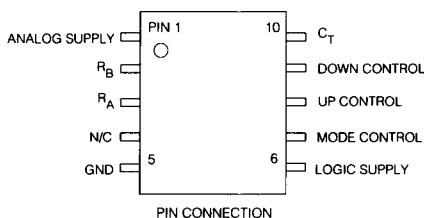
The impedance can be controlled using one of two methods. The first method utilizes a Single Pole Single Throw (SPST), momentary contact switch which combines the up/down function in one action (see Fig. 2). The second method (see Fig. 3) uses one Single Pole Double Throw (SPDT), or two SPST switches which provide a separate action for the up-down function. These switches can be mechanical or touch sensitive.

To operate the GT/LV560 using a single switch, the Mode Control (MC) is connected to the positive supply, the switch will then act in an alternating manner first increasing impedance when activated, then decreasing impedance when activated a second time, both at a rate determined by the external timing capacitor.

If separate UP or DOWN switches are used, the Mode Control pin connects to ground. Making contact to the DOWN switch, the diode impedance will decrease until the switch is released or the diodes reach minimum impedance (4kΩ). Similarly, contact to the UP switch will increase the diodes impedance until the switch is released or the maximum value of diode impedance has been reached (500kΩ).



FUNCTIONAL BLOCK DIAGRAM



Once the minimum (4 k Ω) or maximum (500 k Ω) impedance is reached and the switch is still closed, the impedance will stop changing until the switch is released and the direction is reversed. Should both switches be closed simultaneously, the output impedance will remain unchanged.

In order for the LV560 to be activated and change impedance the switch must be pressed for at least one time constant, t_c ,

$$\text{where } t_c = \frac{1}{f_c}$$

Normally the timing capacitor C_T is connected to ground, as shown in Figure 1. When the circuit is turned on, C_T is required to charge from 0 VDC to approximately 0.56 VDC. During this charge up condition, the clock is disabled and ramping of the impedance by the touch contacts or switches will be inactive until C_T is charged.

Small values of C_T eg. 0.1 μ F, will cause a time delay of less than 2 seconds, however as the value of C_T is increased, eg. 1.0 μ F the charge time can be as high as 20 seconds.

If the length of the charge time is undesirable, the capacitor can be referenced to a microphone decoupling point as shown in Figure 13. In this configuration the capacitor charge time will be less than 2 seconds with a 1.0 μ F capacitor.

It is required that C_T be connected to a positive reference voltage which has a high supply line rejection ratio, such as a voltage regulator, or a microphone decoupling point. If C_T was referenced directly to the supply, any battery line signals greater than 10 mVRMS will affect the clock rate on the GT/LV560. This would cause the ramp speed to become erratic as the impedance is being changed.

When the hearing aid is initially turned on, e.g. insertion of the battery, the diode impedance will be at a random setting for the LV560 and a mid gain setting (which is typically 7 steps from the minimum impedance setting) for the GT560. Once the desired impedance is determined this value will be held constant by the memory circuitry on the LV560. Connecting the memory supply (VM), to the battery positive bypassing the on-off switch, will allow the volume control to retain the selected impedance even with the hearing aid switched off. The memory current drain is extremely low at 6 μ A. If however the battery is removed, memory will be lost.

The 560 may be used as the feedback impedance across an inverting gain block, such as a LC508 preamplifier. The gain of the amplifier would then be determined by the ratio of the diode impedance to the source impedance of the LC508 preamplifier. For example, if a microphone with a typical impedance of 4 k Ω were to be used as the source to the LC508 preamplifier, and the GT/LV560 connected across the input and output pins with a minimum impedance of 4 k Ω , the minimum gain would be a ratio of 4:4 (or 0 dB).

With the maximum impedance at 500 k Ω , the maximum gain would be a ratio of 500:4 approximately (or 42 dB). The volume control range is 42 dB.

It is important that either R_A or R_B on the LV560 be DC coupled to the LC/LP508 preamplifier stage to set up a reference voltage on the diodes, otherwise the volume control will not be biased properly. The LV560 pins R_A and R_B , will operate from 200 mV below supply to 500 mV above ground.

Note: A resistor of 1.2 M Ω is required between Pin 2 and Pin 3 to limit the step size to 3.0 dB. If this resistor is not used at high gain settings the steps will be greater than 3.0 dB, resulting in high distortion on the LC/LP508.

ABSOLUTE MAXIMUM RATINGS

Parameter	Value & Units
Supply Voltage	5 VDC
Power dissipation at $T_A \leq 70^\circ\text{C}$	25 mW
Operating Temperature	-10 $^\circ\text{C}$ to +40 $^\circ\text{C}$
Storage Temperature	-20 $^\circ\text{C}$ to +70 $^\circ\text{C}$

ELECTRICAL CHARACTERISTICS

(refer to test circuit and test conditions)

Parameter	Min	Typ	Max	Units
I_{Analog}	40	70	130	μA
I_{Logic}	-	6	10	μA
Distortion	-	1	2.9	%
Step Size	1.0	2.5	4.0	dB
Impedance :				
Low	2.5	4	6	k Ω
High	250	500	700	k Ω
VCO	36	42	48	dB

TEST CONDITIONS (refer to test circuit)

Parameter	Value	Units
Supply Voltage	1.3	VDC
Source Impedance	3.94	k Ω
Frequency	1.0	kHz
Output Level for		
Impedance Test	15	mVRMS
Distortion	10	mVRMS
Temperature	25	$^\circ\text{C}$

TEST PROCEDURES

- 1) I_{Analog} measured with the 560 impedance set to minimum.
- 2) To calculate the minimum impedance, set the LV560 to lowest impedance setting.

$$V_{OUT} = 15 \text{ mV and measure } V_{IN}$$

$$Z_{MIN} = \frac{V_{OUT} (3.94k)}{V_{IN}}$$

- 3) To calculate Z_{MAX} set the impedance of the 560 to maximum.

Set the output (V_{OUT}) to 15 mV and measure V_{IIN}

$$Z_{MAX} = \frac{V_{OUT} (3.94k)}{V_{IN}}$$

NOTE:

S1 and S2

- for GT560, is referenced to the power supply
- for the LV560, is referenced to ground

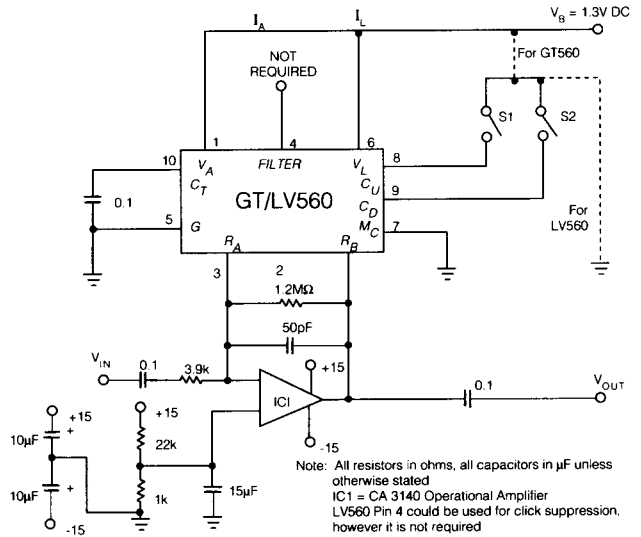
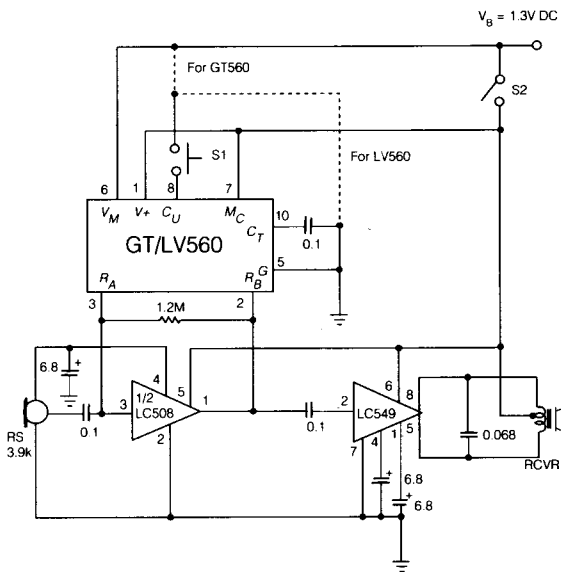
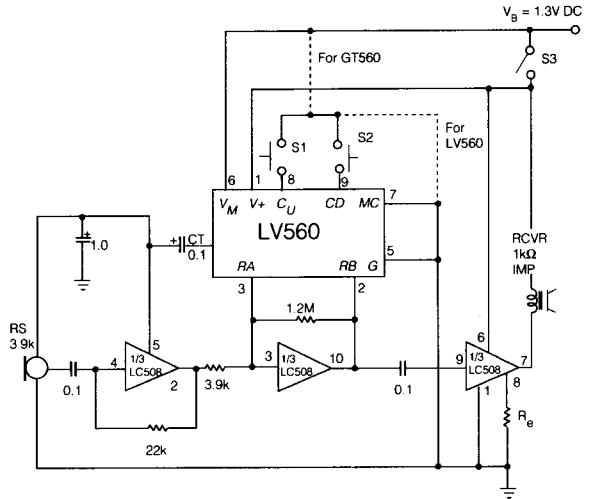


Fig.1 LV560 Test Circuit



Note: All resistors in ohms, all capacitors in μF unless otherwise stated
 S1 can be a momentary SPST switch or a pair of contacts.
 On initial power-up (insertion of the battery) the gain will be at a random setting

Fig.2 Typical Hearing Aid Circuit



Note: All resistors in ohms, all capacitors in μF unless otherwise stated
 S1, S2 are momentary switches or contacts
 Closing S1 increases gain
 Closing S2 decreases gain

Fig.3 Typical Hearing Aid Application

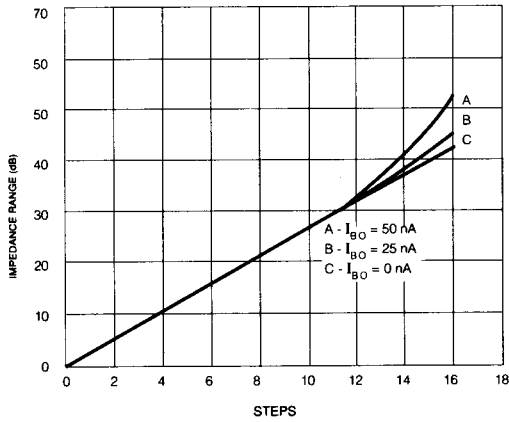
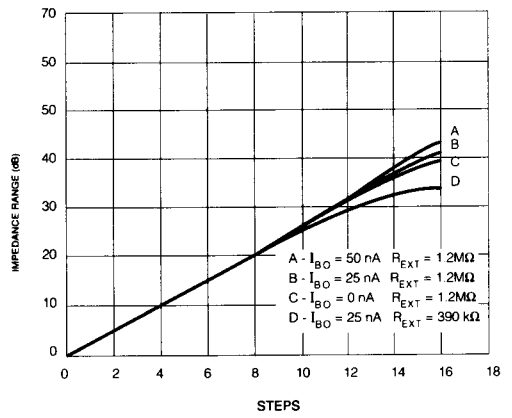


Fig.4 Output Impedance Characteristics without External Shunt Resistor



Note: I_{BO} is the Input Bias Current of the LP/LC508 Preamplifiers

Fig.5 Output Impedance Characteristics with $R_{EXT} = 1.2 \text{ M}\Omega$

AVAILABLE PACKAGING
 10 pin MICROpac,
 PLID®, and SLT

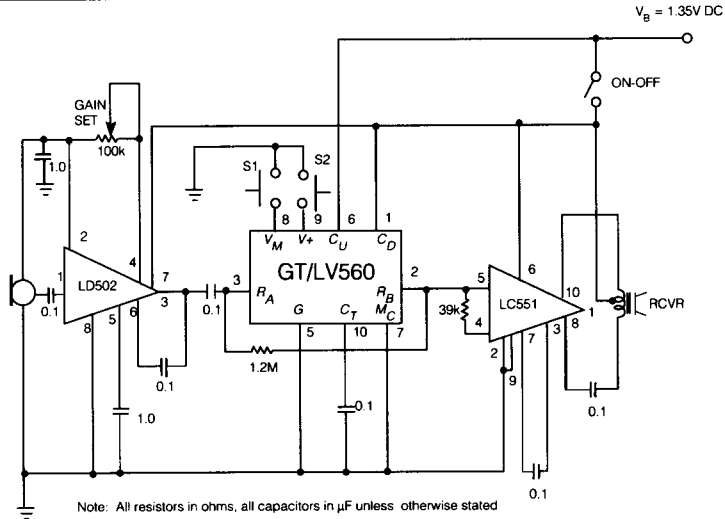


Fig.6 LD502/LV560/LC551 Typical Application