

DIY Kit 23. OPAMP FUNCTION GENERATOR

INTRODUCTION

You do not need a lot of money to have access to square, triangle or sine waves in the audio range. This simple Kit uses four operational amplifiers (opamps) to deliver these waveforms in the 6 Hz to 7000 Hz range. The sine wave is a pseudo sine wave produced by a very simple wave shaping circuit.

The kit is constructed on a single-sided printed circuit board (PCB). A computer-aided design program was used to design the board.

ASSEMBLY INSTRUCTIONS

Identify all the components supplied in the kit against the Components listing. Make sure you get the 4 diodes and the integrated circuit (IC) around the correct way. Match the bar on the diodes with the bar shown on the PCB overlay.

CIRCUIT DESCRIPTION

Square, sine and triangle waves are produced using an LM348 and passive components. The LM348 is a quad operational amplifier IC package; that is, it contains four separate opamps all in the one IC. They are marked A, B, C & D in the schematic diagram.

Square Wave.

One opamp (LM348:D) is used. The voltage level to pin 13 is set by the resistor divider pair R1 and R2. The input to pin 12 depends on two things; firstly the potential of pin 14, and secondly, the voltage output of opamp C at pin 8. When the input at pin 13 is higher than the input at pin 12 the output goes low. If it is lower then the output goes high. Switching back and forth between the two states causes a square wave to be produced. The time constant $(R4+R5)C2$ determines the frequency.

Triangle Wave.

You can also consider that opamp D is set up as a bi-directional threshold detector with positive feedback provided by R3. R3 also gives hysteresis. The output provides a bias which tends to keep it in its existing state before allowing switching to take place. The inverting input is set up at about half the opamp output swing voltage by resistors R1 and R2. Accordingly the signal required from opamp C to cause switching is offset from this midpoint voltage by $R11/(R11+R3)$ which is approximately $2/3$ the voltage from midpoint to swing limit and is symmetrical above and below the switching point.

Opamp C is set up as an integrator. It performs the mathematical operation of integration with respect to time. For a constant input the output is a constant multiplied by the elapsed time, that is, the output is a ramp. Since the input signal goes to the inverting input, a high input will produce a ramp down and a low input will produce a ramp up. The input signal is a square wave symmetrical about the midpoint potential. The current this potential produces through R4 and R5 is constant so the up and down ramps are of equal gradient and the resultant

triangular wave is symmetrical.

Any increase in the trimpot R5 reduces the current and the integration constant which lowers the gradient of the ramp. The switching levels haven't changed so the frequency reduces while the amplitude remains constant. In a similar way the current depends on the value of integration capacitor. Accordingly the integration constant and hence the frequency vary with the value of the capacitor. (Higher value, lower frequency since the capacitor takes longer to charge.) If C2, for example, is increased to say 680nF then the minimum frequency will be less than 1Hz.

The output triangle wave does not require amplification but it does require buffering so that that loading does not affect the waveform generator circuit. It is buffered here with opamp A connected as a unity gain buffer. Unity gain is achieved by directly coupling back the output to the inverting input.

Sine Wave.

A pseudo or imitation sine wave is produced by a wave shaping circuit. A diode is a non-linear device. As the potential difference across it increases the current rises in the characteristic way published in all textbooks. This circuit 'joins together' this characteristic curve to produce an approximation to a sine wave. Two diodes have been joined together as a series pair in order to provide a higher amplitude than would be obtained using only a single diode.

The shape of the pseudo sine wave could be improved at any particular frequency by filtering, but filtering will cause distortion at lower frequencies and loss of amplitude at higher frequencies. You can have perfect sine waves at particular frequencies by switching in appropriate filters at those frequencies.

The sine wave is sensitive to loading and must be buffered. It is also low in amplitude and needs amplification. R9 & R10 set the gain of opamp B by forming a voltage divider between the source and the output. If the wave shaper voltage is 1 volt higher than the reference (at the non-inverting input) the opamp reduces the output voltage until the inverting input voltage set by the divider is equal to the non-inverting voltage. The ratio of the values of R10 to R9 give the gain. The gain here is about 2.

WHAT TO DO IF IT DOES NOT WORK

Poor soldering is the most likely reason that the circuit does not work. Check all solder joints carefully under a good light. Next check that the four diodes and the IC are in their correct orientation on the PCB. Is the battery flat? A cathode ray oscilloscope (CRO) is the ideal test instrument to check the operation of the Kit.

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COMPONENTS

Resistors, 5%, 1/4W		
560R	green blue brown	1
820R	grey red brown	1
1K	brown black red	1
8K2	grey red red	1
10K	brown black orange	1
15K	brown green orange	1
82K	grey red orange	1
100K	brown black yellow	1
470K	yellow violet yellow	1
1M	brown black green	1
1M Piher log pot + spindle		1
1N4004 diode		4
9V battery snap		1
47nF ceramic capacitor		2
LM348 IC		1
14 pin IC socket		1
Kit 23 pcb		1

