

## The Bed of Nails: How it Works

The Bed of Nails is built around the idea of amplifier feedback to create oscillation and noise.

A dual operational amp (op-amp) is used (2 op amps).

The outputs from the op amps are cascaded: from the output of the first to the input of the second.

And then, a feedback loop is formed (and oscillation) by connecting the output of the second op amp (nail 7) back into the input of the first op amp (nail 2) through a resistor.

The resistor can be fixed, a potentiometer (pot/variable resistor), or a body contact (skin resistance on touch). The resistance value will change the behaviour of the sound circuit, for example, the frequency of the oscillator. Re. touch. With this circuit, the greater the pressure and skin surface area, the lower the pitch.

The Bed of Nails can be played in many ways. Typically touching nails 2 and 7 to complete the feedback loop (marked A and B on the schematic) will create oscillation. Other nails can be touched simultaneously to produce a variety of sounds.

## The Circuit: a single-supply op-amp inverting amplifier

### 1. Inverting Amplifier

See 1: Bed of Nails\_annotated.pdf

Our circuit is based on the inverting amplifier to create gain and thus feedback.

The gain is set by the input resistor (R1) and the feedback resistor (R3); and is calculated:

feedback resistor (R3) / input resistor (R1)

$1M/10k$  (1,000,000 /10,000) = 100 (a gain factor of 100!)

See video for more on op amps and gain calculations:

<https://www.youtube.com/watch?v=4M4H-aLvloA&t=258>

### 2. Single-supply Power

Many op-amp circuits use a split (dual) power supply: a power supply that provides positive voltage as well as negative voltage (current in both directions). When working with audio (alternating current, AC), there are benefits of this. A split supply allows the op-amp to output an AC signal, centred on 0V to directly drive a loudspeaker.

But we want to use a common-all-garden 9 volt (PP3) battery to power our circuit. The battery provides direct current (DC). Current in one direction only.

### Virtual Ground

See 2: Bed of Nails\_annotated.pdf

Instead of alternating between a positive and negative voltage, a voltage reference point is created, for example, at half the supply voltage.

Voltage divider (2 x resistors at equal value) to produce 4.5 volts (see 2: Bed of Nails\_annotated.pdf).

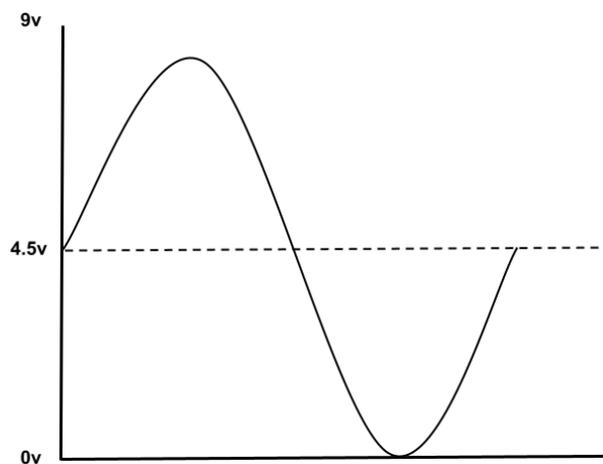


Figure 1. Virtual Ground centred around 4.5v

See A Single-Supply Op-Amp Circuit Collection for further reading.

### 3. Attenuation resistor and DC blocking cap

See 3: Bed of Nails\_annotated.pdf

An output resistor and cap are typical in many sound circuits. The resistor (R6) attenuates the signal making it more suitable for line level output. And the cap (C2) blocks any unwanted direct current (DC) at the output stage.

Discuss loudspeakers and alternating current, and the impact of direct current at the output stage.