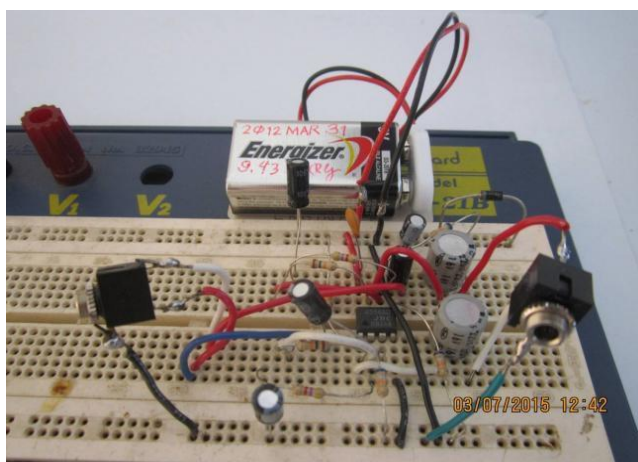


## "BHAKit" the Basic Headphone Amplifier Kit

P/N 2226610



"BHAKit" the Basic Headphone Amplifier Kit is an analog educational kit about op amp applications based on New Japan Radio NJM4556AD dual high current operational amplifier capable of delivering 50mW power into 32 ohms load (enough to produce high volume levels through typical headphones); the kit is intended for bread boarding but can be built on the supplied prototyping board. NJM4556AD is configured as a single supply AC-coupled non-inverting amplifier with a gain of 3 demonstrating one of the most popular consumer electronics applications of op amp, the headphone amplifier. As an analog educational kit you breadboard the circuit to have the convenience to hook up an ammeter to monitor current flowing into each component or solder the components to the prototyping board then enclose in a plastic project case to have your 1st DIY headphone amp on the go. For very detailed headphone amplifier design & testing there are many excellent technical materials at NwAvGuy <http://nwavguy.blogspot.sg/> To maximize analog learning, modifying the circuit with a power transistor & trimmer resistor a basic motor speed controller can be designed, an example of DC application of the operational amplifier even though NJM4556AD is not optimized for DC amplification (Analog Devices OP07CPZ is recommended to improve offset voltage). The kit is all set with 3V hobby motor and circuit operation is discussed by Andy Collinson of Circuit Exchange International. It is suggested to check out Analog Devices Hardware and Housekeeping Techniques at [http://www.analog.com/library/analogDialogue/archives/39-05/Web\\_Ch7\\_final\\_J.pdf](http://www.analog.com/library/analogDialogue/archives/39-05/Web_Ch7_final_J.pdf) to avoid the pitfall of poor circuit assembly.

### WARNING:

**If you are unsure of the dangers involved with your particular project, consult with someone who is experienced. Always wear eye protection and gloves. FAILURE TO INITIATE AND FOLLOW YOUR OWN SAFETY PROCEDURES MAY RESULT IN BODILY INJURY OR DEATH!**

**Time Required: 1 hour depending on experience**

**Experience Level: Beginner**

**Required tools and parts:**

**Note: Some required components are not available from Jameco but are key components to the kit's function.**

### Required

1. Dual High Current Operational Amplifier, NJM4556AD, Jameco does not stock, but this is a major component of this project.
2. Multimeter, Jameco P/N 1537328
3. Pliers Long Nose, Jameco P/N: 177608
4. Wire Cutter, Jameco P/N 179902
5. Screwdriver, Jameco P/N 34041
6. Soldering Station, Jameco P/N 2196801
7. Solderless Breadboard, Jameco P/N 2157693
8. Solder, Jameco P/N 94570
9. Wire Hook-up Solid 22 AWG, Jameco P/Ns: 2152876, 2152905, 2153553
10. 9 volt Battery, Jameco P/Ns: 244620 or 2112461
11. Headphones with 3.5mm plug preferably 16 to 32 ohms
12. CD Audio/MP3 player with 3.5mm headphone jack or 2 RCA jack (Line out)
13. 3.5 mm Male to Male Stereo Cable, Jameco P/N 2174637 or Stereo 3.5mm Male Plug to 2 RCA Male Plugs 6 Foot Cable, Jameco P/N 228401

### Optional

1. Scope, Jameco P/N: 2171655
2. Potentiometer Adjustment Tool, Jameco P/N: 153315
3. Wire Cutter Stripper, Jameco P/N: 215889
4. Speaker, Jameco P/N: 2099585
5. Audio Test CD ex. Lasertrak CD2000 <http://www.testdisc.com/lasertrakcd2000.html>

### Bill of Materials:

Qty	Jameco SKU	Component Name
2	216452	BATTERY SNAP,SAFETY,6 INCH ,26AWG,6 PRONG
2	2095437	JACK, AUDIO STEREO, 3.50mm, 3-TERMINAL, 10.10Hx8.40Wx17.60L mm, BLACK WITH NUT

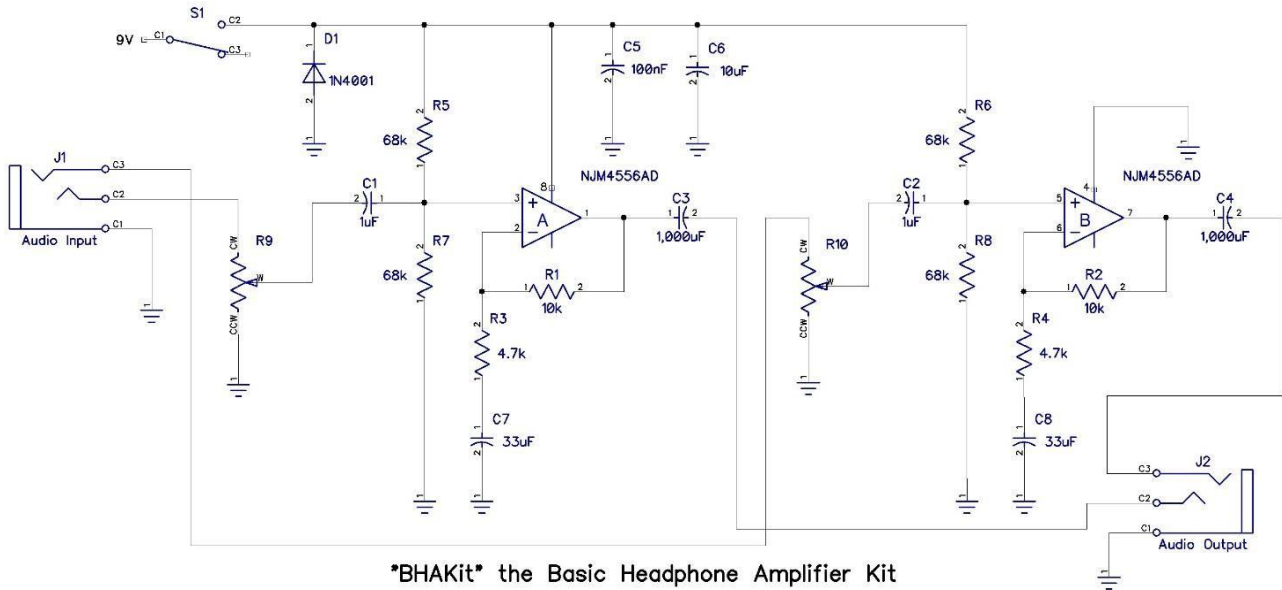
2	158298	Capacitor Aluminum 1000uF 25V 20% (16 X 15mm) Radial 7.5mm 1690mA 5000h 105C
1	2125042	SB300 Solderable PC Breadboard 1 Sided PCB Matches 300 Tie-Point Breadboards
2	2163882	250 Volt 1/2 Watt 10k Ohm 1% Metal Film Resistor
1	1946367	Capacitor Radial10 uF 25 Volt 20% 85c 5x11x5mm
3	920510	Capacitor 0.1 uF 50 Volt PLYE 5% 7.3 X 4 X 5mm Radial 5mm
2	27001	1 uF 100 Volt Mylar Capacitor
6	691307	Resistor Carbon Film 68k Ohm 1/4 Watt 5%
2	691024	Resistor Carbon Film 4.7k Ohm 1/4 Watt 5%
2	112206	Socket IC 08 Pin Dual Wipe Solderail Low Profile 0.30 Inch Width
1	2181466	Dual Audio Potentiometer, 10k
1	1097713	Transistor General Purpose BJT NPN 100 Volt 3 Amp 3-Pin 3+ Tab TO-220
1	76961	Diode 100 Volt 1A 2-Pin DO-41
1	154923	MOTOR,DC,16K RPM@3V,SHAFT .08 INCH DIAMETER X.32 INCH LONG ,SOLDER TABS
1	241146	POTENTIOMETER,10K OHM,3299W-103,25-TURN,.5 WATT,CERMET
1	158289	Capacitor Radial 470 uF 25 Volt 20% 105c 10x16x5mm
1	35975	50 Volt 1 Amp Silicon Rectifier Diode
2	2135857	RED ROUND SINGLE POLE DOUBLE THROW TOGGLE SWITCH
2	93747	33uF 50 VOLT RADIAL CAPACITOR

### Step 1 - "BHAKit" Circuit Schematic

"BHAKit" the Basic Headphone Amplifier Kit circuit schematic.

Amp A is for the left channel & amp B is right.

Gain equals  $1 + R1 (R2) / R3 (R4) = 1 + 10k / 4.7k = 3.13 (9.9dB)$

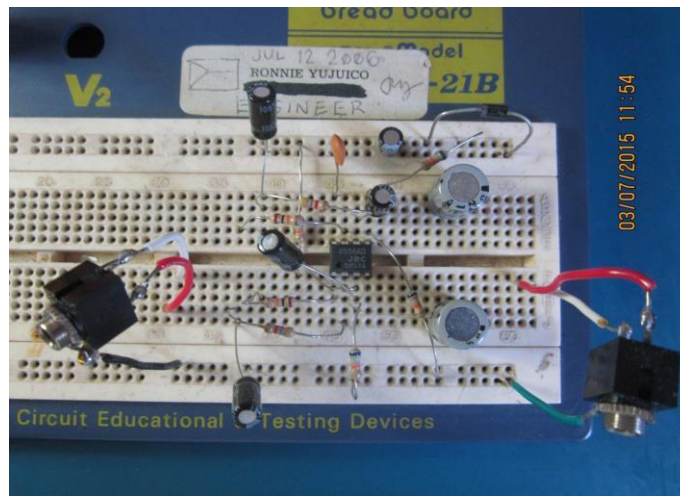


### Step 2 - Component Placement

Place the components on the breadboard according to the schematic. Install 0.1uF bypass capacitor as close as possible to the IC power supply pins 4 & 8.

Potentiometer R9 & R10 (Dual Audio Potentiometer) is optional intended for audio player without volume control.

Solder AWG 22 solid wire to connectors J1 & J2, dual potentiometer R9 & R10, 9V battery snap & toggle switch S1 to facilitate installation on breadboard.



### Step 3 - Component Connection

Connect ICs & passive components via AWG 22 solid wire. It is suggested to use multi-colored wire to ease signal tracing & troubleshooting.

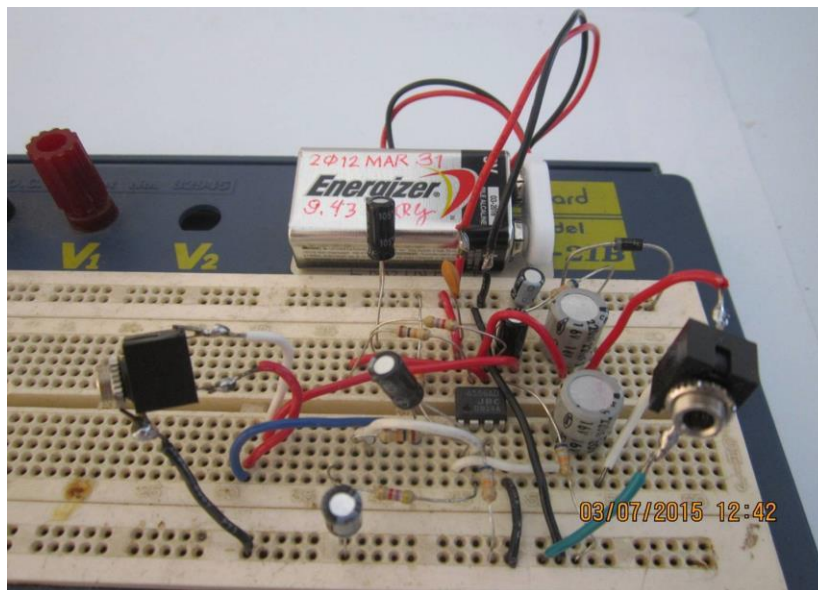
Pay attention to grounding & layout to minimize oscillation.

Separate signal (star/mecca ground) & power ground. Connect power ground closer (compared to signal ground) to power supply ground.

Signal ground are audio input connector J1-C1, resistors R7 & R8, dual potentiometer R9 & R10, capacitors C7 & C8.

Power ground are audio output connector J2-C1, IC pin 4, capacitors C5 & C6.

If potentiometer R9 & R10 (Dual Audio Potentiometer) will not be used connect audio input connector J1-C2 to capacitor C1 & audio input connector J1-C3 to capacitor C2.



### Step 4 - "BHAKit" Setup

Connect a CD Audio/MP3 player headphone output to 3.5 mm Male to Male Stereo Cable (or Line out to 2 RCA Male Plugs to Stereo 3.5mm Male Plug) to the headphone amplifier 3.5mm input jack J1.

Connect a headphone with 3.5mm plug to the headphone amplifier 3.5mm output jack

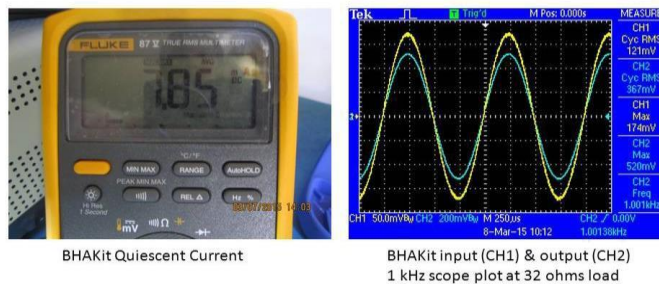
J2. Connect a 9V battery to the 9V battery snap & turn on switch S1.



### Step 5 - "BHAKit" Measurement Result

Series an ammeter by connecting its red test probe to the power supply positive terminal & black test probe to toggle switch S1-C1 to measure quiescent current (no input signal & load).  
 The scope (Tektronix TDS 2012B) plot shows a 1 kHz 121mVrms input (CH1) & 367mVrms output (CH2) @ 32 ohm load, gain is equal to 3.03 (9.64dB).

### BHAKit Measurement Result

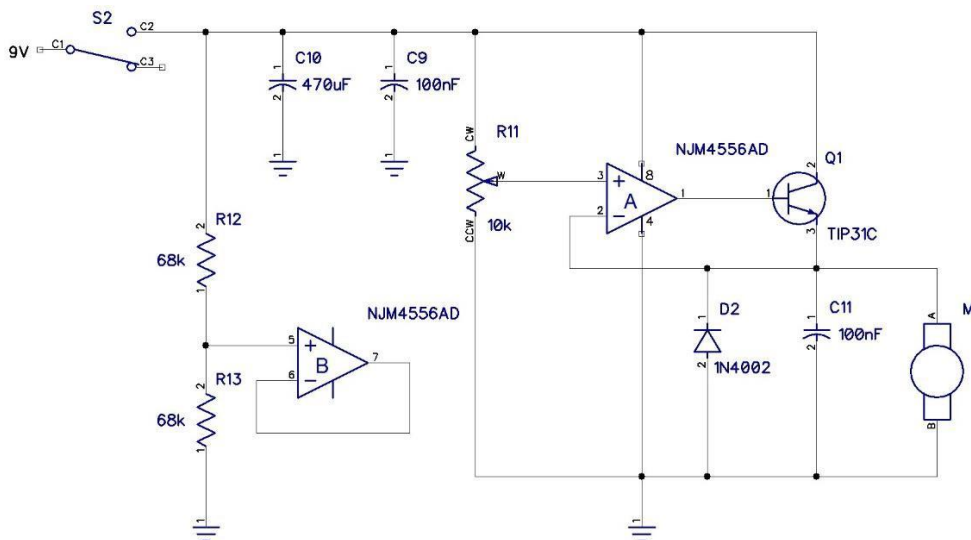


BHAKit Quiescent Current

BHAKit input (CH1) & output (CH2)  
1 kHz scope plot at 32 ohms load

### Step 6 - Motor Speed Controller Circuit Schematic

Motor Speed Controller circuit schematic.  
 Amp B is not used, it is biased halfway the power supply equal to 4.5V for 9V power supply.



Constant Motor Speed Controller

### Step 7 - Trimmer Adjustment

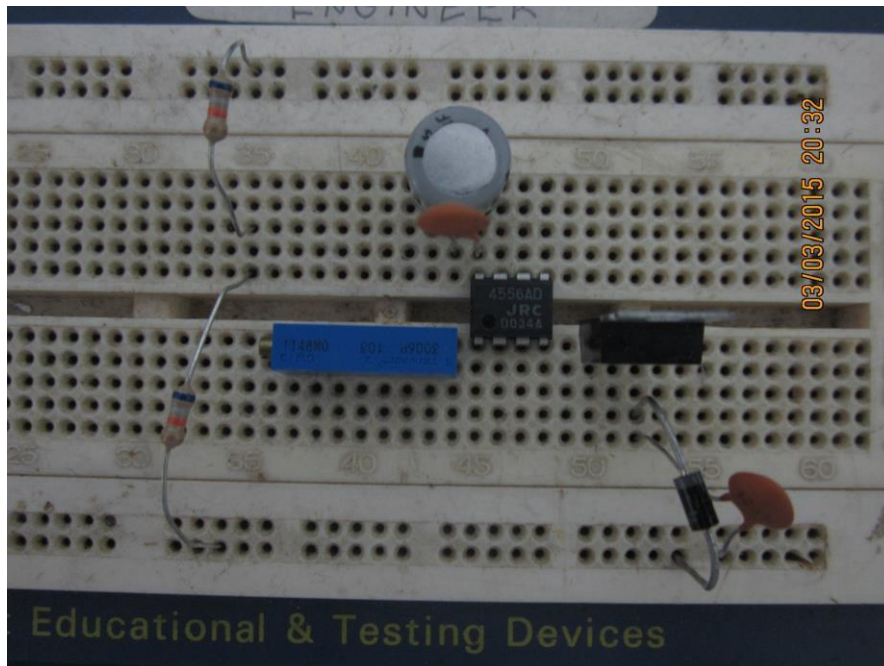
Set trimmer R11 resistance between wiper & ground to 3.3kohms for 3V motor voltage with 9V power supply. If power supply is other than 9V use this formula  $R_x = 3V \times 10\text{kohms} / V_{cc}$  where  $R_x$  is the resistance between wiper to ground &  $V_{cc}$  is the power supply voltage.



### Step 8 - Component Placement

Place the components on the breadboard according to the schematic. Install 0.1uF bypass capacitor as close as possible to the IC power supply pins 4 & 8.

Solder AWG 22 solid wire to 9V battery snap, motor M1 & toggle switch S2 to facilitate installation on breadboard.



### Step 9 - Component Connection

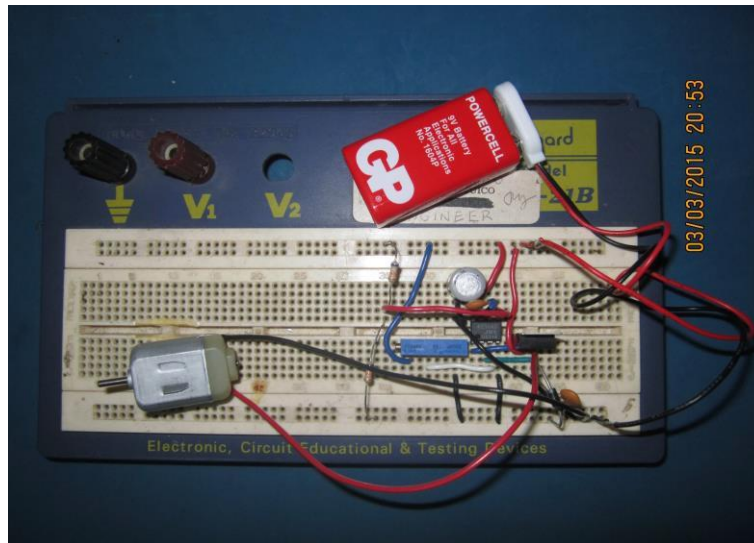
Connect ICs & passive components via AWG 22 solid wire. It is suggested to use multi-colored wire to ease signal tracing & troubleshooting.

Pay attention to grounding & layout to minimize oscillation.

Separate signal (star/mecca ground) & power ground. Connect power ground closer (compared to signal ground) to power supply ground.

Signal ground are trimmer R11 & resistor R13.

Power ground are capacitors C9, C10 & C11, diode D2, IC pin 4 & motor M1.



### Step 10 - Motor Speed Controller Measurement Result

Q1 base & collector current at no load.

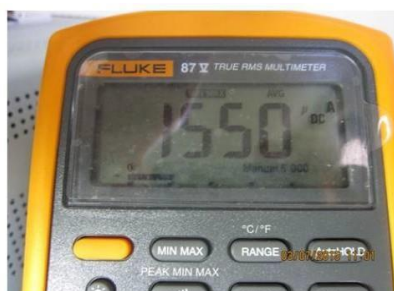
Measure base current by connecting an ammeter between op amp pin 1 & Q1 base.

Collector current is measured with an ammeter in series with the collector.

Ammeter resolution equal to or less than 100nA is recommended to measure accurately the base current.

Slowly turn counterclockwise trimmer R11 while observing (peculiar) behavior of motor speed & voltage.

### Motor Controller Measurement Result



Motor Controller Q1 Base Current



Motor Controller Q1 Collector Cur