

OHMS LAW

OHMS LAW IS A FUNDAMENTAL PRINCIPLE IN ELECTRONICS. IT DEFINES THE RELATIONSHIP BETWEEN VOLTAGE (V), CURRENT (I), AND RESISTANCE (R).

CURRENT IS THE RATE OF FLOW OF ELECTRONS, MEASURED IN AMPS.

AMP = A

$$1 \text{ MILLIAMP} = 1 \text{ mA} = 0.001 \text{ A} = 1e-3$$

$$1 \text{ MICROAMP} = 1 \mu\text{A} = 0.000001 \text{ A} = 1e-6$$

RESISTANCE IS THE PROPERTY OPPOSING THE FLOW OF ELECTRONS, MEASURED IN OHMS.

OHM Ω = r

$$1 \text{ KILO OHM} = 1 \text{ k} = 1000 \text{ r} = 1e3$$

$$1 \text{ MEGA OHM} = 1 \text{ M} = 1,000,000 \text{ r} = 1e6$$

CURRENT AND RESISTANCE ARE RELATED BY ANOTHER PROPERTY VOLTAGE, WHICH MEASURES THE POTENTIAL DIFFERENCE BETWEEN TWO POINTS. THE DIFFERENCE IN POTENTIAL CAUSES CURRENT TO FLOW.

VOLT = V

$$1 \text{ MILLIVOLT} = 1 \text{ mV} = 0.001 \text{ V} = 1e-3$$

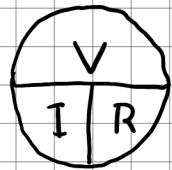
$$1 \text{ MICROVOLT} = 1 \mu\text{V} = 0.000001 \text{ V} = 1e-6$$

OHMS LAW DEFINES THE RELATIONSHIP BETWEEN VOLTAGE, CURRENT, AND RESISTANCE.

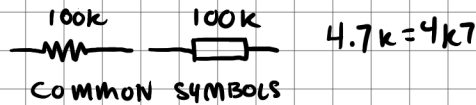
$$V = I * R$$

$$I = V / R$$

$$R = V / I$$



RESISTORS



RESISTORS OPPOSE (OR RESIST) THE FLOW OF ELECTRONS.

TWO OR MORE RESISTORS IN SERIES CAN BE TREATED AS A SINGLE LARGER RESISTOR.

$$R_{total} = R_1 + R_2$$

CALCULATE THE COMBINED RESISTANCE OF PARALLEL RESISTORS WITH THIS FORMULA:

$$R_{total} = (R_1 \times R_2) / (R_1 + R_2)$$

$$\frac{10k \cdot 10k}{10k + 10k} = \frac{100k}{20k} = 5k$$

FOR RESISTORS OF EQUAL VALUE YOU CAN SIMPLIFY THE FORMULA TO:

$$R_{total} = \frac{R}{n}$$

R = VALUE
n = NUMBER OF RESISTORS

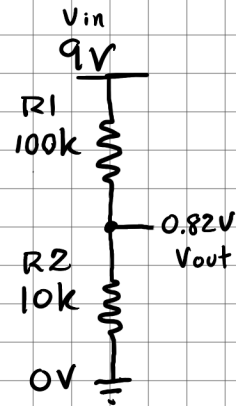


VOLTAGE DIVIDER

RESISTORS IN SERIES FORM A VOLTAGE DIVIDER. CALCULATE THE VOLTAGE AT THE NODE V_{out} WITH THIS FORMULA:

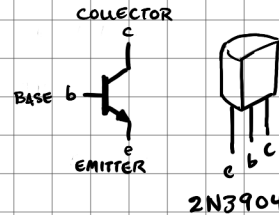
$$V_{in} \times \frac{R_2}{R_1 + R_2} = V_{out}$$

$$9V \times \frac{10k}{100k + 10k} = \frac{10k}{110k} = 0.82V$$



TRANSISTORS NPN BJT

THIS ZINE IS CONCERNED WITH NPN TRANSISTORS. THESE ARE THREE TERMINAL DEVICES WITH BASE (B), COLLECTOR (C), AND EMITTER (E).

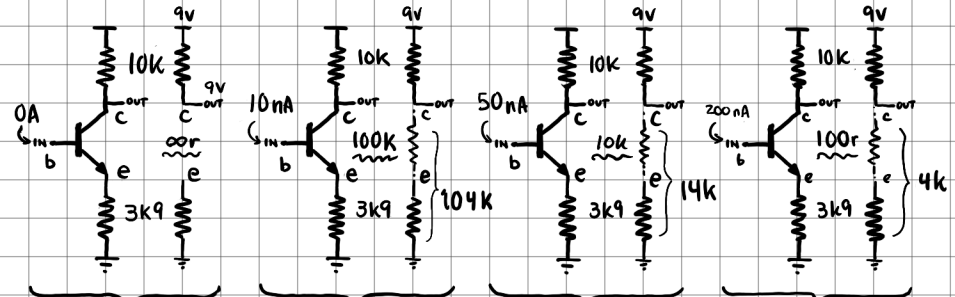


TYPICAL U.S. PART NUMBERS BEGIN 2N FOLLOWED BY THREE OR FOUR DIGITS. COMMON PART NUMBERS ARE 2N3904, 2N2222, 2N5088, AND 2N5089.

THIS ARTICLE DESCRIBES TRANSISTORS AS CURRENT CONTROLLED RESISTORS.

CURRENT APPLIED TO THE BASE CONTROLS THE FLOW OF CURRENT FROM THE COLLECTOR TO EMITTER. APPLYING A SMALL CURRENT TO THE BASE ALLOWS A LARGER CURRENT TO FLOW FROM COLLECTOR TO EMITTER, THIS QUALITY ALLOWS THE BJT TO ACT AS AN AMPLIFIER.

A SMALL 10nA CURRENT AT THE BASE CONTROLS A LARGER 10mA CURRENT FROM COLLECTOR TO EMITTER.



WITH NO CURRENT AT THE BASE NO CURRENT FLOWS FROM C TO E

IMPORTANT!
NOTICE VOLTAGE AT C DECREASES AS BASE CURRENT RISES!

A SMALL CURRENT AT THE BASE ALLOWS A SMALL CURRENT FLOW FROM C TO E

$$9V \left(\frac{104k}{114k} \right)$$

VOUT 8.2V

AS BASE CURRENT INCREASES MORE CURRENT FLOWS FROM C TO E

$$9 \left(\frac{14k}{24k} \right)$$

VOUT 5.25V

A LARGE CURRENT SATURATES THE BASE AND THE C E PATH IS OPEN

$$9 \left(\frac{4k}{14k} \right)$$

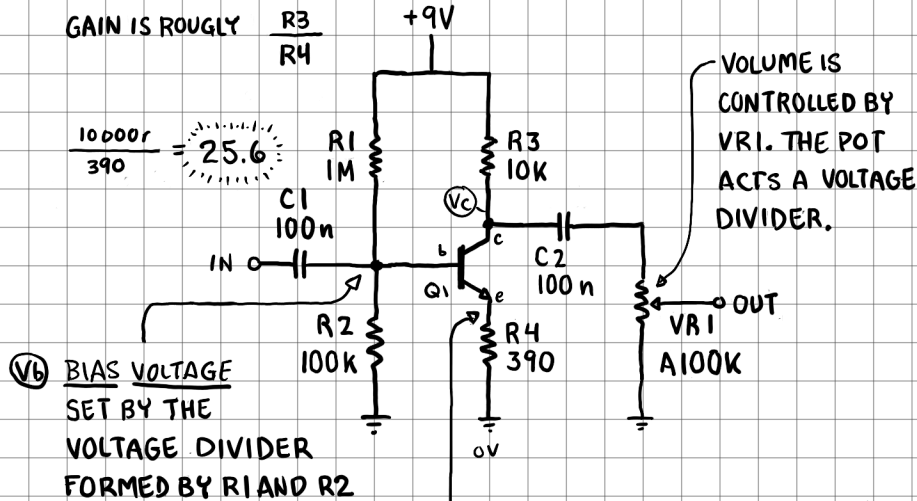
VOUT 2.57V

COMMON EMITTER AMPLIFIER

THE LPB-1 IS A BOOSTER/BUFFER MADE BY ELECTRO-HARMONIX SINCE 1968. IT IS AN EXAMPLE OF A COMMON EMITTER AMPLIFIER, A COMMON BUILDING BLOCK FOUND IN MANY GUITAR PEDALS.

GAIN IS ROUGLY $\frac{R3}{R4}$

$$\frac{10000r}{390} = 25.6$$



VOLUME IS CONTROLLED BY VR1. THE POT ACTS A VOLTAGE DIVIDER.

V_b BIAS VOLTAGE SET BY THE VOLTAGE DIVIDER FORMED BY R1 AND R2

$$\frac{R2}{R1 + R2} \times 9V$$

$$\frac{100k}{1100k} \times 9V = 0.82V$$

V_e EMITTER VOLTAGE

$$V_e = 0.82V - 0.6V = 0.22V$$

I_e EMITTER CURRENT

$$I_e = \frac{V_e}{R4} = \frac{0.22V}{390} = 0.56mA$$

V_c COLLECTOR VOLTAGE

$$9V - (I_c \times R3)$$

$$9V - (0.56mA \times 10k) = 3.4V$$

HEADROOM

WITH NO CURRENT AT THE BASE OF Q1 THERE IS 9V AT THE COLLECTOR. WITH A HIGH CURRENT AT THE BASE Q1 IS FULLY ON AND ACTS AS A VERY LOW RESISTANCE BETWEEN C AND E.

COLLECTOR VOLTAGE IS:

$$\frac{390}{10k + 390} = \frac{390}{10390} \times 9V = 0.34V$$

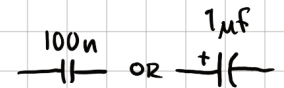
CAPACITORS

CAPACITORS BLOCK DC AND PASS AC SIGNALS. THEY ARE USED TO COUPLE AUDIO (AC) SIGNALS, AND FILTER AUDIO.

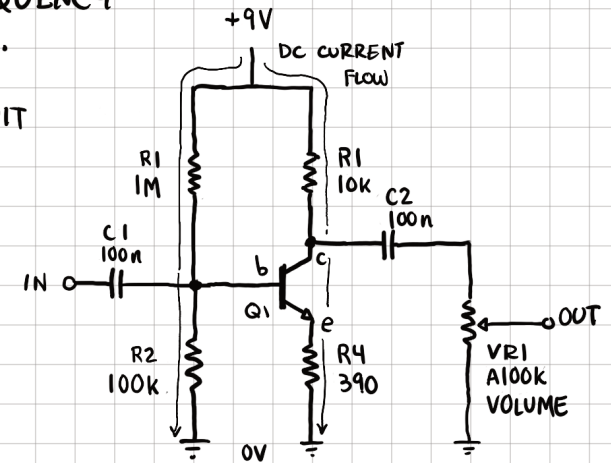
CAPACITORS HAVE A PROPERTY CALLED CAPACITANCE, MEASURED IN FARADS. A FARAD IS A VERY LARGE VALUE, VALUES COMMONLY ENCOUNTERED ARE MICRO FARADS, NANO FARADS, AND PICO FARADS.

FARAD	= F		
1 MILLI FARAD	= 1mF	= 0.001F	= 1e-3
1 MICRO FARAD	= 1μF	= 0.000001F	= 1e-6
1 NANO FARAD	= 1nF	= 0.000000001F	= 1e-9
1 PICO FARAD	= 1pF	= 0.000000000001F	= 1e-12

THE SYMBOL FOR CAPACITOR LOOKS LIKE TWO PARALLEL LINES. DC CURRENT CANNOT CROSS THE GAP. THE AMOUNT OF AC A CAPACITOR PASSES DEPENDS ON FREQUENCY AND CAPACITANCE.

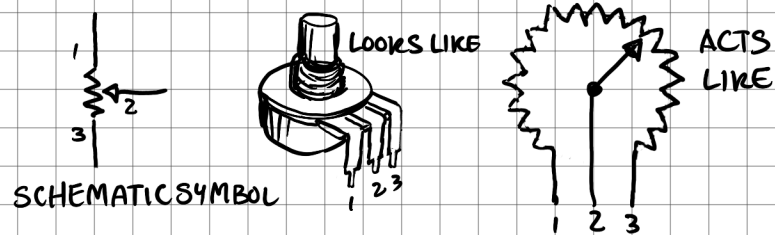


IN THE LPB-1 CIRCUIT C1 AND C2 BLOCK DC CURRENT.

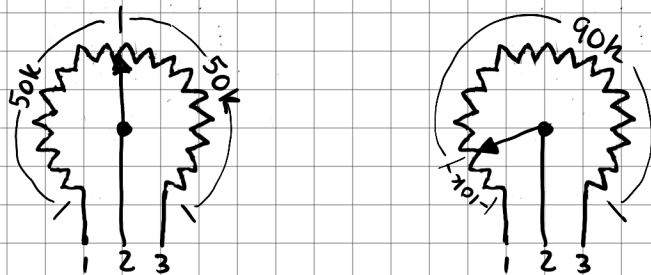
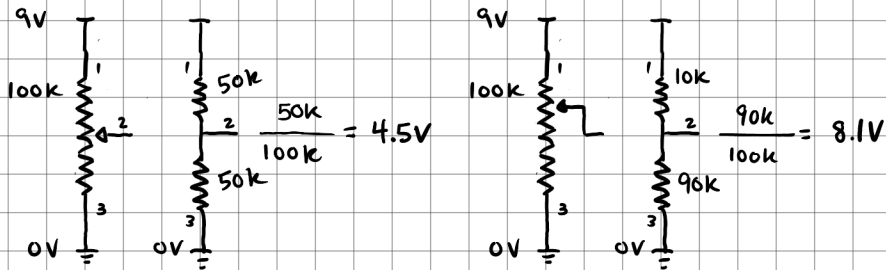


POTENTIOMETER

A POTENTIOMETER IS AN ADJUSTABLE RESISTOR DIVIDER. THESE HAVE THREE LEGS. THE SYMBOL LOOKS LIKE THIS.



POTS ARE USED AS ADJUSTABLE PARAMETERS. IMAGINE A 100K POT



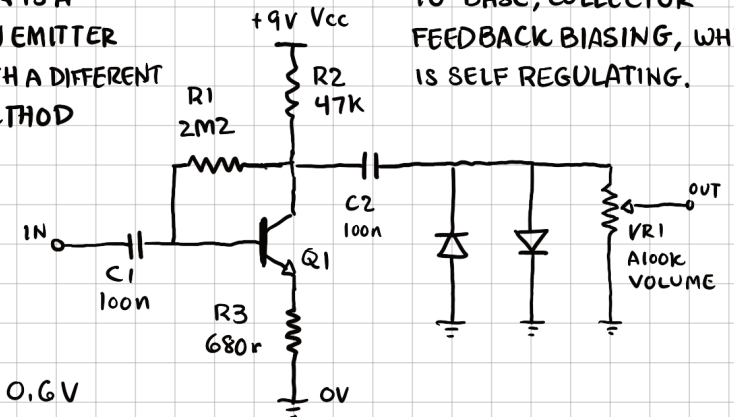
ELECTRA FUZZ

THIS IS A DISTORTION CIRCUIT FROM THE EARLY 1970s THAT HAS BEEN CLONED AND USED AS A BUILDING BLOCK IN MANY OTHER CIRCUITS.

THIS CIRCUIT USES DIODES TO CREATE DISTORTION. THE DIODES CLIP THE SIGNAL WHEN IT EXCEEDS THE DIODE'S FORWARD VOLTAGE.

ELECTRA IS A COMMON EMITTER AMP WITH A DIFFERENT BIAS METHOD

R1 CONNECTS COLLECTOR TO BASE, COLLECTOR FEEDBACK BIASING, WHICH IS SELF REGULATING.



$$V_{be} = 0.6V$$

$$I_c = \frac{V_{cc} - V_{be}}{R_c + R_e + R_b/h_{FE}}$$

$$= \frac{9 - 0.6}{47k + 680r + 2.2M/200}$$

$$= \frac{8.4}{47680 + 11000}$$

$$= 0.14mA$$

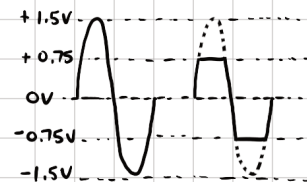
COLLECTOR VOLTAGE

$$V_c = 9V - (0.14mA \times 47k) = 2.4V$$

BASE VOLTAGE

$$V_b = V_e + 0.6V = (0.14mA \times 680r) + 0.6V = 0.7V$$

DIODE CLIPPING OCCURS WHEN VOLTAGE EXCEEDS FORWARD VOLTAGE 0.7V FOR SILICON DIODES, 0.3V FOR GERMANIUM DIODES.

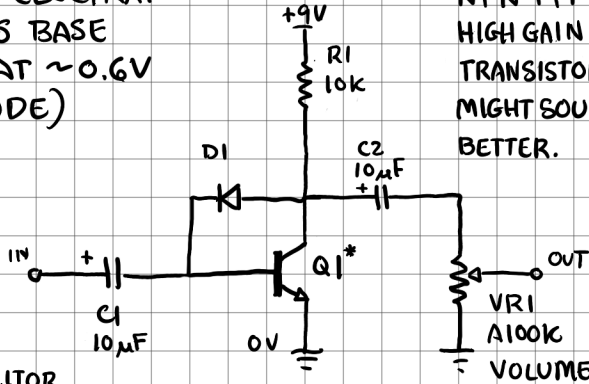


BAZZ FUSS

A CIRCUIT FROM THE EARLY DIY COMMUNITY, BY CHRISTIAN Né HEMMO. IT HAS BEEN MODIFIED AND CLONED FOR DECADES.

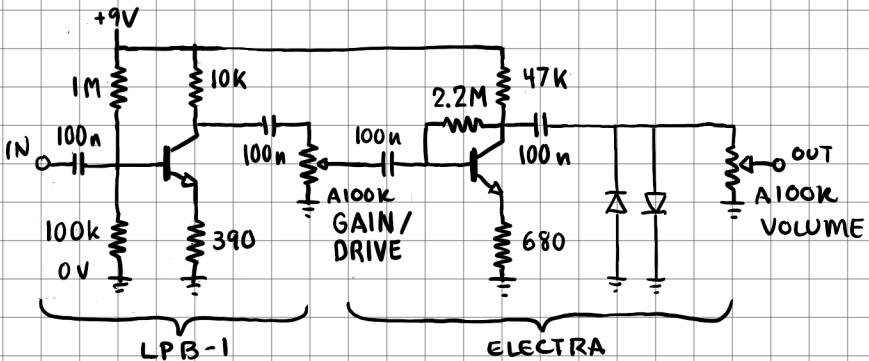
COLLECTOR FEEDBACK BIAS
SIMILAR TO ELECTRA.
DI CLAMPS BASE
VOLTAGE AT $\sim 0.6V$
(V_f OF DIODE)

* Q1 CAN BE ANY
NPN TYPE.
HIGH GAIN
TRANSISTORS
MIGHT SOUND
BETTER.



INPUT CAPACITOR
C1 HAS A STRONG
EFFECT ON THE
SOUND. A SMALLER
VALUE WILL CUT
BASS.

DIODE D1 CAN BE
ANY TYPE. DIODES
WITH DIFFERENT
FORWARD VOLTAGES
WILL SOUND DIFFERENT



COMBINE CIRCUITS TOGETHER TO MAKE
SOMETHING NEW.