LM386

EE17BTECH11023 EE17BTECH11024

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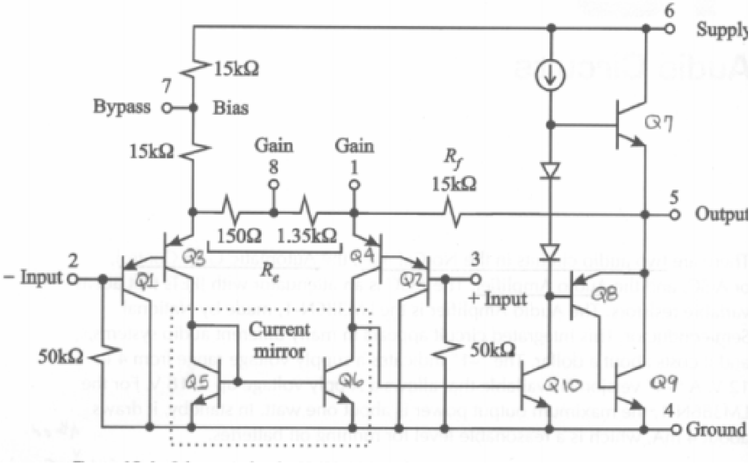
LM386

The IC LM386 is a low-power audio amplifier, and it utilizes low power supply like batteries in electrical and electronic circuits. This IC is available in the package of mini 8-pin DIP. The voltage gain of this amplifier can be adjusted to 20, and the voltage gain will be enhanced to 200 by employing external components like resistors as well as capacitors among the pins 1 and 8.

Supply Voltage - 9V   C1=220μF

Input Voltage - (-0.4V to 0.4V)   Input Current - (10mA -20 mA)

Circuit Diagram



Circuit

There are three stages of amplification in LM386:

1.pnp common emitter amplifier(Q1 and Q2)

2.differential amplifier(Q3 and Q4)

3.Class AB power amplifier

Stages

Q1 and Q2:

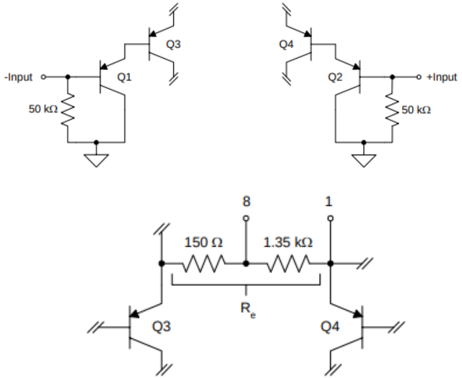
1.Q1 and Q2 buffer the input to the LM386.

2.The two 50K ohm resistors provide DC paths to the base currents of Q1 and Q2.

Q3 and Q4:

Q3 and Q4 form A differential amplifier

Stages



Stages...

Q5 and Q6:

Q5 and Q6 form a current mirror.The differential amplifier is biased by the current mirror.

In the current mirror,

$$V_{be(Q5)} = V_{be(Q6)} = V_b$$

$$I_c = I_{cs} e^{V_b/V_t}$$

$$I_{c5} = I_{c6}$$

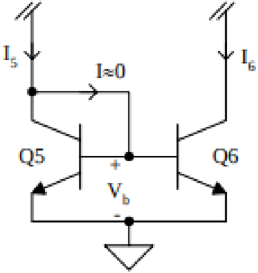
Since the two transistors are matched,

$$I_{E5} = I_{E6}$$

Neglecting the base currents by assuming large β.

$$I_5 = I_6$$

Stages

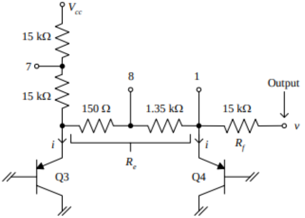


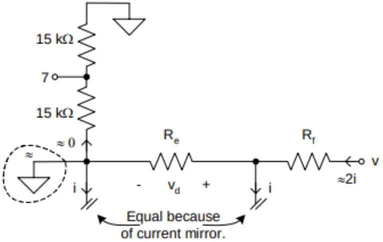
Gain

The current mirror forces the currents on both halves of the differential amplifier to be equal: both dc and ac components.
Consequently, the currents i at the emitters of Q3 and Q4 must be the same, as shown in Fig.
Due to the mirror, the current through $R_f = 2i$(approx) , neglecting the current in the two 15-k resistors (which are large impedances relative to the other parts of the circuit). Therefore,

$$\frac{v - v_d}{R_f} = 2i$$

Gain


V_{cc}
15 kΩ
7
15 kΩ
8
1
Output
150 Ω
1.35 kΩ
15 kΩ
v
i
i
R_f
R_e
Q3
Q4


15 kΩ
7
15 kΩ
≈ 0
R_e
R_f
v
≈
i
- V_d +
i
≈2i
Equal because
of current mirror.

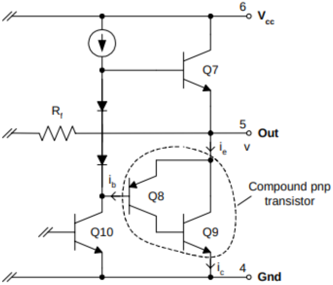
Gain

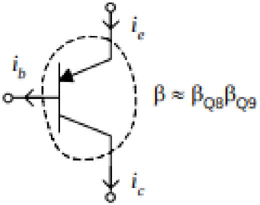
Now, the output voltage v is produced by a so-called "class AB" power amplifier as shown in figure in next slide.
Here,

$$\beta = \beta_{Q8}\beta_{Q9}$$

which is easy to show starting with $i_{c8} = \beta_{Q8} i_{b8}$ and $i_{c9} = \beta_{Q9} i_{b9}$.
Compounding pnp's was done in early IC's to improve the traditionally poor performance of pnp transistors wrt frequency response, etc.

Gain


6
V_{cc}
Q7
R_f
5
Out
i_e
v
i_b
Q8
Compound pnp
transistor
Q10
Q9
i_c
4
Gnd


i_e
i_b
$\beta \approx \beta_{Q8}\beta_{Q9}$
i_c

Gain

After amplification by class AB amplifier we can assume $v >> v_d$
Therefore ,

$$\frac{v}{R_f} = 2i$$

Also from small signal model we got,

$$\frac{v_d}{R_e} = 2i$$

From the above equations we get Gain,

$$G = \frac{2R_f}{R_e}$$

Substituting values from the IC we get

$$G = \frac{2 \times 15k}{150} = 20$$