EEE-2103: Electronic Devices and Circuits

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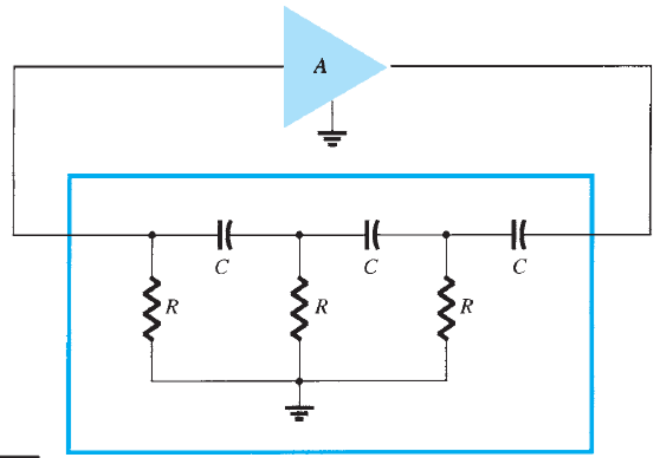
Phase-Shift Oscillator

Feedback circuit = phase-shift oscillator.
Requirements for oscillation →

loop gain $\beta A > 1$

phase shift around feedback network is 180°.



Feedback network

Using classical network analysis →

$$f = \frac{1}{2\pi RC\sqrt{6}}$$

$$\beta = \frac{1}{29} \rightarrow A > 29$$

Phase-shift = 180°.

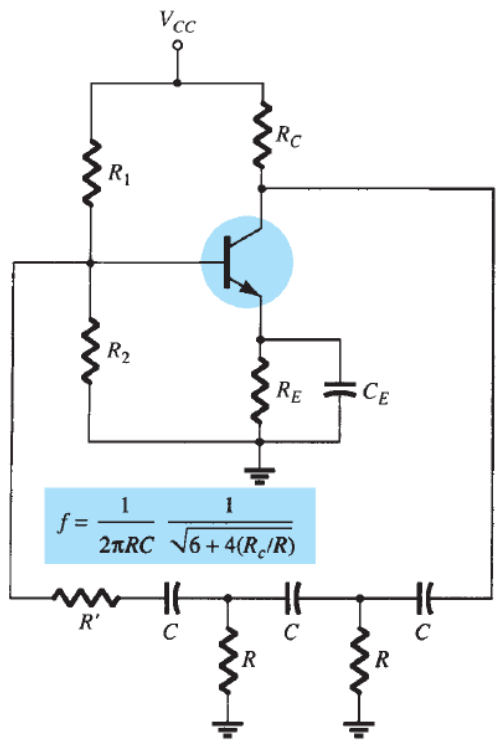
<u>Transistor phase-shift oscillator:</u>

Resulting oscillator frequency:

$$f = \frac{1}{2\pi RC}\frac{1}{\sqrt{6+4(R_C/R)}}$$

To $\beta A > 1$, current gain of transistor:

$$h_{fe} > 23 + 29\frac{R}{R_C} + 4\frac{R_C}{R}$$

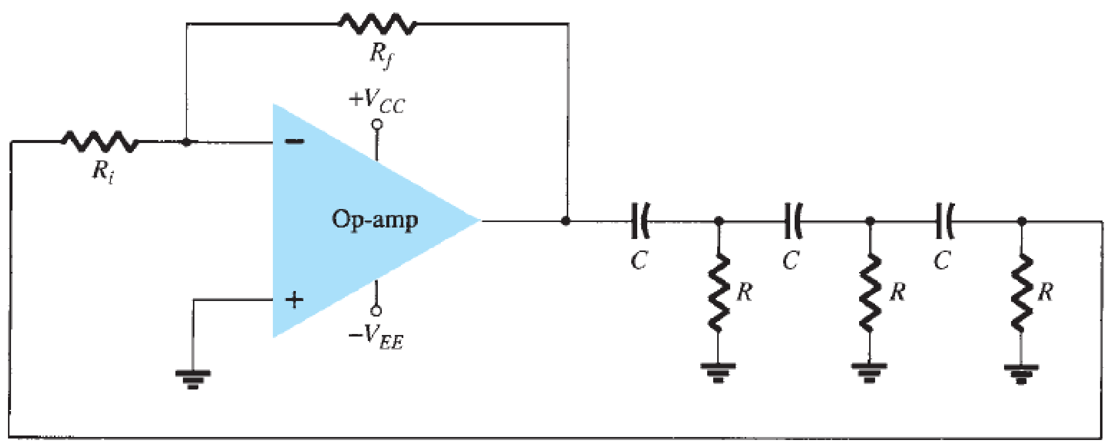


Phase-Shift Oscillator

IC (op-amp) phase-shift oscillator:
Output of op-amp is fed to 3-stage *RC* network.

RC network provides → 180° phase shift.
attenuation factor = 1/29.

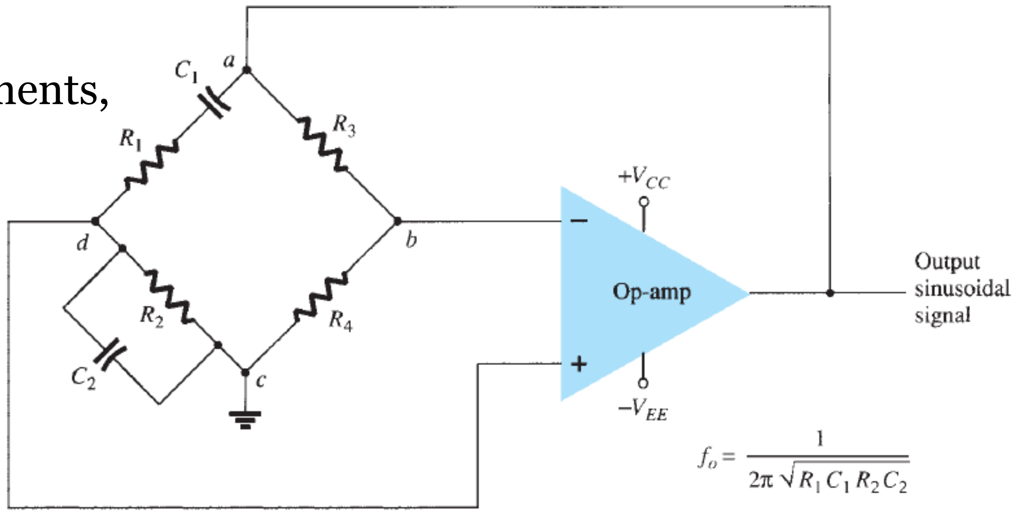
Op-amp provides → gain > 29 ($-R_f/R_i > 29$).



Wien Bridge Oscillator

IC (op-amp) phase-shift oscillator:
Oscillator circuit = op-amp + *RC* bridge circuit.
Oscillator frequency → *R* and *C* components.

R_1, R_2 and C_1, C_2 → frequency-adjustment elements,
R_3 and R_4 → part of feedback path.
Op-amp output → points *a* and *c*.
Op-amp input → points *b* and *d*.



Analysis of bridge circuit →

$$\frac{R_3}{R_4} = \frac{R_1}{R_2} + \frac{C_2}{C_1} = 2 \quad [R_1 = R_2 = R]$$

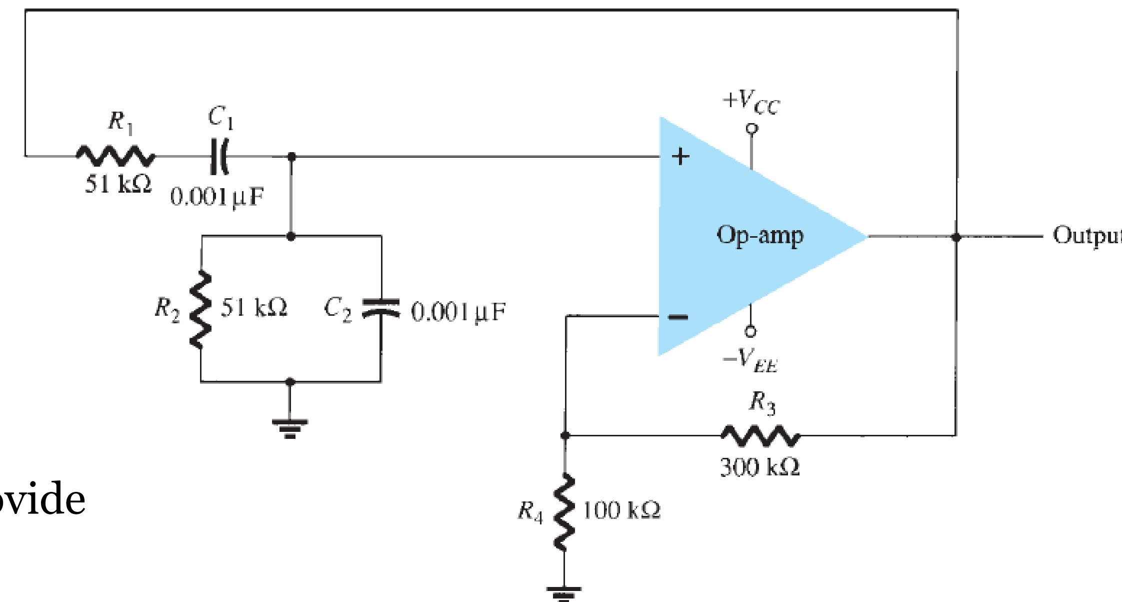
$$[C_1 = C_2 = C]$$

$$f_o = \frac{1}{2\pi\sqrt{R_1C_1R_2C_2}} = \frac{1}{2\pi RC}$$

Wien Bridge Oscillator

Problem-50:
Calculate the resonant frequency of the Wien bridge oscillator of Fig. 50. Also, design the *RC* elements of a Wien bridge oscillator as in Fig. 50 for operation at f_o = 10 kHz.

$$f_o = \frac{1}{2\pi RC}$$
$$= \frac{1}{2\pi(51\times10^3)(0.001\times10^{-6})} = 3120.7 \text{ Hz}$$



Using equal values of *R* and *C*,
select *R* = 100 kΩ

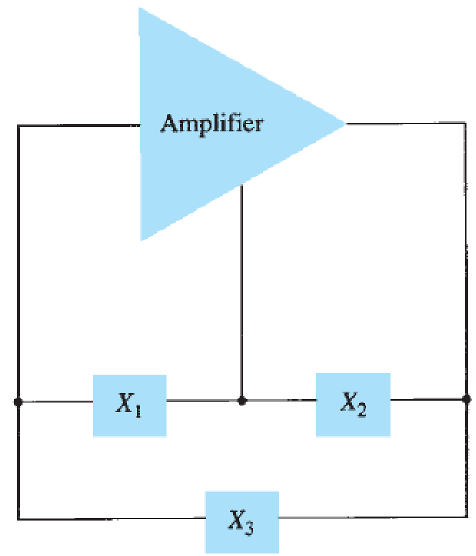
$$C = \frac{1}{2\pi f_o R} = \frac{1}{2\pi(10\times10^3)(100\times10^3)} = 159 \text{ pF}$$

Let, R_3 = 300 kΩ and R_4 = 100 kΩ to provide
$R_3/R_4 > 2$.

Tuned Oscillator

Tuned-input, tuned-output oscillator circuits →

	Reactance Element		
Oscillator Type	X_1	X_2	X_3
Colpitts oscillator	C	C	L
Hartley oscillator	L	L	C
Tuned input, tuned output	LC	LC	—



Tuned Oscillator

Colpitts oscillator →

CE amplifier + *LC* oscillator

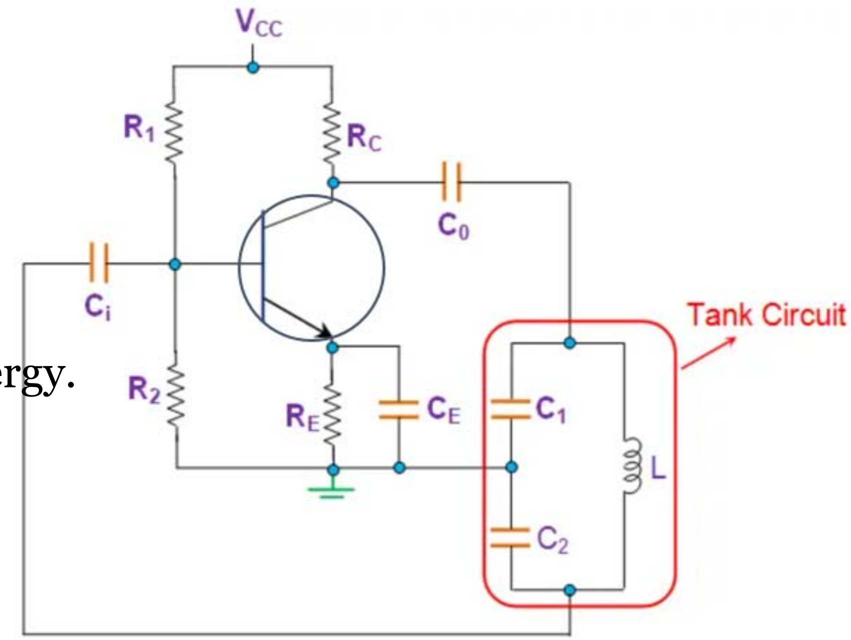
feedback → voltage divider made of C_1 and C_2 in series across *L*.

Power supply is switched ON →

transistor starts to conduct, I_C increases.

C_1 and C_2 get charged to maximum →

start to discharge via *L*.



Electrostatic energy stored in *C* → magnetic flux.
Magnetic flux is stored within *L* as electromagnetic energy.
L starts to discharge, which charges *C* again.
Cycle continues → oscillations in tank circuit.

V_{out} appears across C_1 and
in-phase with tank circuit's voltage →
makes-up for energy lost by re-supplying it.

Tuned Oscillator

Colpitts oscillator →
V_{fb} to transistor is obtained across C_2,
out-of-phase with voltage at transistor by 180°.

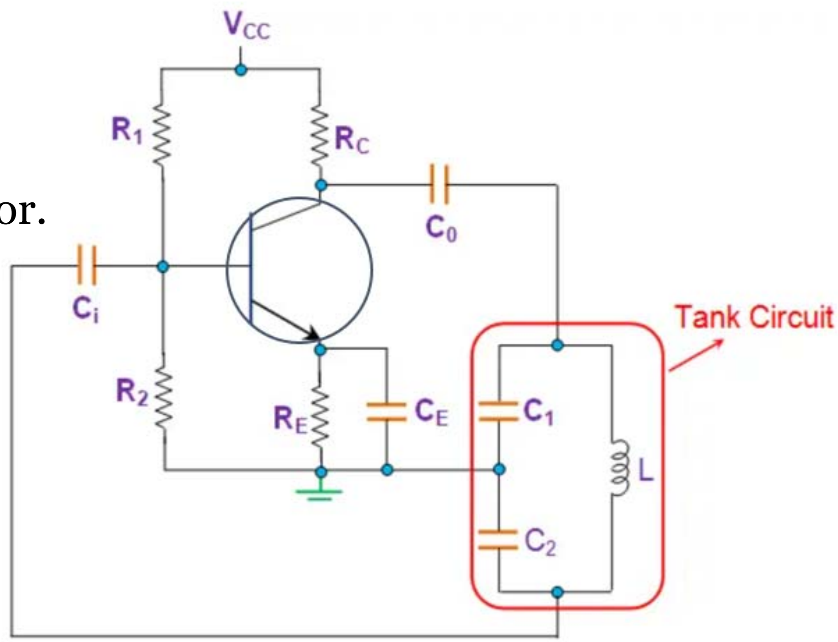
Point where C_1 and C_2 join is grounded →
V_{C_1} and V_{C_2} are opposite in polarity.
V_{fb} is provided with 180° phase-shift by transistor.

Net phase-shift around loop = 360° →
phase-shift criterion of Barkhausen principle.

Frequency of Colpitts oscillator depends on tank circuit.

$$f_o = \frac{1}{2\pi\sqrt{LC_{eq}}}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

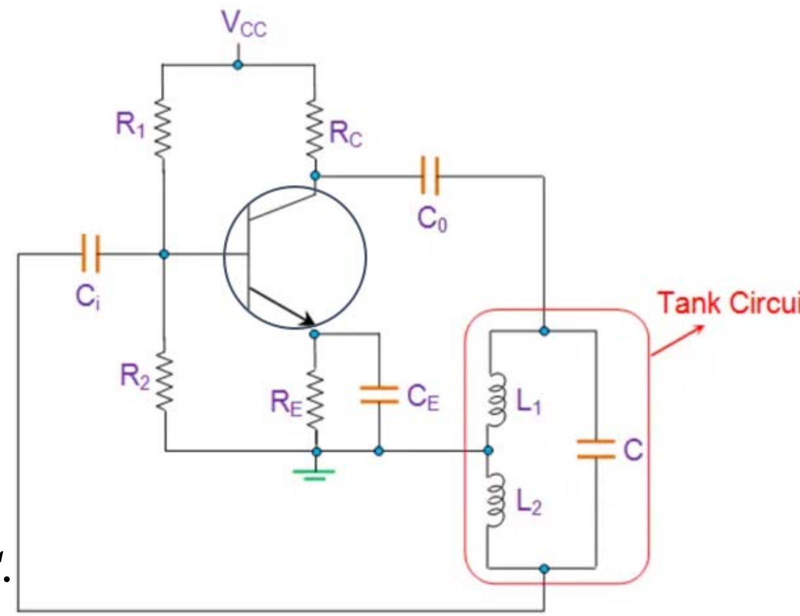


Tuned Oscillator

Hartley oscillator →

Gain = transistor amplifier.

Feedback = tuned LC circuit.



Phase change →

180^o phase change V_B and V_C +

180^o phase shift in feedback loop =

360^o phase shift between V_{in} and V_{out}.

Frequency determining network →

parallel resonant circuit = L_1 and L_2 along with C.

L_1 and L_2 are inductively coupled.

L_1 is in output circuit and L_2 provides V_{fb}.

V_{CC} produces transient current in tank circuit → oscillatory current produces ac V_{L1}.

Frequency of Hartley oscillator depends on tank circuit.

$$f_o = \frac{1}{2\pi\sqrt{L_{eq}C}}, L_{eq} = L_1 + L_2$$

Integrated Circuits

Integrated circuit (IC) →

several components

interconnected in one small package

external connecting terminals →

input, output, supply voltage.

Classification (function) →

1) Analog – amplifiers, voltage regulators

2) Digital – logic gates, counting circuits

Classification (manufacturing) →

1) Monolithic

2) Hybrid

3) Thin film

4) Thick film

Integrated Circuits

Monolithic IC →

all components are fabricated on single chip of Si.
uses diffusion process – most economical for mass production.
interconnections are provided on surface of structure.
external connecting wires are taken out to terminals.

Thin film →

surface – glass or ceramic base.
depositing films of conducting material on surface.
resistors and conductors → different materials are selected
controls width and thickness of films.
capacitors → sandwiching film of insulating oxide
between two conducting films.
inductors → depositing metal film in spiral formation.
transistors and diodes → tiny discrete components are connected in circuit.

Integrated Circuits

Thick film →

printed thin-film circuits.

ceramic substrate – desired circuit pattern.

silk-screen printing techniques →

1) printing: conductive, resistive or dielectric pastes.

2) fuse films to substrate: circuits are fired at high temperature in furnace.

passive components – same way as thin film circuits.

active components – added as separate devices.

Hybrid or multichip IC→

interconnect number of individual chips.

active components – diffused transistors or diodes.

passive components – group of diffused resistors or capacitors on single chip.
thin film components.

connections between chips – fine wire or metal film.

expensive for mass production; economical for small quantities.

better performance than monolithic circuits.