Sinusoidal Oscillator

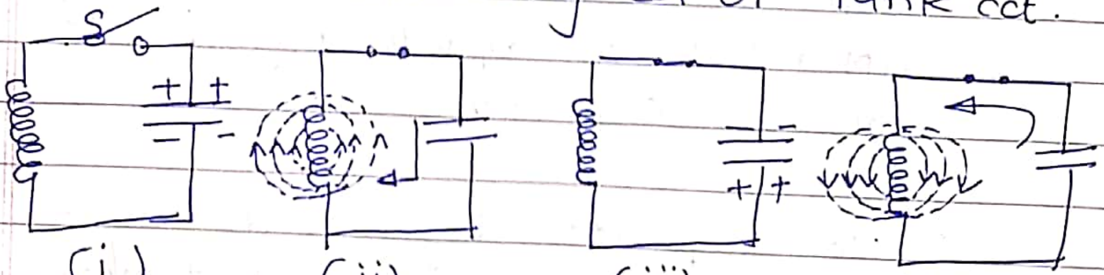
An electronic device that generates sinusoidal oscillations of desired frequency is known as "Sinusoidal Oscillator"

It does not create energy, but merely act as energy convertor. It receives d.c energy and changes it into a.c energy of desired frequency.

Frequency of oscillation depends on the constant of the device. (like L, C values)

Oscillatory Circuit. / tank cct.

A circuit which produces electrical oscillations of any desired frequency is known as Oscillatory cct or tank cct.



(i) (ii) (iii) (iv)

(i) Suppose capacitor has charged from a dc source with polarities as shown. (i) Upper plate has deficit of ē and lower plate has excess of ēs. Therefore there is a voltage across the capacitor and capacitor has electrostatic energy.

(ii) When switch S is closed, capacitor discharg through inductor. ē flow as direction shown in fig (ii). This current set up

magnetic field around coil. Due to inductive effect current builds up slowly towards maximum value. Circuit current will be maximum when the capacitor is fully discharged.
Here we can say that electrostatic energy across the capacitor is completely converted into magnetic field energy around the coil

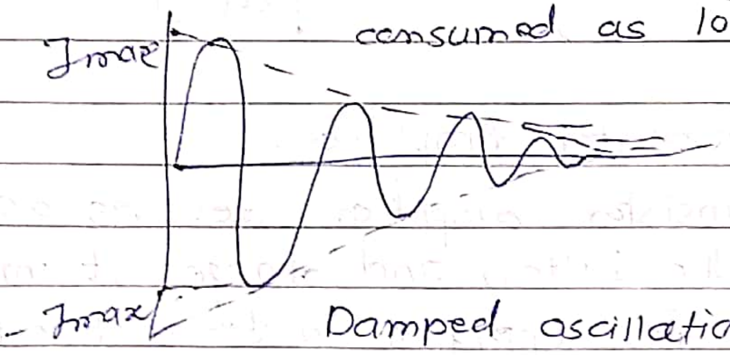
(iii) When capacitor is discharged, the magnetic field will begin to collapse and produce counter emf. According to Lenz's law, the counter emf will keep the current flowing in the same direction. Now capacitor charged with opposite polarity (wrt to fig(N)) making upper plate of capacitor negative and lower plate positive as shown.

(iv) Now capacitor begins to discharge. current now flows in opposite direction. This current set up magnetic field around coil. and then process repeats.

This sequence of charge and discharge results in alternating motion of $\bar{e}$s or an oscillating current.
The energy is alternately stored in electric field of capacitor (C) and the magnetic field of inductor (L).
This interchange of energy b/n L+C

is repeated over and again resulting in production of oscillations.

In Practical tank cct resistive and radiation losses in the coil and dielectric losses in the capacitor are present. During each cycle, a small part of the originally imparted energy is used up to overcome these losses. So amplitude of the oscillating current decreases gradually and eventually it becomes zero. when all energy is consumed as losses'



Damped oscillations'

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Undamped Oscillations from tank cct.

In order to make the oscillations in the tank cct undamped.

* The amount of energy supplied should be such as to meet the losses in the tank cct and ac o/p being taken e.g.

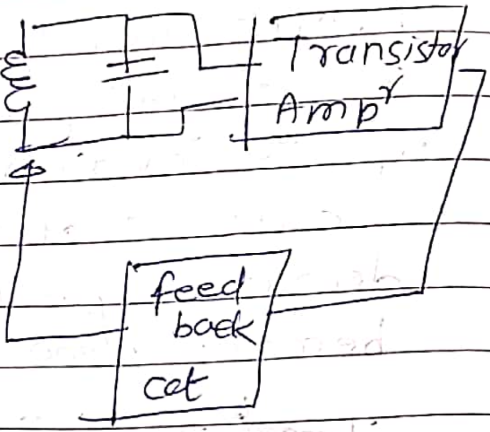
Losses are 5mw and a.c o/p is 100mw then the power of 105mw should be continuously suppled to cct

* Applied energy should have same frequency and phase as the oscillations set up in the tank circuit.

Essential element of Oscillator.

① Tank circuit:

$||^{al}$ combination of L & C

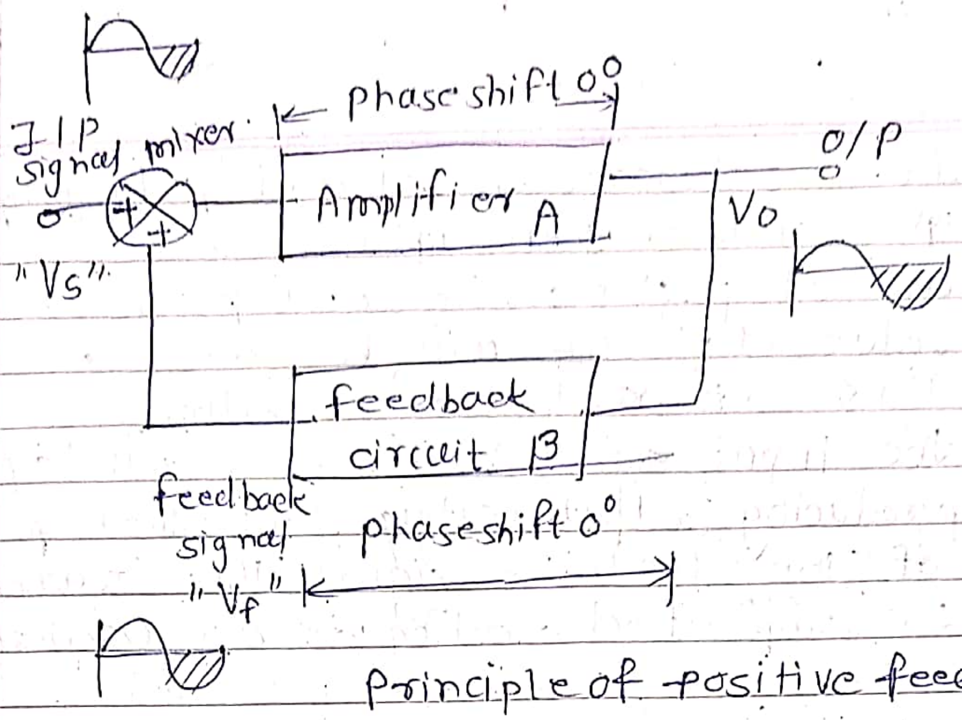


(ii) Transistor Amplifier ;-

Transistor amplifier receives d.c power from the battery and changes it into a.c power for supplying to the tank cct.

Oscillations from tank cct are applied the input of transistor amp^r. Because of amplifying properties of the transistor, we get increased o/p of these oscillation.

(iii) Feedback cct: It supplies part of collector (o/p) energy to the tank cct in correct phase to aid the oscillations ie it provides +ve feedback.



Principle of positive feedback

An Oscillator is an amp^r with +ve feedbade

A part of output is fed back through feedback network in phase with original I/P signal.

Here amp^r is assumed as a noninverting amp^r.

$$V_f = \beta V_o \quad \rightarrow ①$$, β. feedback factor

If inverting amp^r is used. It gives 180° phase shift b/n I/P and O/P.
Then feedback N/W. is designed to give additional 180° phase shift. So that total phase shift will be 360°. Hence feedback signal is fed to I/P (mixer) without phase shift (i.e. with same phase).

Amplifier gain with~~out~~ feedback (AF) is given by

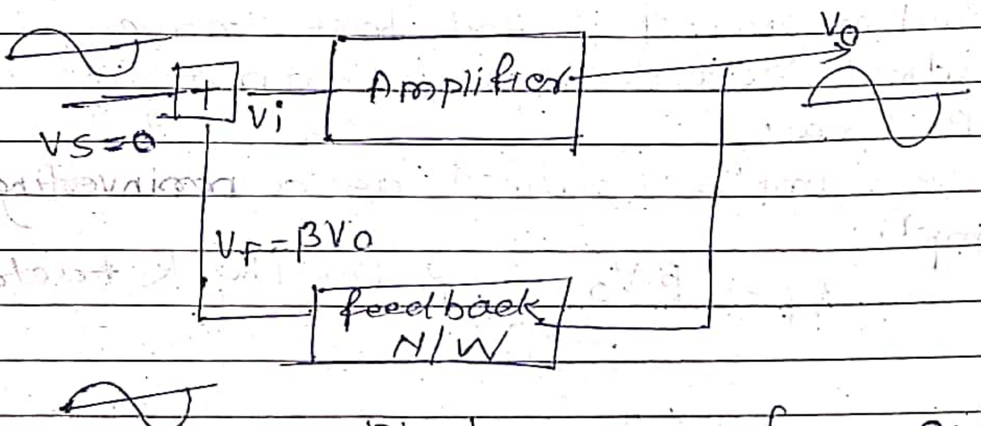
$$A_F = \frac{A}{1-A\beta} \quad \rightarrow ②$$, A = open loop gain of amp^r

conclusions

ⓐ In eq^n ② Aβ is positive quantity (1−Aβ) will be less than 1 and therefore $A_F > A$
Thus positive feedback will increase the amp^r gain.

ⓑ If we increase the value of "β" keeping "A" constant then A_f will increase and at particular value of β, the value of A_f will become ∞. This means that even without the input signal V_s the amp^r will keep producing output voltage with the help of the feedback signal. This is when the amp^r starts acting as an Oscillator

Barkhausen Criteria



Block Diagram of an Oscillator

For an osc^r ckt, there is no input signal "V_s", hence the feedback signal V_f itself should be sufficient to maintain the oscillations.

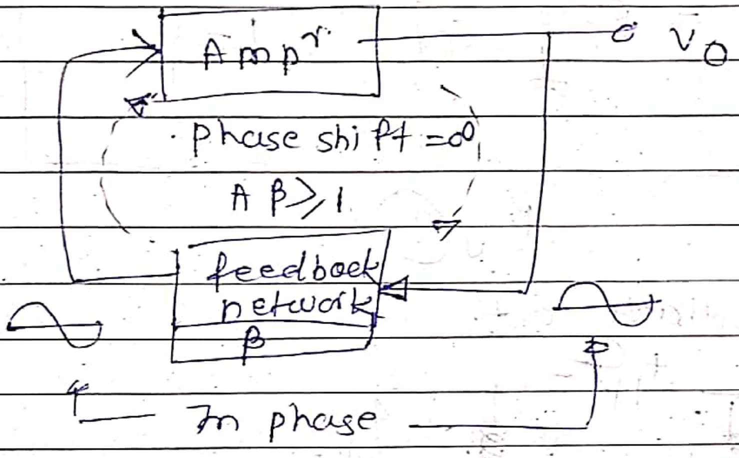
Statement of Barkhausen Criteria

An oscillator will operate at that freq for which the total phase shift introduced, as the signal proceeds from the input terminal, through the amp^r and feedback network and back again to the input precisely 0° or 360° or integral multiple of 360°

2) At the oscillator frequency the magnitude of the product of open loop gain of amplifier A and the feedback factor β is equal to or greater than unity.

$\therefore \quad |A\beta| \geq 1.$

∴ The product Aβ is called loop gain



Hartley Oscillator:

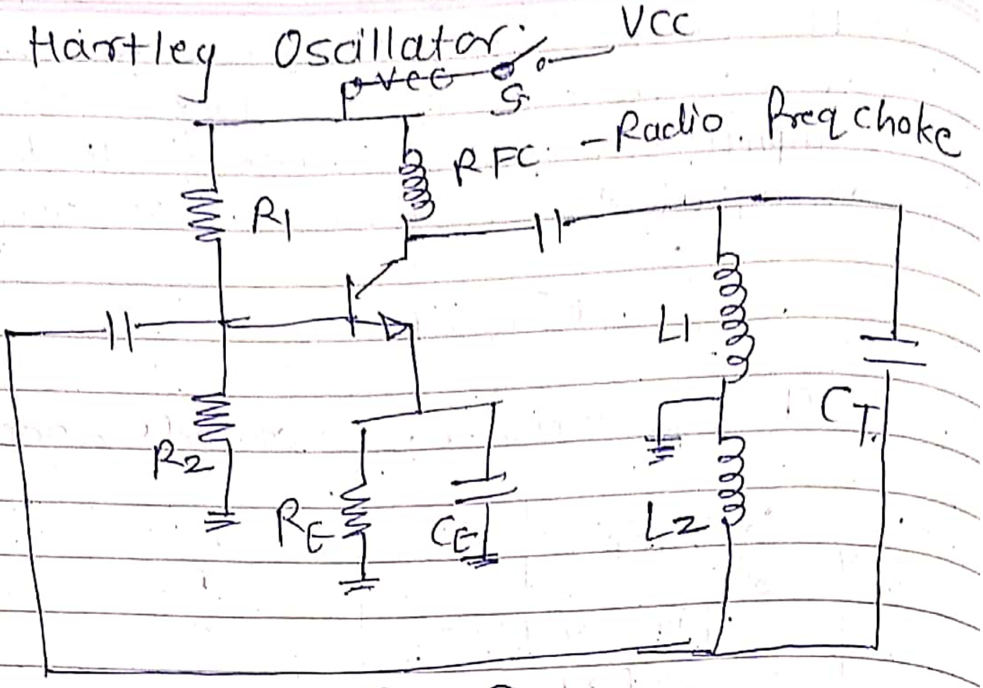


fig ⓐ

feedback cct.

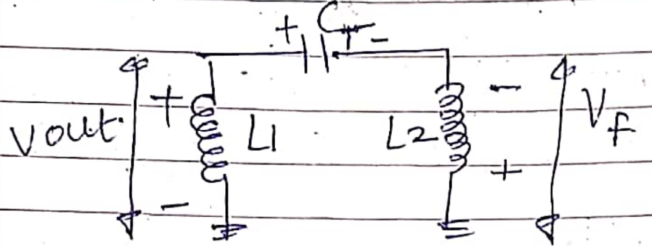


fig ⓑ

feedback fraction $\beta = \frac{V_f}{V_{out}} = \frac{X_{L2}}{X_{L1}}$

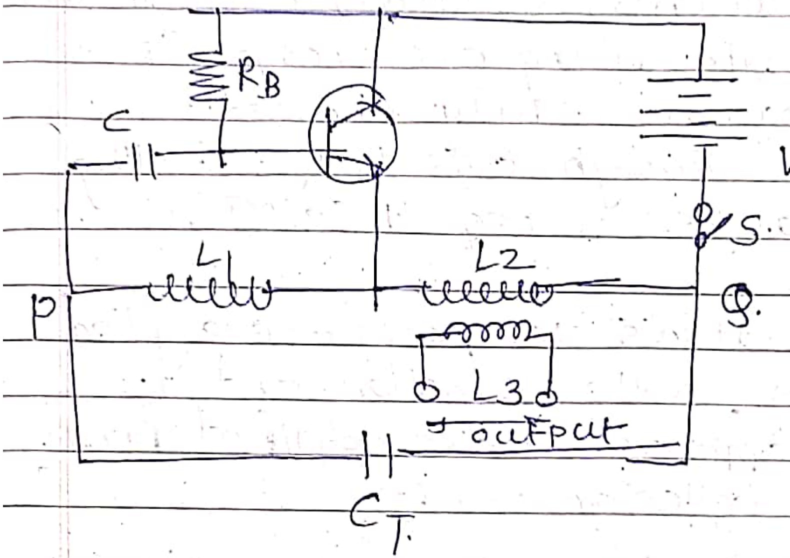
$$\beta = \frac{L_2}{L_1}$$

RFC **

Note that $L_1 - L_2 - C$ is also feedback N/W that produces phase shift of 180^0.

working

Hartley Oscillator



Hartley Oscillator is very popular and is commonly used as a local oscillator in radio receivers.

Advantages:

① Adaptability to a wide range of frequencies

② and it is easy to tune.

Tank cct is made up of CT, L1 and L2
coil L1 is inductively coupled to coil L2,*
Resistance RB between collector and base provides the necessary biasing.

capacitor C blocks the dc component.

Frequency of oscillations is

$$F = \frac{1}{2\pi\sqrt{C_T C(\overset{Leq}{\cancel{L_1+L_2}})}} \longrightarrow ①$$

$L_{eq} = L_1 + L_2 + 2M$.

$$= \frac{1}{2\pi(\sqrt{C_T(L_1+L_2+2M)})}$$

M = mutual inductance between L1 & L2

* this combination functions as auto transformer.

Circuit operation.

When switch S is closed, collector curr current starts rising and charges C_T. When capacitor is fully charged, it discharges through coils L_1 & L_2, setting up oscillations of freq f (eq^n ①)

The oscillations across L_1 are applied to base-emitter junction and it get appeared in the amplified form in the collector circuit.

The ~~collector~~ coil L_2 couples the collector circuit energy back into the tank cct by means of mutual inductance between L_1 & L_2. (feed ba vol

In this way, the energy is being continuously supplied to the tank cct to overcome the losses occuring in it. Consequently, continuous undamped output is obtained.

The ends P and Q of auto transformer ~~are~~ L_1 & L_2 are 180° out of phase. A further phase shift of 180° is produced by base & collector cct of transistor. In this way, energy fedback to the tank cct is in phase with the generated oscillations.

Find the operating freq of a transistor Hartley Oscillator if $L_1 = 100\mu H$, $L_2 = 1mH$, mutual inductance b/n the coils $M = 20\mu H$ and $C = 20pF$

sol^n- total inductance $= L_1 + L_2 + 2M$

~~$= (100 + 1 + 20) \times 10^{-6}$~~

$= 100 \times 10^{-6} + 1 \times 10^{-3} + 20 \times 10^{-6} \times 2$

$= (100 + 1000 + 40)\,\mu H$

L ~~C~~ $= 1140\,\mu H$

$C = 20pF$

$$F = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2\pi\sqrt{1140 \times 10^{-6} \times 20 \times 10^{-12}}}$$

$$= \frac{1}{2\pi\sqrt{114 \times 2 \times 10^{-20}}}$$

$$\boxed{f = 1052\ KHz}$$

**RFC - Radio frequency choke - choke's impedance increases with frequency. It is used ~~to~~ if an inductor is used for blocking or decoupling higher frequencies

It passes low frequency or direct current

Working: When the circuit is turned on, the capacitor is charged. when this capacitor is fully charged, it starts discharging through L_1 + L_2. setting up oscillations of frequency determined by eq^n ①

The output voltage of the amp^r appears across L_1 and feedback voltage across L_2.
The voltage across L_2 is 180° out of phase with respect to voltage developed across L_1 (Vout) as shown in fig ⓑ

It is easy to see that the voltage fedback (i.e voltage across L_2) to transistor to provide positive feedback

A phase shift of 180° is produced by L_1 - L_2 voltage divider. and additional 180° phase shift is produced by transistor. In this way, feedback is properly phased to produce continuous undamped oscillations.

Colpitt's oscillator

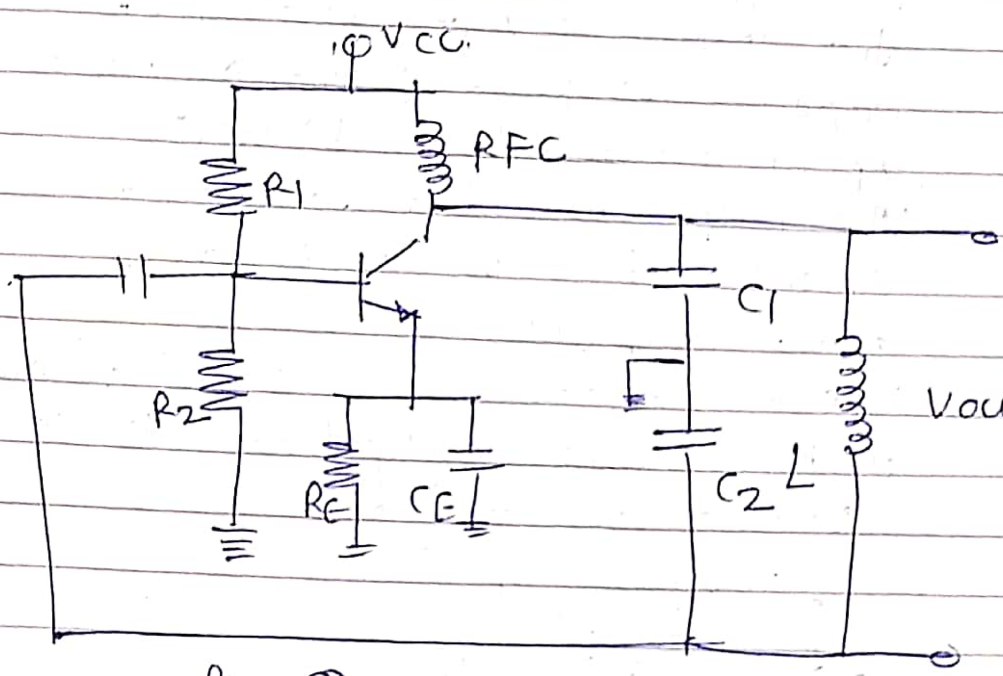


fig ⓐ

It uses two capacitors placed across a common inductance L and centre of two capacitors is tapped.
The tank ckt is made up of C_1, C_2 & L
frequency of oscillation is given by

$$f = \frac{1}{2\pi\sqrt{LC_T}} \quad \text{or } C_{eq} = C_T$$

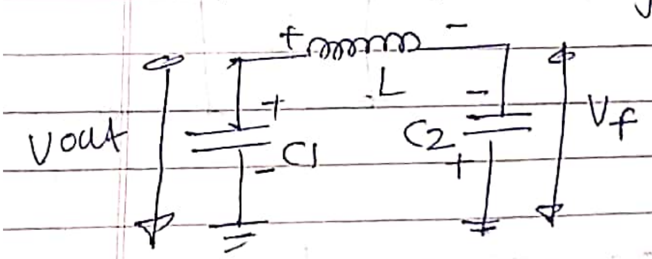
$$C_T = \frac{C_1C_2}{C_1+C_2}.$$

note that $C_1 - C_2 - L$ is also the feedback circuit that produces phase shift of 180^0

Working :- When the circuit is turned on, the capacitor C1 & C2 are charged. The capacitor discharge through L, setting up an oscillations given by eqn ①

The output voltage is developed across C1 and feedback voltage is developed across C2 (~~Vout~~)'.

The voltage across it is 180° out of phase with the voltage developed across ~~V~~ C1 ie Vout as shown in fig ⓑ



feedback circuit

It is easy to see that voltage fedback (voltage across C_2) to transistor provides positive feedback.

A phase shift of 180° is produced by the transistor and farther phase shift of 180° is produced by C1-C2 voltage divider. In this way feedback is properly phased to produce continuous undamped oscillation.

Feedback factor/fraction

$$\beta = \frac{V_f}{V_{out}} = \frac{X_{C2}}{X_{C1}} = \frac{C_1}{C_2}$$

$$\beta = \frac{C_1}{C_2}.$$

$C_1 = 0.001 \mu f$

$C_2 = 0.01 \mu F$

$L = 15 \mu H.$

Find freq of oscillation & feedback factor.

$$C_T = C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{0.001 \times 0.01 \times 10^{-12}}{(0.001 + 0.01) \times 10^{-6}}$$

$$= \cancel{\frac{0.011 \times 10^{-6}}{0.0}}$$

$$= 9.09 \times 10^{-4} \mu F$$

$$= 909 \times 10^{-12}$$

$$= 909 \, pF$$

$$\text{freq } f = \frac{1}{2\pi\sqrt{L C_T}}$$

$$= \frac{1}{2\pi\sqrt{15 \times 10^{-6} \times 909 \times 10^{-12}}}$$

$$= 1361 \times 10^{3}$$

$$\boxed{\text{freq} = 1361 \, KHz}$$

$$\beta = \frac{C_1}{C_2} = \frac{0.001}{0.01} = 0.1$$

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