24	03	2021

$f_{im} = f_{RF} + 2f_{IF}$ (High)

or $f_{im} = f_{RF} - 2f_{IF}$ (Low side injection)

High : $f_{LO} > f_{RF} \Rightarrow f_{LO} = f_{RF} + f_{IF}$

Low : $f_{LO} < f_{RF} \Rightarrow f_{LO} = f_{RF} - f_{IF}$

$f_{IF} > \frac{B_{RF}}{2}$ ⟶ RF bandwidth

FM radio : 88 - 108 MHz (f_{RF})

$B_{RF} = 20$ MHz

$f_{IF} > \frac{20}{2} = 10$ MHz ; $f_{IF} = 10.7$ MHz

FM radio :

RF = 88 − 108 MHz

IF = 10.7 MHz

$f_{IF} > \frac{B_{RF}}{2}$

VCO ← LO = 98.7 to 118.7 MHz

(High side injection)

or

LO = 67.3 to 97.3 MHz

(Low side injection)

$f_{im} = f_{RF} - 2f_{IF}$

= 66.6 to 86.6 MHz

$f_{im} = f_{RF} + 2f_{IF}$

= (88 to 108) + 2(10.7)

= (88 to 108) + 21.4

$\boxed{f_{im} = 109.4 \text{ to } 129.4 \text{ MHz}}$ → which is not the in RF band (88 − 108 MHz)

To avoid image

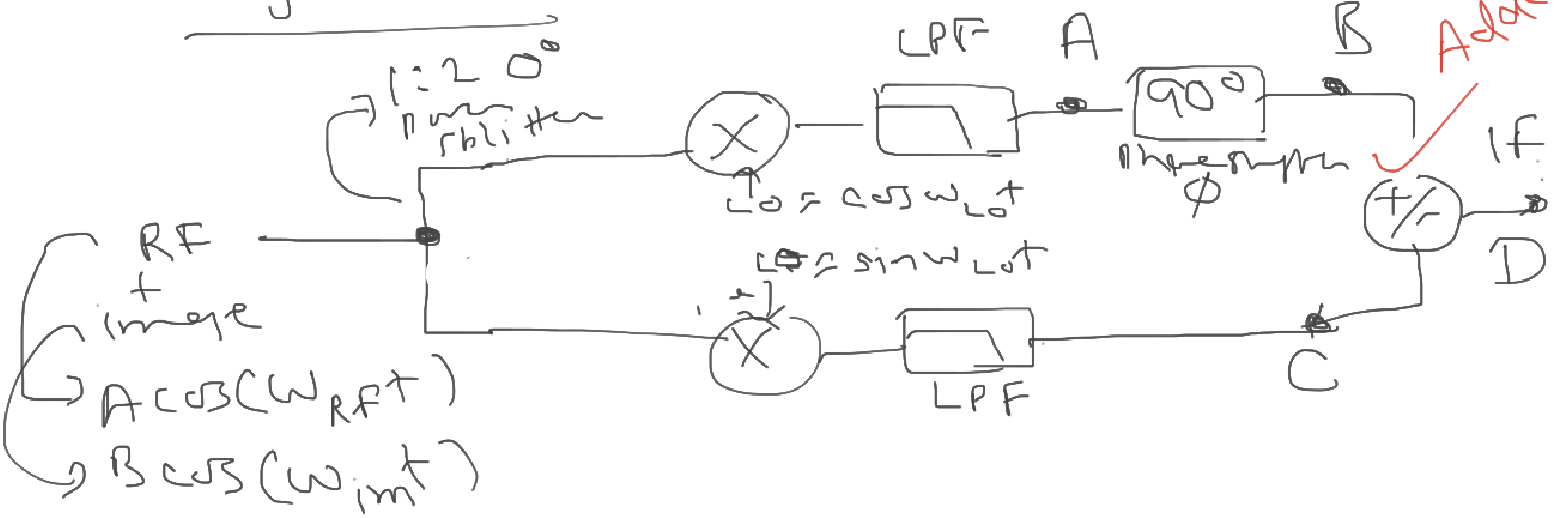
$$f_{im} = f_{RF} \pm 2 f_{IF}$$

or

→ Lower IF → tracking accuracy is lowered

Higher IF → poor selectivity
or
poor adjacent channel rejection

Hartley architecture for image rejection



Signal at A :

$A\cos(\omega_{RF}t)\cos(\omega_{LO}t) +$

$B\cos(\omega_{im}t)\cos(\omega_{LO}t)$

$= \frac{A}{2}\cos(\omega_{RF} - \omega_{LO}t) +$

$\frac{B}{2}\cos(\omega_{im} - \omega_{LO})t$

after LPF

$(\omega_{RF} + \omega_{LO})t$

&

$(\omega_{im} + \omega_{LO})t$

→ rejected

$= \frac{A}{2}\cos(\omega_{IF}t)$ → true if

$+ \frac{B}{2}\cos(\omega_{IF}t)$ → not desired IF

Signal at (B): after 90° phase

$$\frac{A}{2}\cos(\omega_{IF}t+90^\circ)+\frac{B}{2}\cos(\omega_{IF}t+90^\circ)$$

$$= -\frac{A}{2}\sin(\omega_{IF}t) - \frac{B}{2}\sin(\omega_{IF}t)$$

Signal at (C):

$$A\cos(\omega_{RF}t)\sin(\omega_{LO}t) + B\cos(\omega_{im}t)\sin(\omega_{LO}t)$$

$$= -\frac{A}{2}\sin(\omega_{IF}t) + \frac{B}{2}\sin(\omega_{IF}t)$$

true IF

→ not true IF

after LPF & putting IF

IF = RF − LO or IF = Im − LO

Signal at D : = B + C

$$= A \sin(\omega_{IF} t)$$

phase error

true IF, because it is from RF with amplitude A

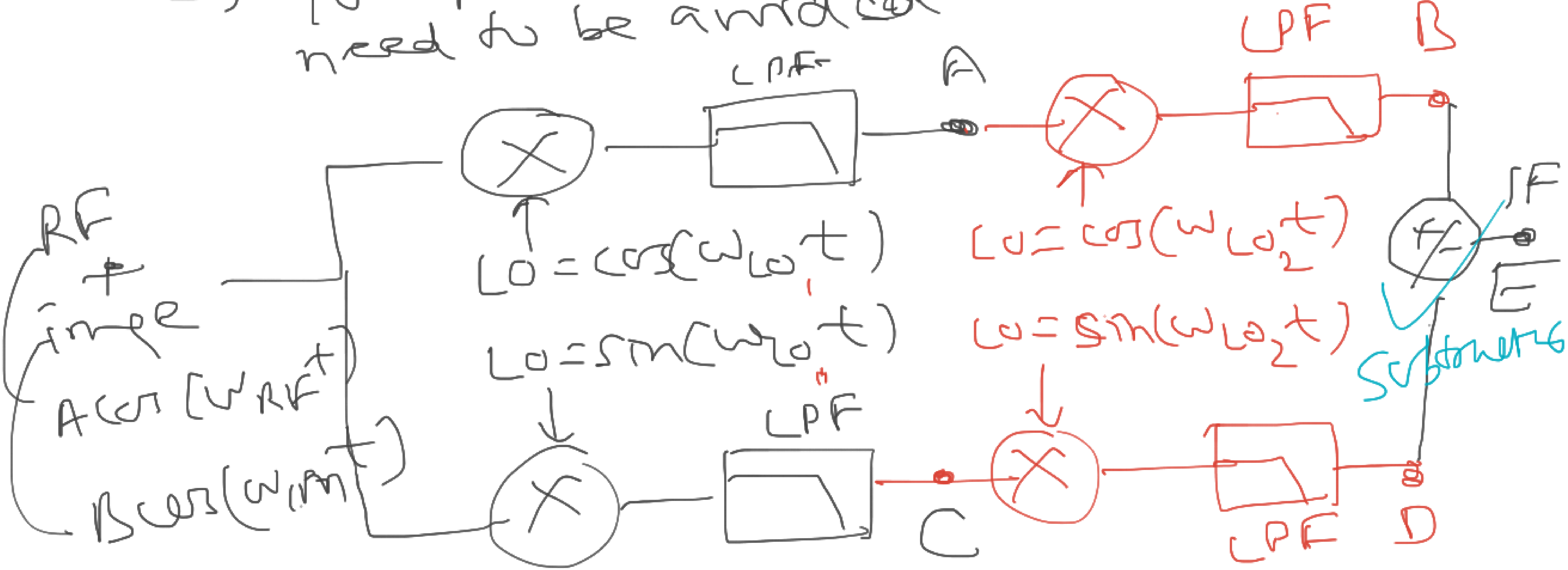
$\boxed{\text{Drawback}}$: → add ~~ed~~ system

(main) → to achieve exactly 90° phase change

Weaver's architecture for image rejection

↳ Ext. of Hartley's architecture

↳ 90° phase achievement problem need to be avoided



A : $\frac{A}{2}\cos(\omega_{IF}t) + \frac{B}{2}\cos(\omega_{IF}t)$

C : $-\frac{A}{2}\sin(\omega_{IF}t) + \frac{B}{2}\sin(\omega_{IF}t)$

same as in Hartley's

B : $\frac{A}{2}\cos(\omega_{IF}t)\cos(\omega_{LO_2}t)$

$+ \frac{B}{2}\cos(\omega_{IF}t)\cos(\omega_{LO_2}t)$

$= \frac{A}{4}\cos(\omega_{IF}-\omega_{LO_2}t) +$

$\frac{B}{4}\cos(\omega_{IF}-\omega_{LO_2}t)$

after LPF

Ⓓ : $-\frac{A}{4}\sin(\omega_{IF}t)\sin(\omega_{LO_2}t) + \frac{B}{4}\sin(\omega_{IF}t)\sin(\omega_{LO_2}t)$

$= -\frac{A}{4}\cos(\omega_{IF}-\omega_{LO_2}t) + \frac{B}{4}\cos(\omega_{IF}-\omega_{LO_2}t)$ after LPF

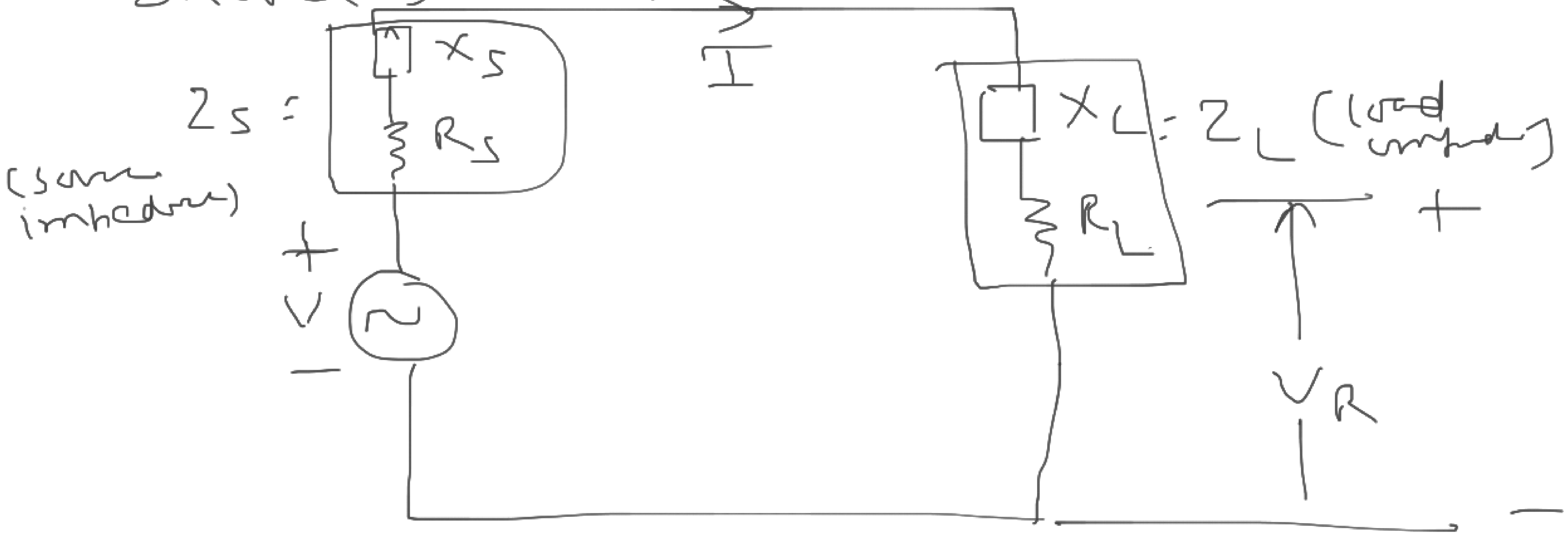
Ⓔ : $B - D$

$= \frac{A}{2}\cos(\omega_{IF}t)$ → true IF

Adv : no 90° phase shift required

Maximum Power Transfer → Impedance matched

When a signal source (generator) is required to deliver to a load, the power transfer should be maximum.



Average power delivered to load Z_L is:

$$P_L = V_R \cdot I$$

$$[P = I^2 R]$$

$$= [I \cdot R_L] \cdot I$$

$$= \underbrace{\frac{V}{\sqrt{(R_s+R_L)^2+(X_s+X_L)^2}}}_{=I} \cdot R_L \cdot \underbrace{\frac{V}{\sqrt{(R_s+R_L)^2+(X_s+X_L)^2}}}_{=I}$$

$$P_L = \frac{V^2 R_L}{(R_s+R_L)^2 + (X_s+X_L)^2}$$

Power delivered to load, i.e. P_L should be maximum, i.e.

$$P_L = \frac{V^2 R_L}{(R_s+R_L)^2+(X_s+X_L)^2} \quad \text{— (1)}$$

should be maximum

Looking first at effect of X_L on P_L,

it will be seen that by making in (1)

$$\boxed{X_L = -X_s,} \quad \text{— (A)}$$

P_L will be at maximum currently

$$P_L = \frac{V^2 R_L}{(R_s+R_L)^2} \quad \text{— (2)}$$

R_L can now be varied to maximize the expression (2), the best (maximum) value of P_L is obtained by equating

$dP_L / dR_L = 0$

From (2),
$$\frac{dP_L}{dR_L} = V^2 \left[R_L \frac{d}{dR_L} (R_S + R_L)^{-2} + (R_S + R_L)^{-2} \cdot \frac{dR_L}{dR_L} \right]$$

$$= V^2 \left[R_L \cdot (-2)(R_S + R_L)^{-3} + (R_S + R_L)^{-2} \cdot 1 \right]$$

$$\frac{dP_L}{dR_L} = V^2 \left[\frac{-2R_L}{(R_S + R_L)^3} + \frac{1}{(R_S + R_L)^2} \right]$$

$$\Rightarrow \frac{dP_L}{dR_L} = V^2 \left[\frac{-2R_L + (R_S + R_L)}{(R_S+R_L)^3} \right]$$

$$\Rightarrow \frac{dP_L}{dR_L} = \frac{V^2\left[(R_S+R_L) - 2R_L\right]}{(R_S+R_L)^3} = 0$$

for max P_L

from which

$$\boxed{R_S = R_L} \quad B$$

Combine A ~~&~~ B

condition for max power transfer

$$\boxed{R_L + jX_L = R_S - jX_S}$$

conjugate matching of impedance

$$Z_L = Z_S^*$$