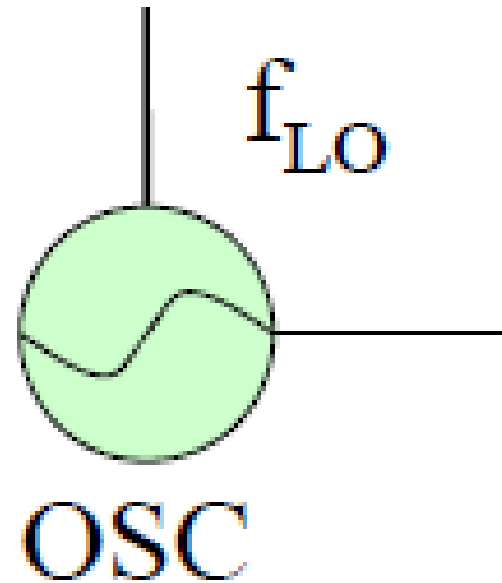


# MICROWAVE OSCILLATORS

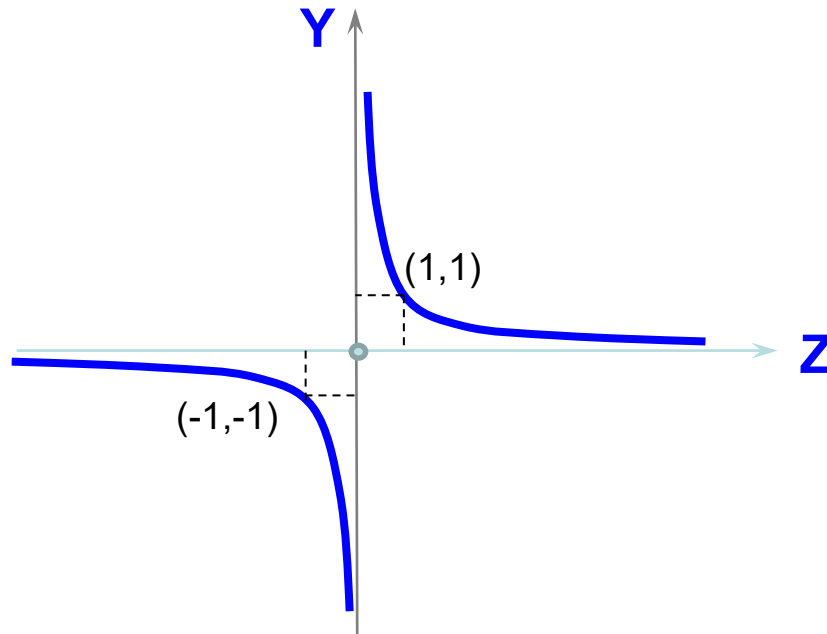
EE5303 – Part 2



$$Z * Y = 1$$

If both  $Z$  and  $Y$  are real numbers

A pictorial  
interpretation



Impedance (Z)

Resistance (R)

Reactance (X)

$$Z = R + jX$$

Unit: Ohm,  $\Omega$

Capacitors

$$X_C = \frac{1}{2\pi fC}$$

Inductor

$$X_L = 2\pi fL$$

SI Unit: L  $\rightarrow$  Henry (H); C  $\rightarrow$  Farad (F)

Admittance (Y)

Conductance (G)

Susceptance (B)

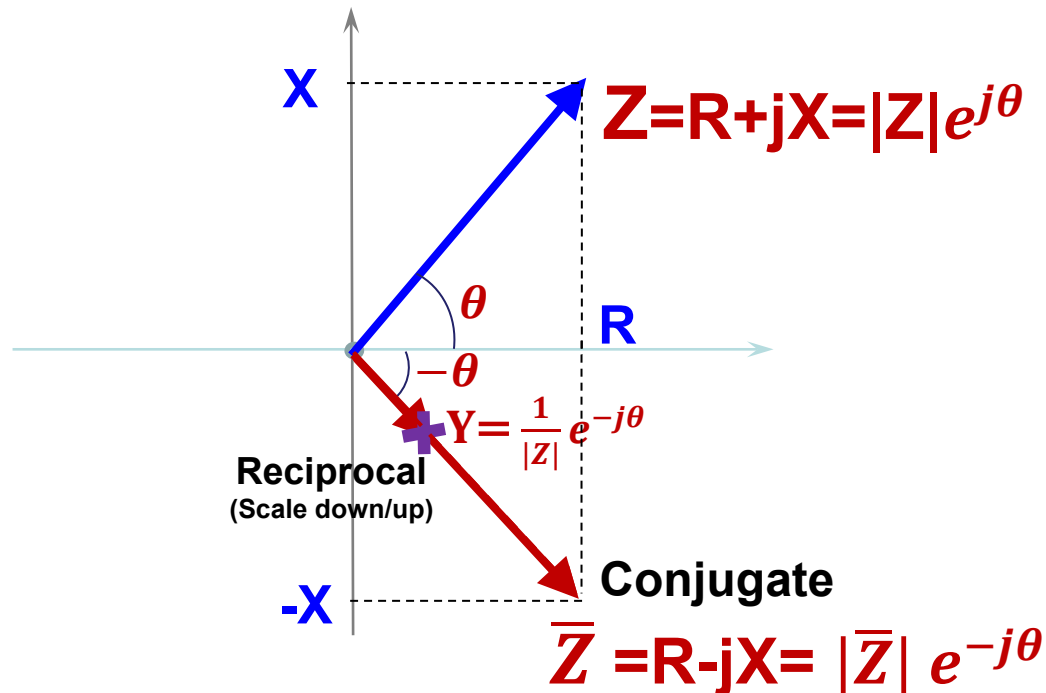
$$Y = G + jB$$

Unit:  $\Omega^{-1}$ , mho, Siemens, S



$$Z^*Y = 1$$

A pictorial interpretation



Impedance (Z)

Resistance (R)

Reactance (X)

$$Z = R + jX$$

Unit: Ohm,  $\Omega$

Capacitors

Inductor



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$-X$



Conjugate

$$\bar{Z} = R - jX = |\bar{Z}| e^{i\theta}$$

# One-Port Negative Resistance Oscillator

## The starting & holding of the Oscillation

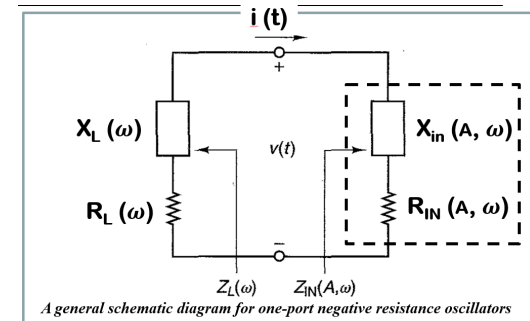
- The process of oscillation depends on the non-linear behavior of  $Z_{IN}$
- It is necessary for the overall circuit to be unstable at a certain frequency i.e.  
 $R_{IN}(A, \omega) + R_L < 0$
- Any transient excitation or noise will cause the oscillation to build up at the frequency,  $\omega$
- As  $A$  increases,  $R_{IN}(A, \omega)$  must become less negative until the current  $A_0$  is reached such that

$$R_{IN}(A_0, \omega) + R_L = 0$$

$$X_{IN}(A_0, \omega) + X_L(\omega) = 0$$

- Then the oscillator is running in steady state.
- The final frequency,  $\omega_0$ , generally differs from the startup frequency because  $X_{IN}$  is current dependent, so that  $X_{IN}(A, \omega) \neq X_{IN}(A_0, \omega_0)$ .

**$Z_{IN}(A, \omega)$  must be amplitude and frequency dependent**



# One Port Negative Resistance Oscillator

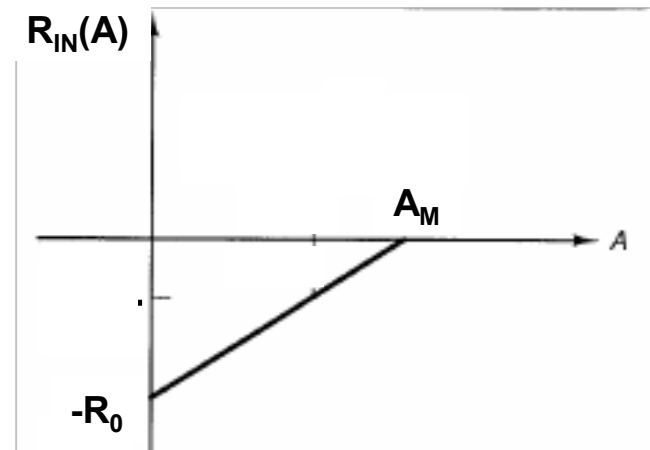
## Selecting $R_L$

A practical way of designing  $R_L$  is to select the value of  $R_L$  for maximum oscillator power.

If the magnitude of the negative resistance is a linearly decreasing function of  $A$ , we can express  $R_{IN}(A)$  in the form

$$R_{IN}(A) = -R_0 \left[ 1 - \frac{A}{A_M} \right]$$

where  $-R_0$  is the value of  $R_{IN}(A)$  at  $A = 0$ , and  $A_M$  is the maximum value of  $A$ .



Linear variation of the negative resistance as a function of the current amplitude

# One-Port Negative Resistance Oscillator

the power delivered to  $R_L$  by  $R_{IN}$  (for  $A < A_M$ ) is

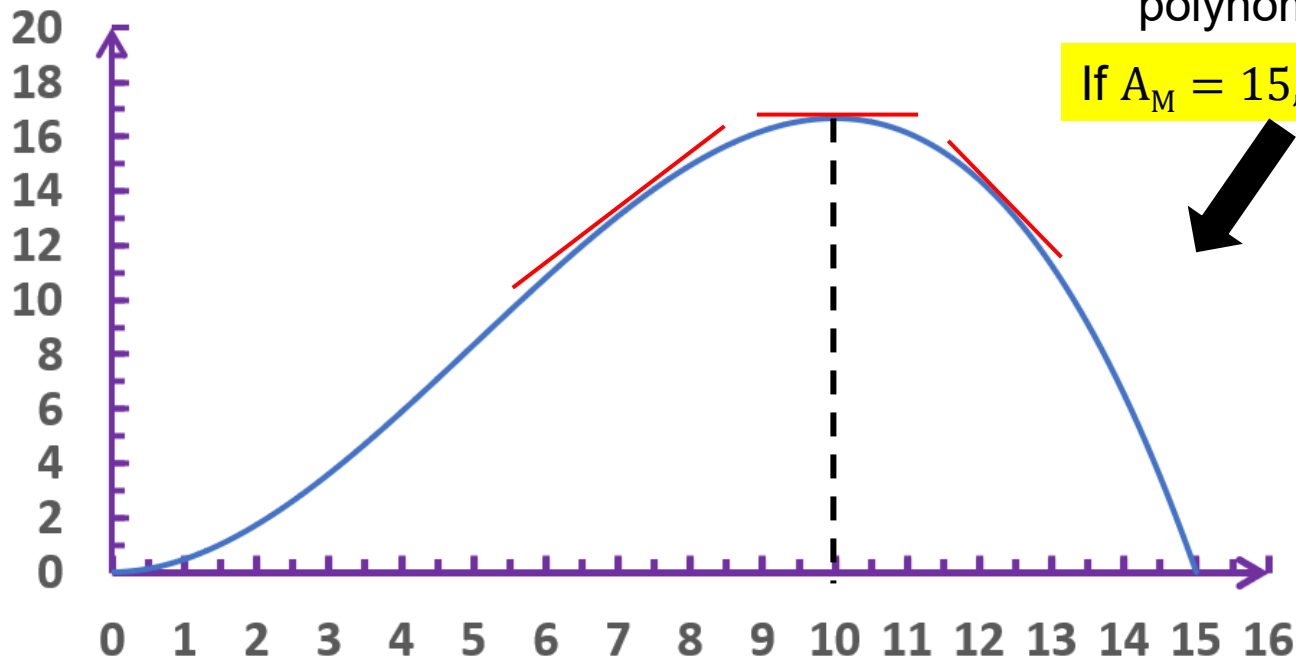
$$P = \frac{1}{2} \text{Re}[VI^*] = \frac{1}{2} |I|^2 |R_{IN}(A)| = \frac{1}{2} A^2 R_0 \left[ 1 - \frac{A}{A_M} \right]$$

$$R_{IN}(A) = -R_0 \left( 1 - \frac{A}{A_M} \right)$$

$$P = \frac{1}{2} A^2 R_0 \left[ 1 - \frac{A}{A_M} \right] \quad \longrightarrow \quad \frac{P}{R_0} = 0.5 A^2 - \frac{0.5 A^3}{A_M}$$

“polynomial”

If  $A_M = 15$ , ( $A < A_M$ )



# One-Port Negative Resistance Oscillator

$$\mathbf{P = \frac{1}{2} A^2 R_0 \left[ 1 - \frac{A}{A_M} \right] = \frac{1}{2} R_0 \left[ A^2 - \frac{A^3}{A_M} \right]}$$

Hence, the value of  $A$  that maximizes the oscillation power is found from

$$\frac{dP}{dA} = \frac{1}{2} R_0 \left[ 2A - \frac{3A^2}{A_M} \right] = 0 \quad \longrightarrow \quad A \left( 2 - \frac{3A}{A_M} \right) = 0$$

which gives the desired value of  $A$ , denoted by  $A_{o,max}$ , that maximizes the power. That is,

$$A_{o,max} = \frac{2}{3} A_M$$

$$R_{IN}(A) = -R_0 \left( 1 - \frac{A}{A_M} \right)$$

At  $A_{o,max}$ , the value of  $R_{IN}(A_{o,max})$  is

$$R_{IN}(A_{o,max}) = -\frac{R_0}{3}$$

Hence a convenient value of  $R_L$ , which **maximized the oscillator power** is

$$R_L = \frac{R_0}{3}$$

