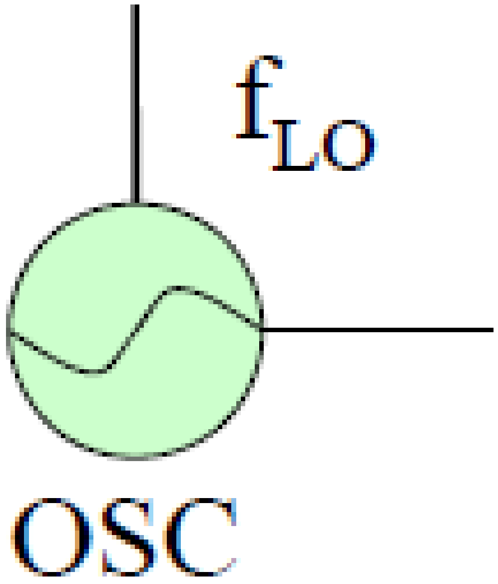
MICROWAVE OSCILLATORS

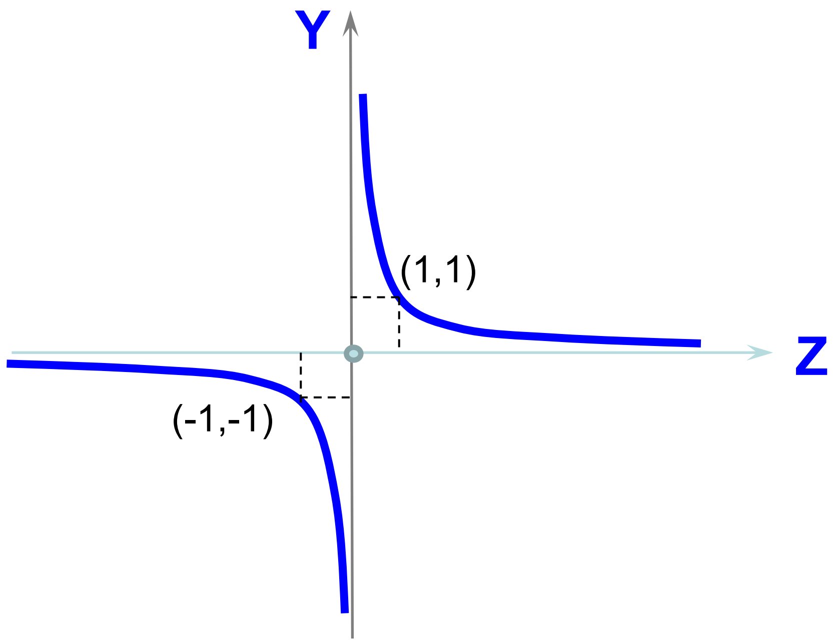


EE5303 – Part 2

$Z*Y = 1$

If both Z and Y are real numbers

A pictorial interpretation



Impedance (Z)	
Resistance (R)	Reactance (X)

$$Z = R + jX$$

Unit: Ohm, Ω

Capacitors	Inductor
$X_C = \frac{1}{2\pi f C}$	$X_L = 2\pi f L$

SI Unit: L → Henry (H); C → Farad (F)

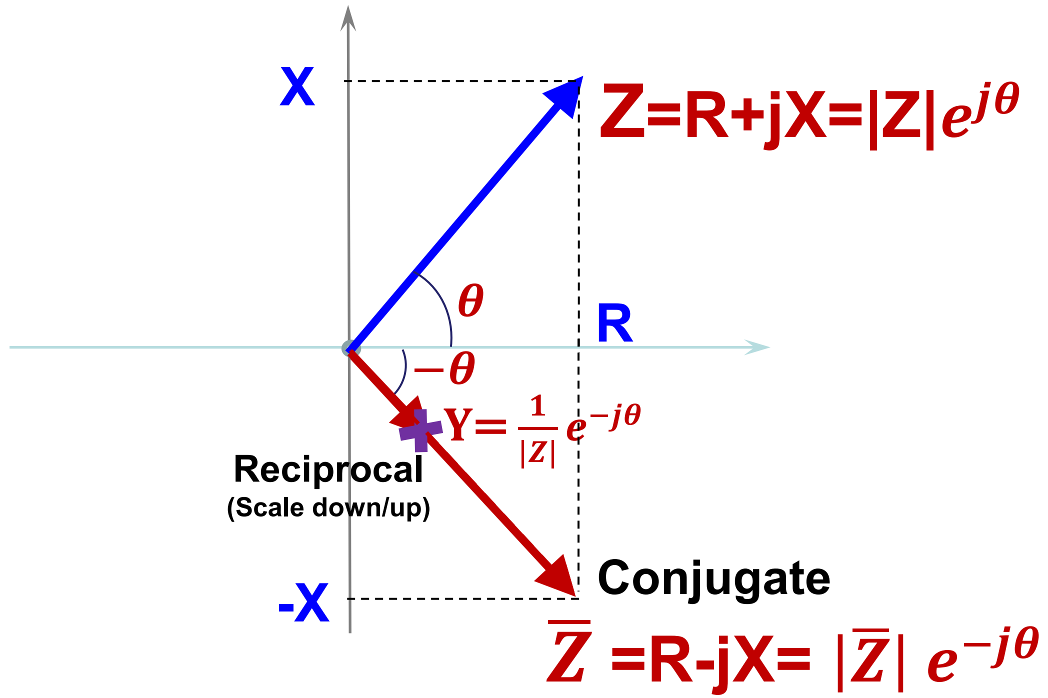
Admittance (Y)	
Conductance (G)	Susceptance (B)

$$Y = G + jB$$

Unit: Ω^{-1}, mho, Siemens, S

$$Z^*Y = 1$$

A pictorial interpretation



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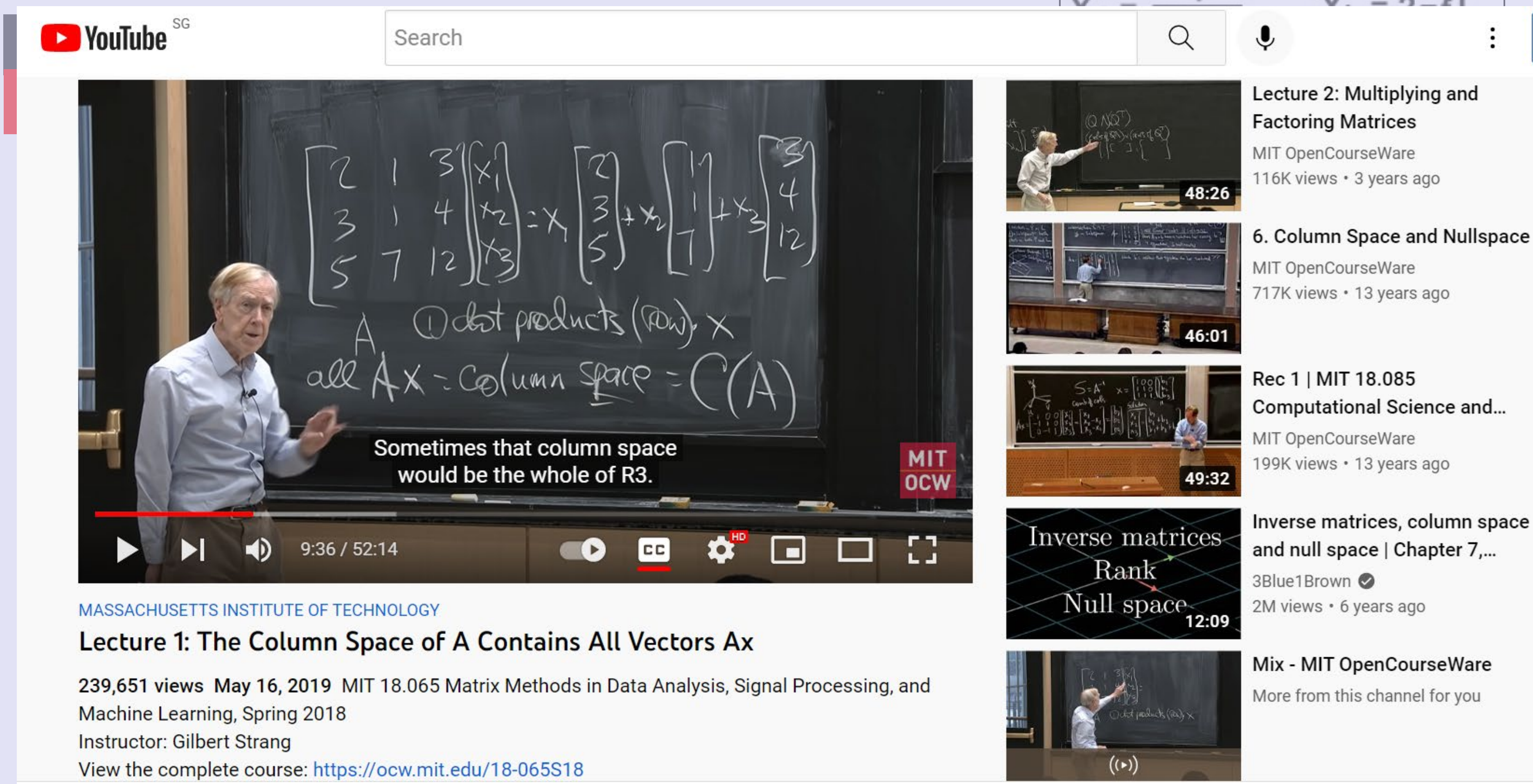


-X

Conjugate

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

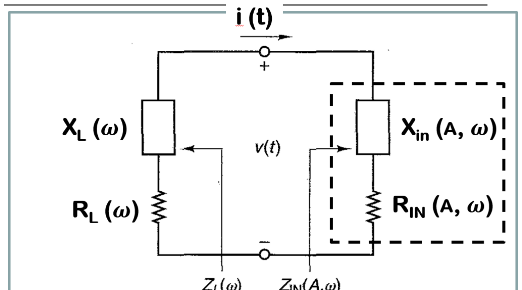
One-Port Negative Resistance Oscillator

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, ω
- As **A** increases, $R_{IN}(A,\omega)$ must become less negative until the current A_0 is reached such that

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

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



A general schematic diagram for one-port negative resistance oscillators

- Then the oscillator is running in steady state.
- The final frequency, ω_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

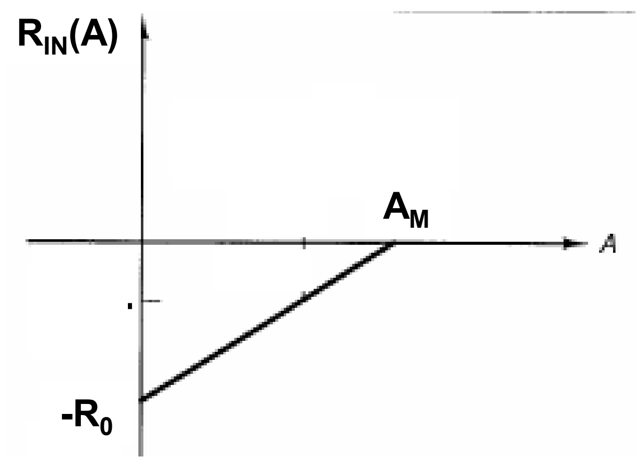
Selecting R_L

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

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

where $-R_o$ 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

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

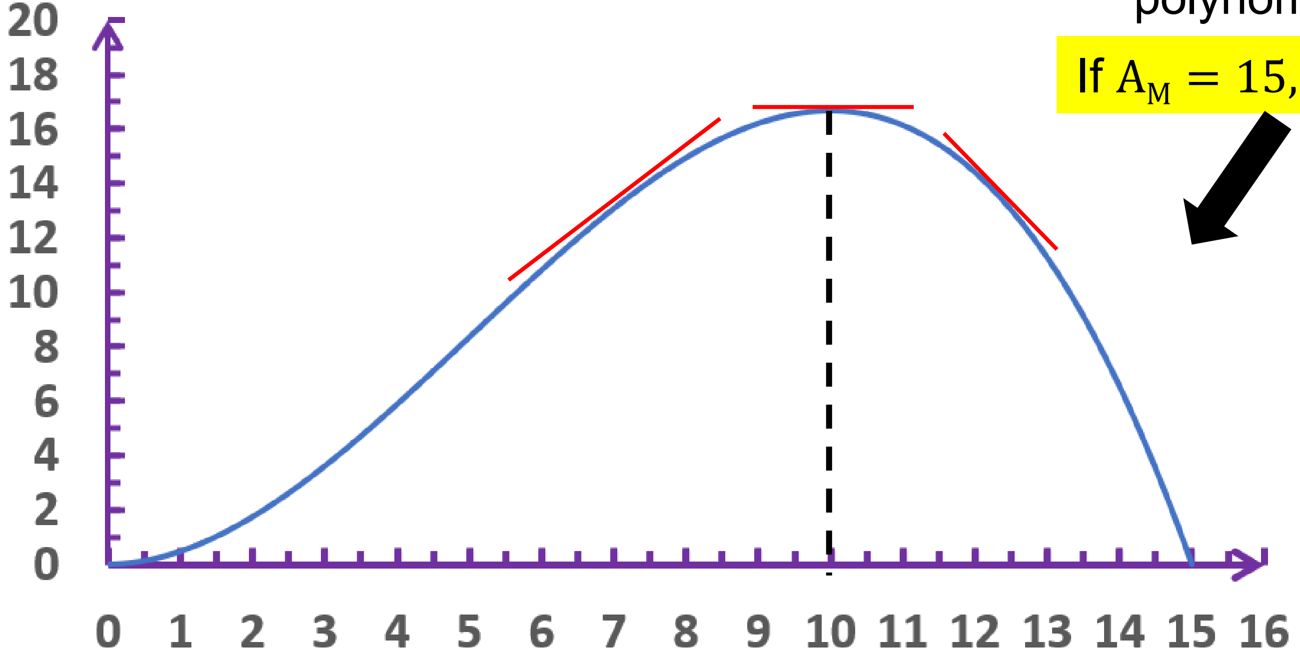
the power delivered to R_L by R_{IN} (for $A < A_M$) is

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

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

"polynomial"

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



One-Port Negative Resistance Oscillator

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

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

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

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

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

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

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

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