Huazhong University
of Science & Technology

Electronic Circuit of Communications

School of Electronic Information
and Commnications

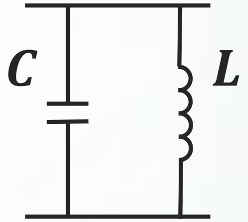
Jiaqing Huang

Quartz Crystal Filter

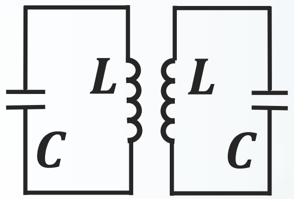
Frequency Selective Circuits

- Resonance
  - Series Resonance

  - Parallel Resonance

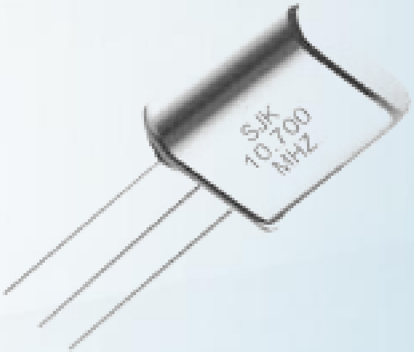


  - Coupling Resonance



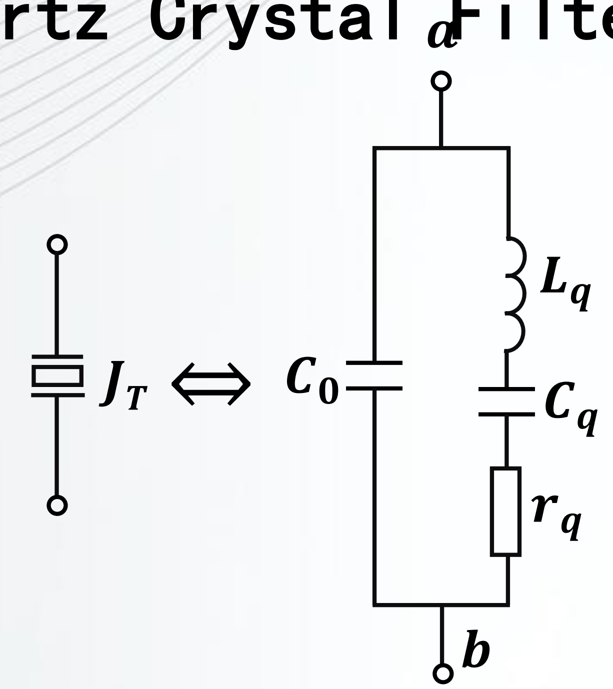
- Filter
  - Quartz Crystal Filter

  - Ceramic filter
  - SAWF

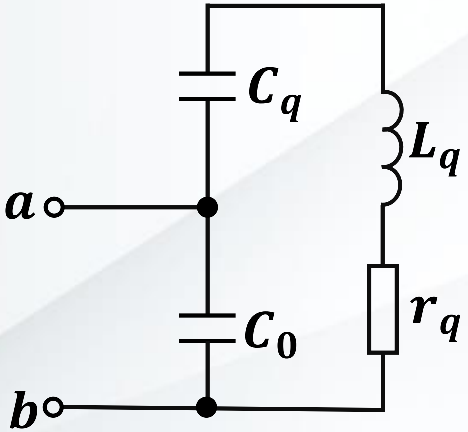


Piezoelectric Effect

Quartz Crystal Filter



Equivalent Circuit ($C_q \ll C_0$)



Series Frequency $\omega_q = \dfrac{1}{\sqrt{L_q C_q}}$

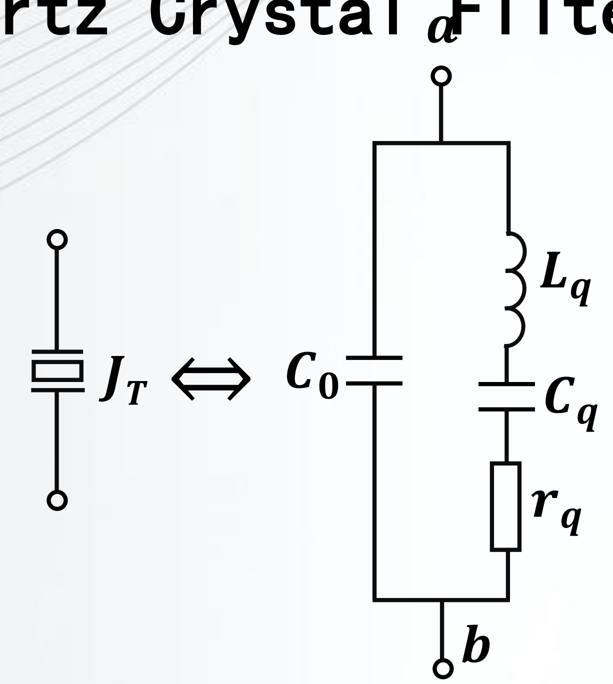
Parallel Frequency $\omega_p = \dfrac{1}{\sqrt{L_q \boxed{\dfrac{C_0 C_q}{C_0 + C_q}}}}$

$C_0 + C_q$

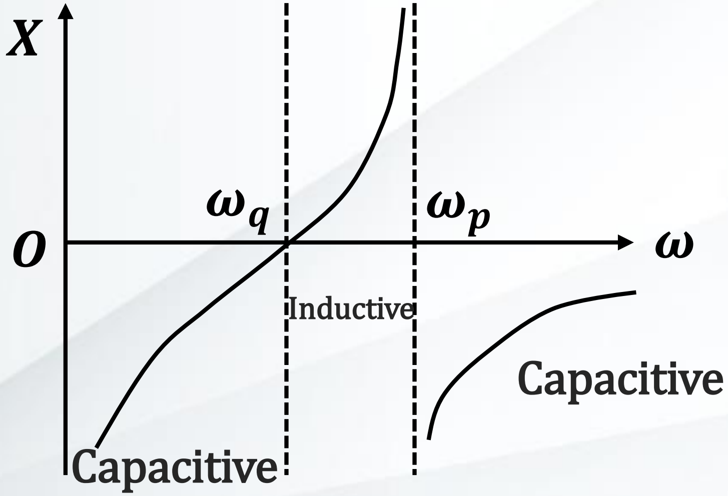
(1) $p \approx \dfrac{C_q}{C_0}$ Very Small 10^{-3}

(2) $Q = \dfrac{1}{r_q}\sqrt{\dfrac{L_q}{C_q}}$ Very Large

Quartz Crystal Filter



Equivalent Circuit（$C_q \ll C_0$）



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Parallel Frequency $\omega_p = \dfrac{1}{\sqrt{L_q \dfrac{C_0 C_q}{C_0 + C_q}}}$

$C_0 + C_q$

(1) $p \approx \dfrac{C_q}{C_0}$ Very Small

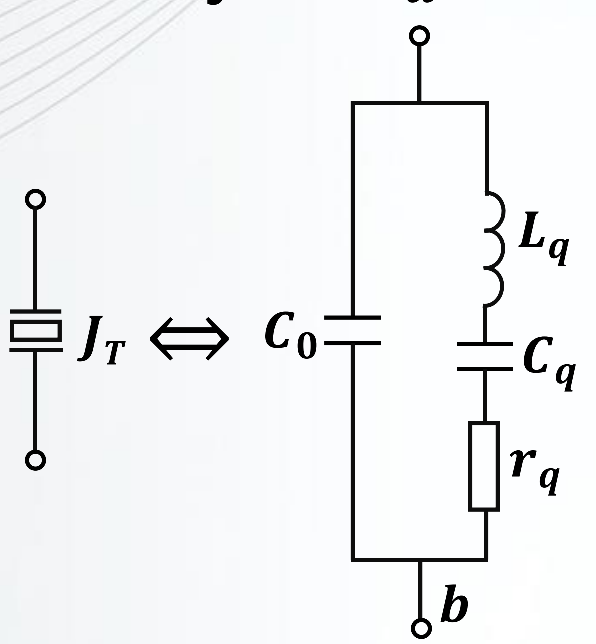
(2) $Q = \dfrac{1}{r_q}\sqrt{\dfrac{L_q}{C_q}}$ Very Large

(3) $\omega_p > \omega_q$

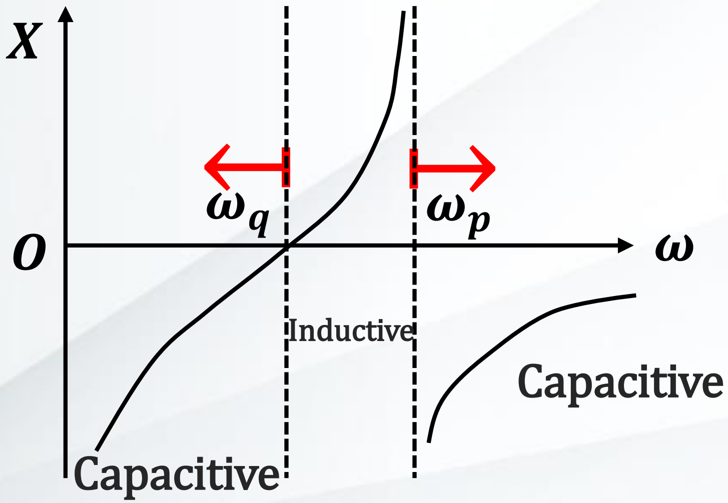
(4) $\omega_p = \omega_q\sqrt{1 + \dfrac{C_q}{C_0}} = \omega_q\sqrt{1+p}$

ω_p ω_q Very Close

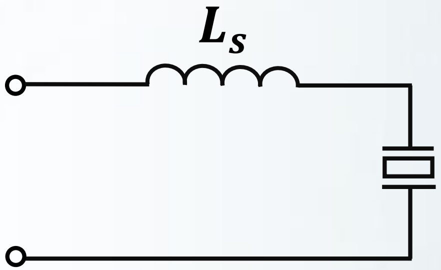
Quartz Crystal Filter



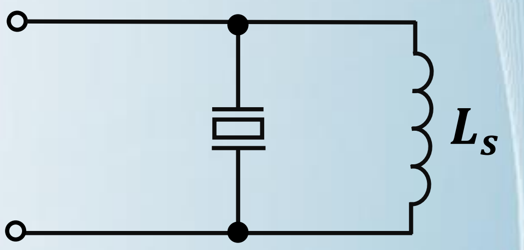
Equivalent Circuit （$C_q \ll C_0$）



Increase bandwidth



Decrease ω_q



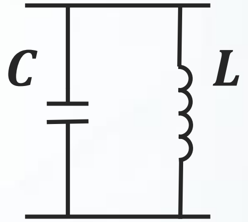
Increase ω_p

Ceramic Filter

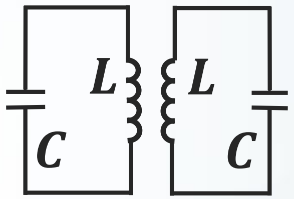
Frequency Selective Circuits

- Resonance
  - Series Resonance

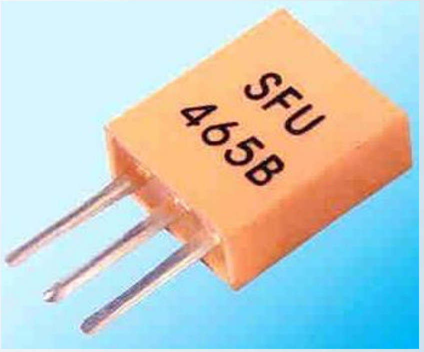
  - Parallel Resonance



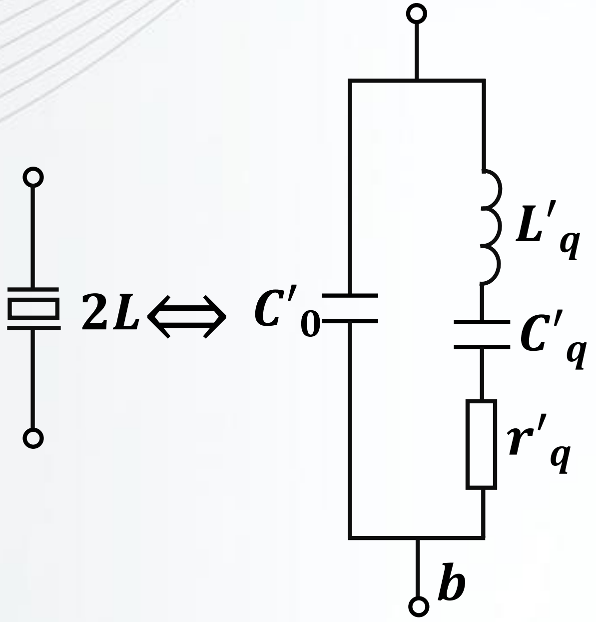
  - Coupling Resonance



- Filter
  - Quartz Crystal Filter
  - Ceramic filter
  - SAWF



Ceramic Filter

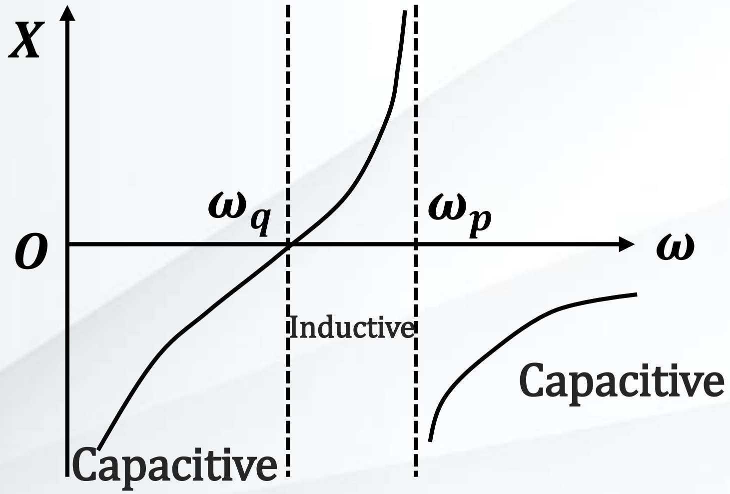


Equivalent Circuit

Series Frequency $\omega_q = \dfrac{1}{\sqrt{L'_q C'_q}}$

Parallel Frequency $\omega_p = \dfrac{1}{\sqrt{L'_q \boxed{\dfrac{C'_0 C_q}{C'_0 + C_q}}}}$

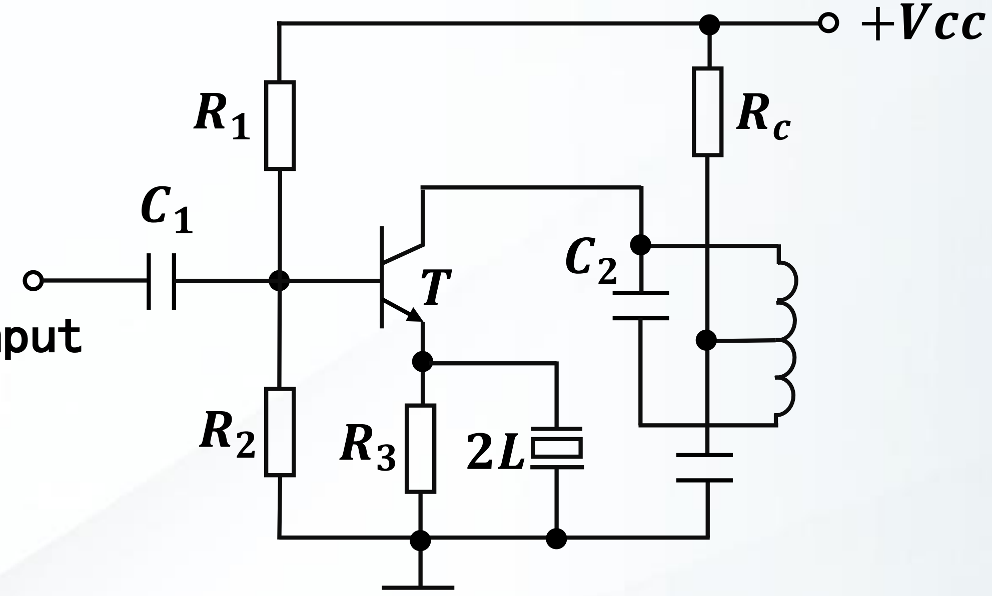
$C'_0 + C'_q$



- LC Resonator $< Q <$ Quartz Crystal

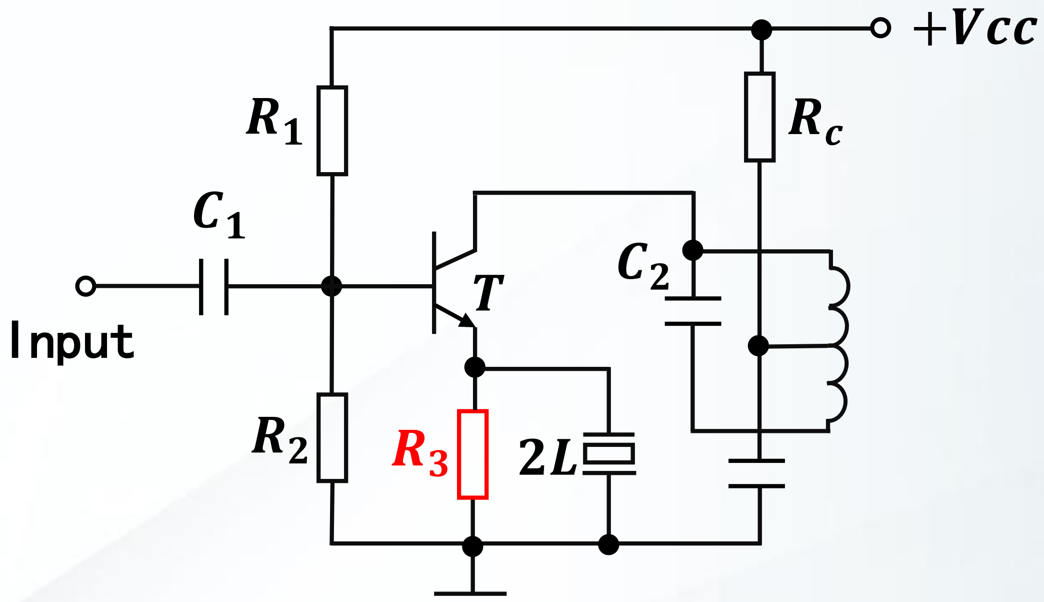
Ceramic Filter

Exp1: $f_0 = 465kHz$, analyze the circuit function.



Ceramic Filter

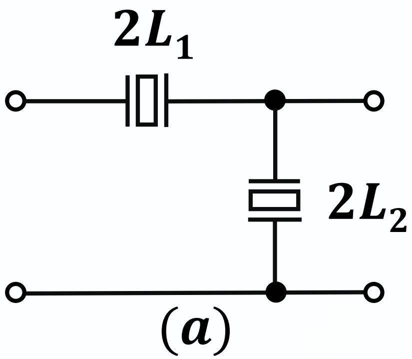
Exp1: $f_0 = 465kHz$, analyze the circuit function.



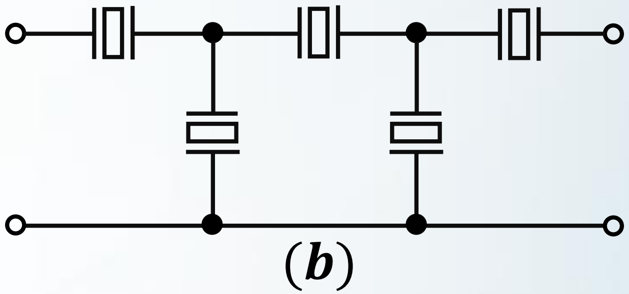
Solve: Serices frequency of $2L = 465kHz$

For $465kHz$, Impedance ↓, Negative Feedback ↓, Gain ↑

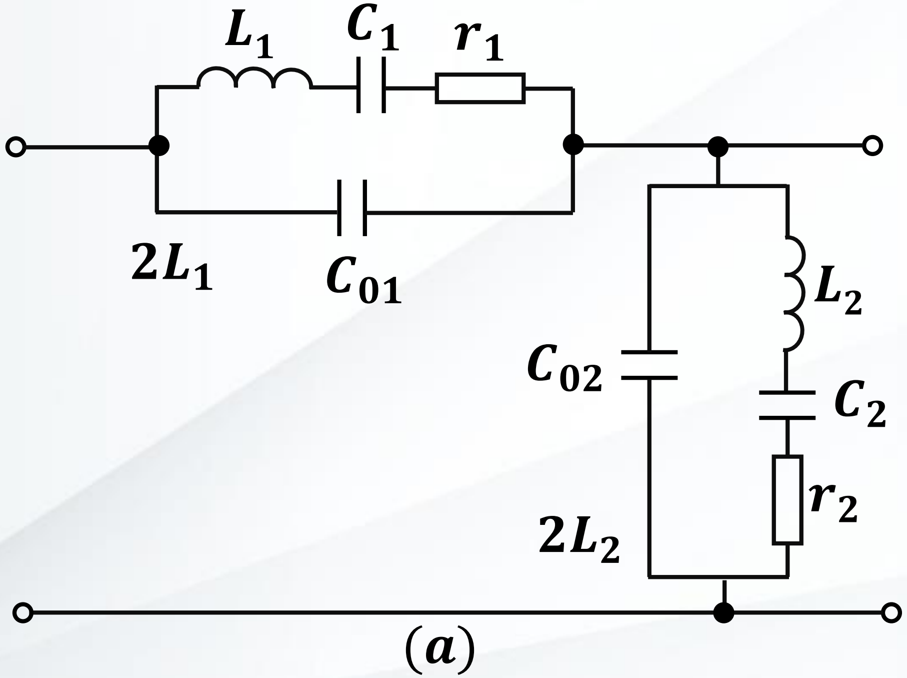
Four-terminal Ceramic Filter : Ceramic Resonator



2 Ceramic Resonator

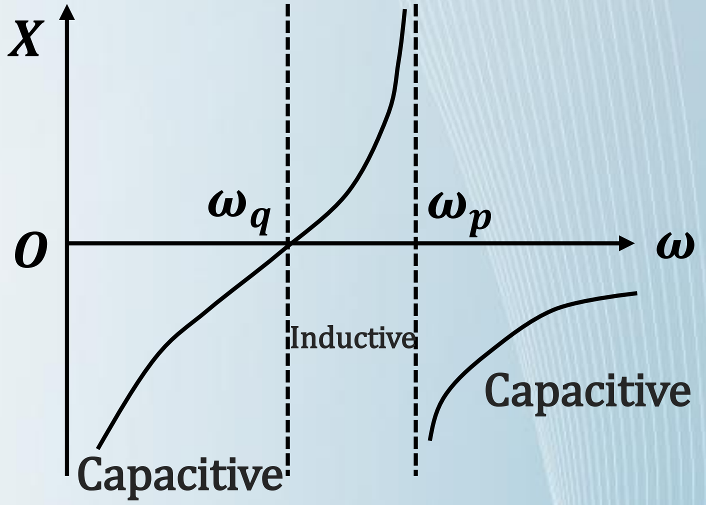


5 Ceramic Resonator



Four-terminal Ceramic Filter

Exp2: How to design $(465 \pm 5)kHz$ filter?

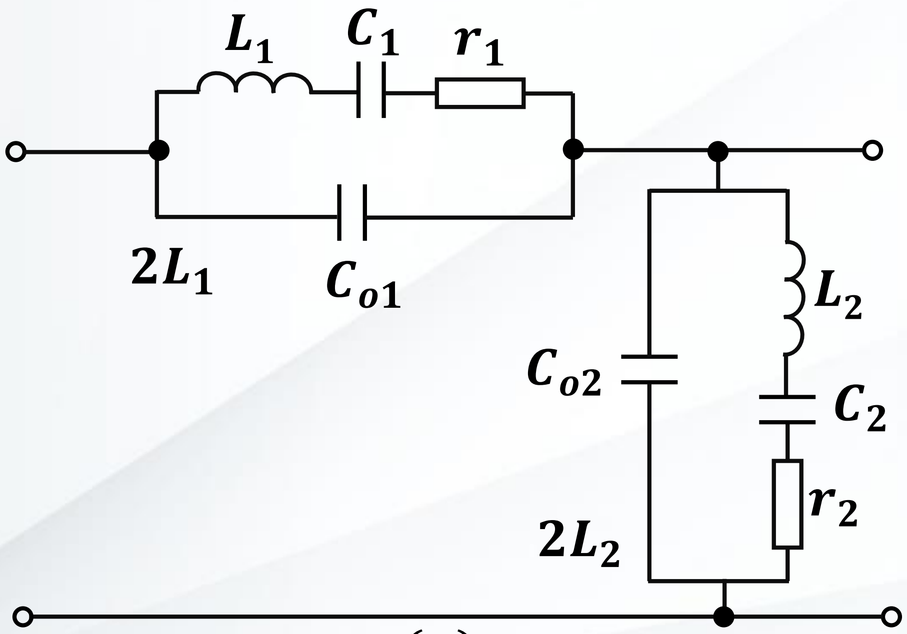


Solve: For $465kHz$:

$2L_1$ Series frequency = $465kHz$

$2L_2$ Parallel frequency = $465kHz$

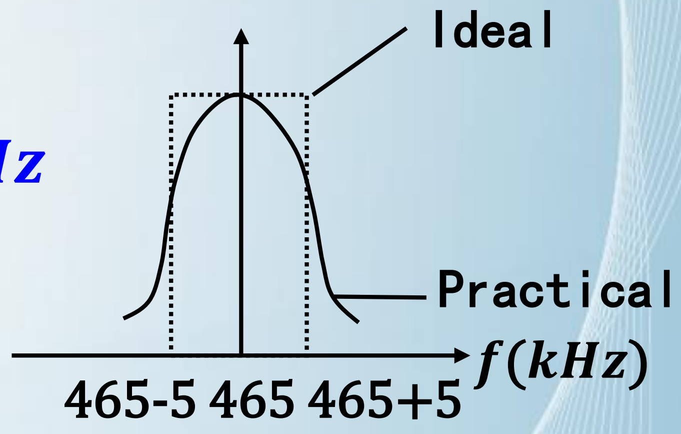
$f_{q1} = 465kHz$ $f_{p1} = (465 + 5)kHz$



(a)

$f_{q2} = (465 - 5)kHz$

$f_{p2} = 465kHz$



(b)