电原复习

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L08 Port

1. Port
   Two terminals s.t. the current flowing into one terminal equals to one flowing out of the other.
   An abstract notion, to simplify as we only focus on:
   Port condition
2. Passive/active one-port
   $\int^{t} u(\tau)i(\tau)d\tau \geq 0(\forall\, t) or < 0\,(\exists t)$
   Passive/active sign convention

L16 Equivalent Resistance of two-terminal network

2. Solution Process
   1st. Serial/Parallel
   2nd. Balanced Bridge
   3rd. Δ-Y Transform
   4th. u->i/i->u method

L55 Serieal RLC Second-order Circuits

1. Review
   $\frac{dx}{dt} + 2x = 0, x = Ae^{-2t}$
   $\frac{dx}{dt} + 2x = t^2, x = x' + x'' = (Ae^{-2t}) + (Bt^2 + Ct + D)$
2. Math
   $\frac{d^2x}{dt^2} + 3\frac{dx}{dt} + 2x = 0, x = Ae^{-2t} + Be^{-t}$

   $(A + Bt)e^{-\lambda t}$

   $Ae^{\lambda t}cost + Be^{\lambda t}sint = Ke^{\lambda t}\sin(t + \theta)$
3. ZIR RLC serial circuit
   a) Equation
      $\frac{d^2u_c}{dt} + \frac{R}{L}\frac{du_c}{dt} + \frac{1}{LC}u_c = 0$
      $\lambda^2 + 2\alpha\lambda + \omega_0^2 = 0$
   b) Natural response

$\alpha^2 ?\, \omega_0^2$	>	=	<	$\alpha = 0$
$\lambda_{1,2}$	$-\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$	$-\alpha$	$-\alpha \pm j\sqrt{\omega_0^2 - \alpha^2}$	$\pm j\omega_0$
u_c	$Ae^{\lambda_1 t} + Be^{\lambda_2 t}$	$Ae^{-\alpha t} + Bte^{-\alpha t}$	$Ke^{-\alpha t}\sin(\omega_d t + \theta)$, $\omega_d = \sqrt{\omega_0^2 - \alpha^2}$	$Ksin(\omega_0 t + \theta)$
	Over-damping	Critical-damping	Under-damping	No-damping

   c) Numerical examples

L56 Parallel RLC Second-order Circuits

$\frac{d^2i_L}{dt} + \frac{1}{RC}\frac{di_L}{dt} + \frac{1}{LC}u_c = 0$

Use duality

L57 Intuitive method for second-order circuits

2. State Equation and Output Equations
   Set uc and iL as state variables
      Use uc, iL (and us) to express uL, ic - State eqn (ODE)
      Other variables expressed - Output eqn (algebraic)
3. Substitution Method for State Equations and Output Equations
4. State Equation -> Characteristic Equation
   $|\lambda I - A|$
5. Output Equation -> Initial Value of the First-order Differentiation
6. Three Elements Method for Second-order Circuits
   Find ZSR (using substitution method)
      广义三要素:
         How -> state eqn
         ∞ -> output eqn
         0+ -> output eqn

L61 Phasor

   "Vector with information of phase"

1. Introduction
   Charles Steinmeintz: father of phasor method
2. Review of Complex Numbers
   $A = |A|e^{j\theta} = |A|\angle\theta$
   $A_1 \cdot A_2 = |A_1||A_2|\angle(\psi_1 + \psi_2)$
3. Representing Sinusoids with Complex Numbers
      rms: effective value don't forget to divide sqrt2
      initial: initial angle
4. Calculation of phasors
5. Why Phasor Matters
      SSS: sinusoidal steady state analysis

L62 Phasor Form of Circuilar Constraints

1. Topological Constriants
      直接替换即可
2. Element Constraints
   - Resistors
   - Inductors jω=X_L
     - U leads I 90度
   - Capacitors X_C= -1/jω Notice the negative sign
     - I leads U 90度
3. Time Domain -> Phasor Domain
      ODE -> Algebraic eqns with complex coefficients

L63 Impedance and Admittance

1. Impedance
   $Z = R + jX = |Z|\angle\phi$
   Phasor graph: reference phasor, head-to-tail (good for solving the circuit) etc
2. Admittance
   $Y = G + jB = |Y|\angle\phi'$
3. Impedance and Admittance
   $Z = \frac{1}{Y}\ (R \neq \frac{1}{G}, X \neq \frac{1}{B})$
4. Serial/parallel Connection
5. Phasor Graph
6. Z Matrix and Y Matrix

L64 Phasor Method for Sinusoidal Steady State Circuits

7 example problems

L65 Instantaneous Power

0. Why NOT multiply directly?
   The result is not physical, i.e. has no physical meanign
1. Definition
   $p_a = ui$
2. Resistors
   $i(t) = \sqrt{2}Isin\omega t, u(t) = \sqrt{2}U_R sin\omega t$
   $p_a(t) = u(t)i(t) = 2U_R Isin^2\omega t = U_R I(1 - cos2\omega t) \geq 0$
3. Inductors
   $i(t) = \sqrt{2}Isin\omega t, u(t) = \sqrt{2}U_L\sin(\omega t + 90°)$
   $p_a(t) = u(t)i(t) = 2U_R Isin\omega tcos\omega t = U_R I(sin2\omega t)$
4. Capacitors consider duality, different reference initial angle
   $u(t) = \sqrt{2}Usin\omega t, i(t) = \sqrt{2}I_C\sin(\omega t + 90°)$
   $p_a(t) = u(t)i(t) = 2UI_C sin\omega tcos\omega t = UI_C(sin2\omega t)$
5. Any one-port
   $u(t) = \sqrt{2}Usin\omega t, i(t) = \sqrt{2}\,Isin(\omega t - \phi)$
   $p_a(t) = u(t)i(t) = 2UIsin\omega t\, sin(\omega t - \phi)$
   $= UIcos\phi - UIcos(2\omega t - \phi)$

   $p_a(t) = UIcos\phi - UIcos(2\omega t - \phi)$
      Constant   Reversible
   $p_a(t) = UIcos\phi(1 - cos2\omega t) - UIsin\phi sin2\omega t$
      Irreversible   Reversible

L66 Average Power

L66 Average Power

1. Average Power
   $UIcos\phi$ power factor; power factor angle
   Only consumed on resistor
   $X > 0, \phi > 0, lag, inductive$
   $X > 0, \phi > 0, lead, capacitive$
2. Wattmeter measuring active power
   $\phi = \psi_u - \psi_i$
3. Maximum Power Transfer
   Conjugate match $Z_L = Z_i^*$

L67 Reactive Power and Apparent Power

1. Reactive Power
   $UIsin\phi$, var(voltage ampere reactive)
   R: $Q = UIsin\phi = 0$
   L: $Q_L = UIsin\phi = -UI$
   C: $Q_C = UIsin\phi = UI$
   Maximum energy exchange rate
2. Apparent Power
   $S = UI$, va
   Power supplies' ability to provide power
3. Increase the power factor
   To decrease I along the transmission line when U at user end remain constant

L68 Complex Power

Derived from exponential functions
$\bar{S} = \dot{U}\dot{I}^* = P + jQ$
Conservation of complex/reactive/active power

L69 Mutual inductance and mutual voltage

$k = \frac{M}{\sqrt{L_1 L_2}} \le 1$

L70 Dot convention

2. The usage of dot convention
   $u_{21} = M\frac{di_1}{dt}$
   i_1 *flowing into the dot* $\rightarrow u_{21}$ *is positive (from dot to the other terminal)*
   Can be applied to SSS seamlessly

L80 Decoupling equivalence of mutual inductance

Serial, Parallel, Single point
1. Serial
   a) Ordinal
      $u = (L_1 + L_2 + 2M)\frac{di}{dt}$
   b) Reversed
      $u = (L_1 + L_2 - 2M)\frac{di}{dt}$
2. Parallel
   构造【去偶】等效电路（分干路电流和指路电流）
   a) Ordinal M
   b) Reversed -M
3. Single Point Connection
   a) M
   b) -M
   E2 use generalized KCL (变压器间引入一条线→单点连)
4. Decoupling is NOT omnipotent
   e.g. If two coils don't have any public terminal
   But have electrical connection

L81 Air-core transformer

1. Transformer
   Primary side, Secondary side
2. Air-core Transformer
   def. $Z_{11} = R_1 + j\omega L_1, Z_{22} = (R_L + R) + j(\omega L_2 + X)$
   a) Seen from source
      Reflected impedance
      (total) $Z_{11}, Z_l = \frac{(\omega M)^2}{Z_{22}}$
   b) Seen from load
      $\frac{j\omega M}{Z_{11}}\dot{U}_S$, $\frac{(\omega M)^2}{Z_{11}}, Z_{22}$
   c) Decoupled 在电机学中所采用的主要电路
      Impedance converting👌

L82 Unity-coupled Transformer

全耦合，无损
(Recall)$L_1 \propto N_1^2, L_2 \propto N_2^2, M \propto N_1 N_2$
Turns ratio n = N1/N2

$\dot{I}_1 = \frac{\dot{U}_1}{j\omega L_1} - \frac{1}{n}\dot{I}_2$,相当于还是有一部分要给一个阻抗供电（第一项），剩下的做电流变换（第二项）
$\dot{U}_1 = n\dot{U}_2$

L83 Ideal Transformer

$\dot{I}_1 = -\frac{1}{n}\dot{I}_2$ 留神这个负号,并定义的电流方向相向流入的
实际应用中，常定义电流一个方向，这样表述简便，于是便没有负号
认为第一项趋近于∞（认为匝数很多，磁导率够大，所以L1够大）
2. Properties of Ideal Transformer
   a) Impedance converting
   b) Power consumption
      $$p_a = u_1 i_1 + u_2 i_2 = n u_2 \left(-\frac{1}{n} i_2\right) + u_2 i_2 = 0$$

电路原理易错点(期中总结)

源变换前后的电阻、电压电流数值
源能不能变

MOSFET数字电路：**非**！非！非！

小信号电阻是动态电阻

二极管导通时两端电压为零！断路时才“保持原样”(错两遍了！)

Tellegen定理中，“注意参考方向”意指计算时要不都按absorb，要不都按deliver

注意电压标的是哪两端电压！

注意电容**换路等效**成理想电压源后的参考方向

电流源置零是断路！算等效电阻时易错！
求Req时也尤其注意**受控源** 严格写出加压求流/加流求压式

注意**运放有源** 输出端后电流不再可由虚短虚断确定（不要下意识地在运放输出端用KCL！！）

模拟题tip：严格**列KVL**，以防电压升降加减出错
节点电压/回路电流标准方程，矩阵形式的等式右边(对应常数)也要检查降低笔误
别落“m”“k”（尤其对应于电流、电阻）
注意**二端口**的囊括范围（前后有没有变化）
接地端 (真正的而非定义的，如运放) 可能有流向地的电流，因此不要在运放外围用广义KCL