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Electronic Circuit of Communications

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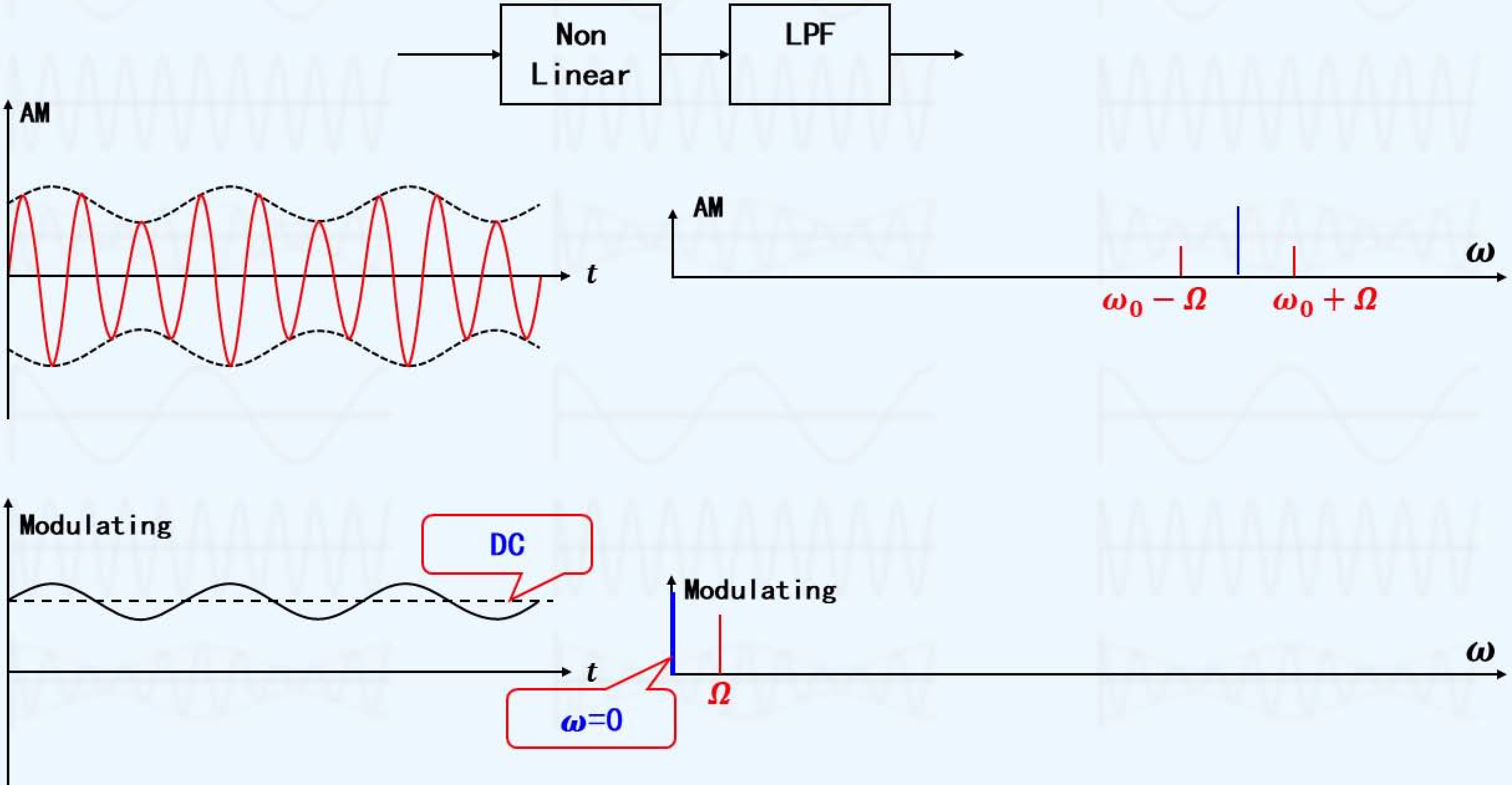
Peak Envelope Detection

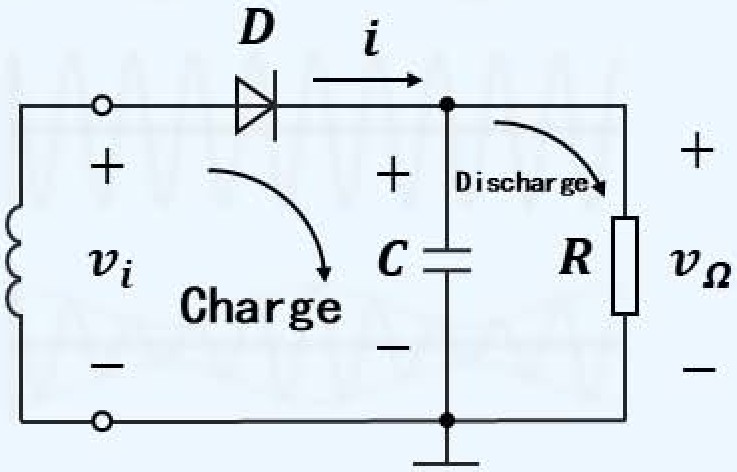
Detection – Classification

- Detection
  - Envelope Detection
    - Square-law Detection
    - Peak Envelope Detection
      - Series Diode
      - Parallel Diode
    - Average Envelope Detection
  - Synchronous Detection
    - Multiplication
    - Superposition

Envelope Detection （Single-Tone AM）



Peak Envelope Detection



RC : Detector Load

LPF

$$\frac{1}{\omega_0 C} \ll R \qquad \frac{1}{\Omega_{\max} C} \gg R$$

➢ Principle:

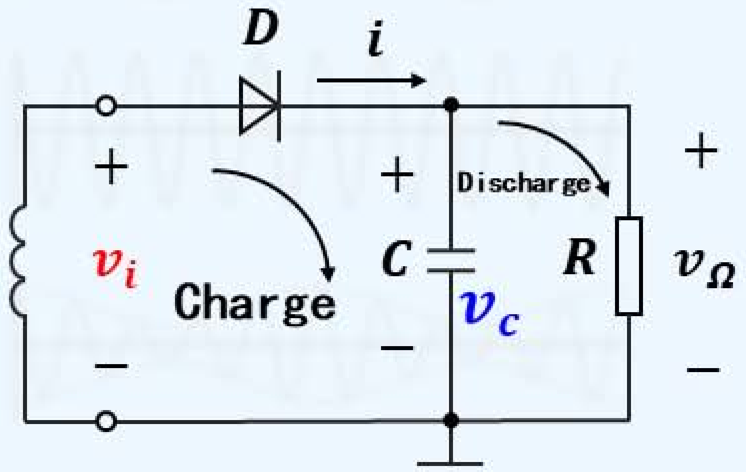
① Diode unilateral conductivity

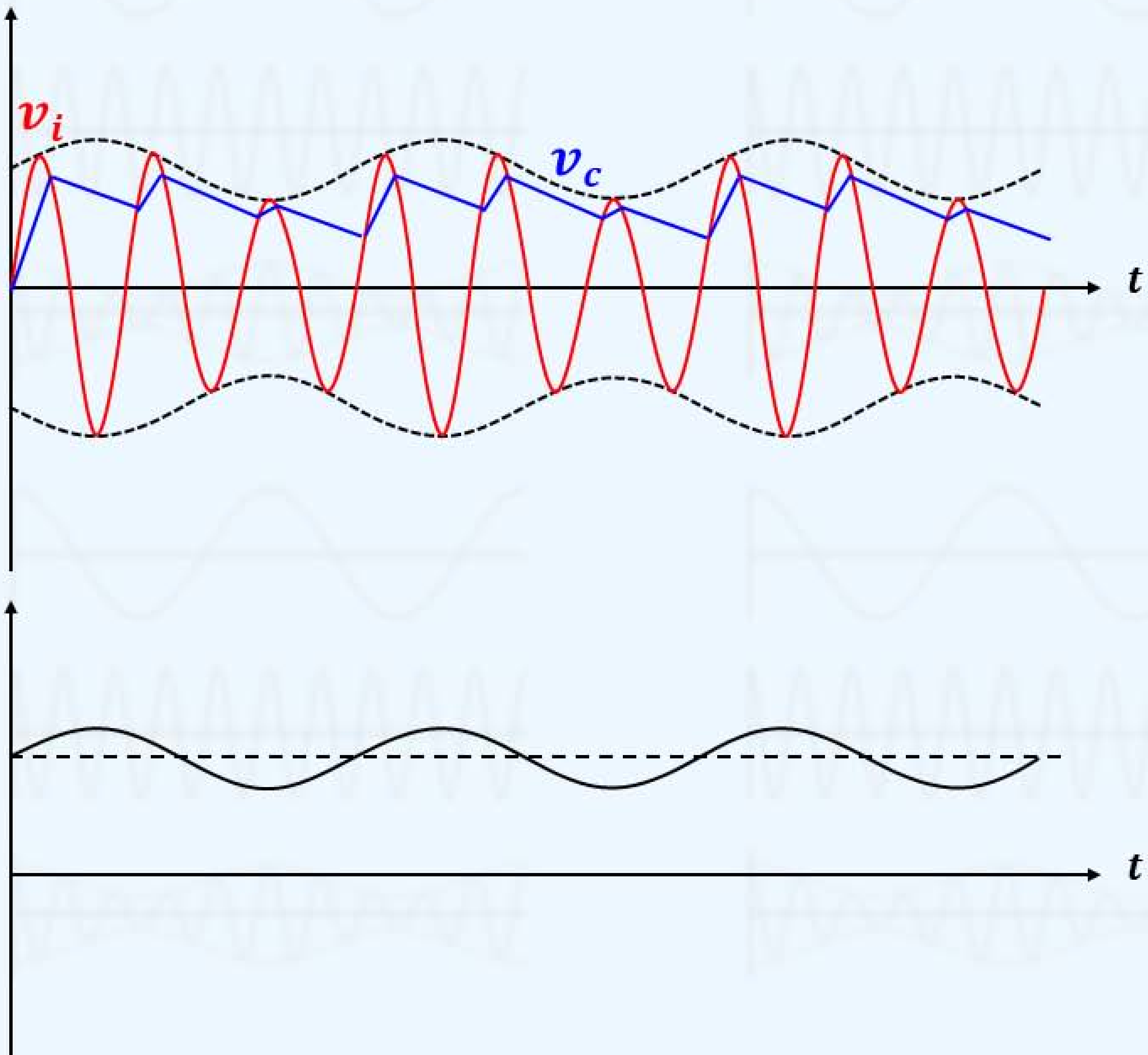
② RC Time constant

Charge $R_d C \ll RC$ Discharge

R_d: D Resistance

Peak Envelope Detection





$$R_d C \ll RC$$

Envelope Detection Distortion

Envelope Detection Distortion

Classification

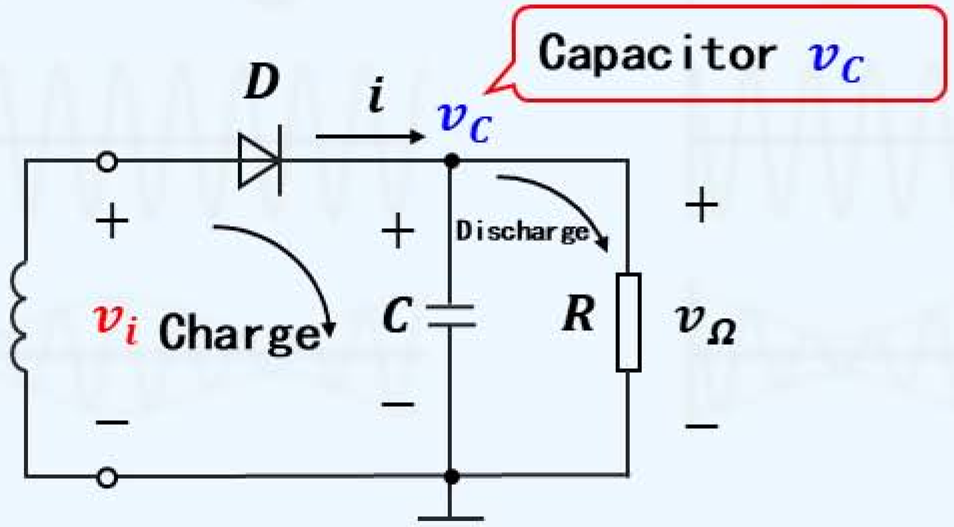
① Diagonal Distortion (Inert)

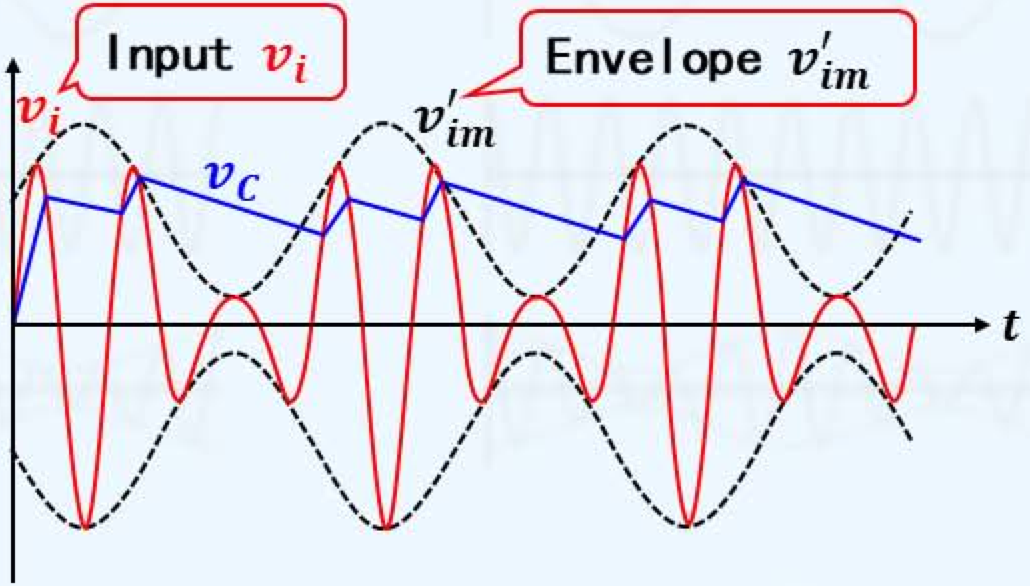
② Negative Peak Clipping Distortion

③ Nonlinear Distortion

④ Frequency Distortion

Envelope Detection Distortion - Diagonal Distortion



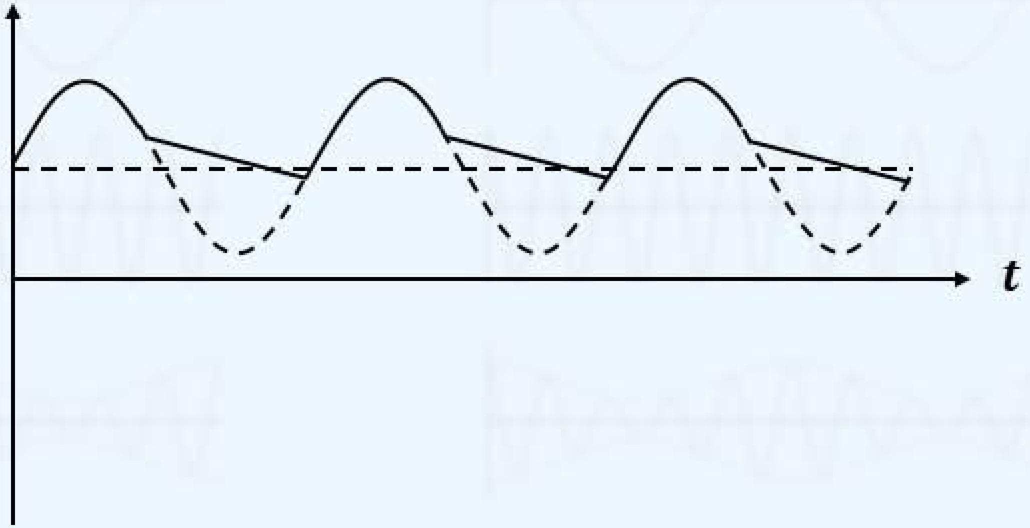


Reason:

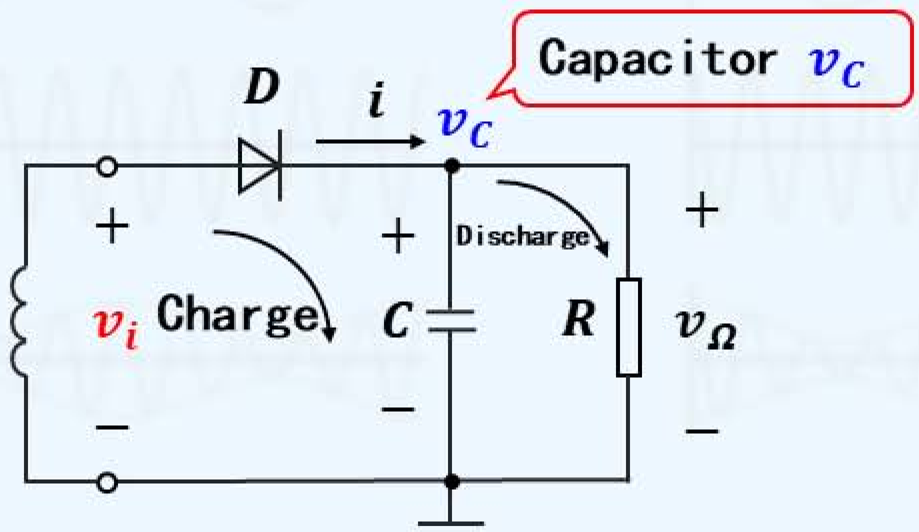
Time constant RC is very big

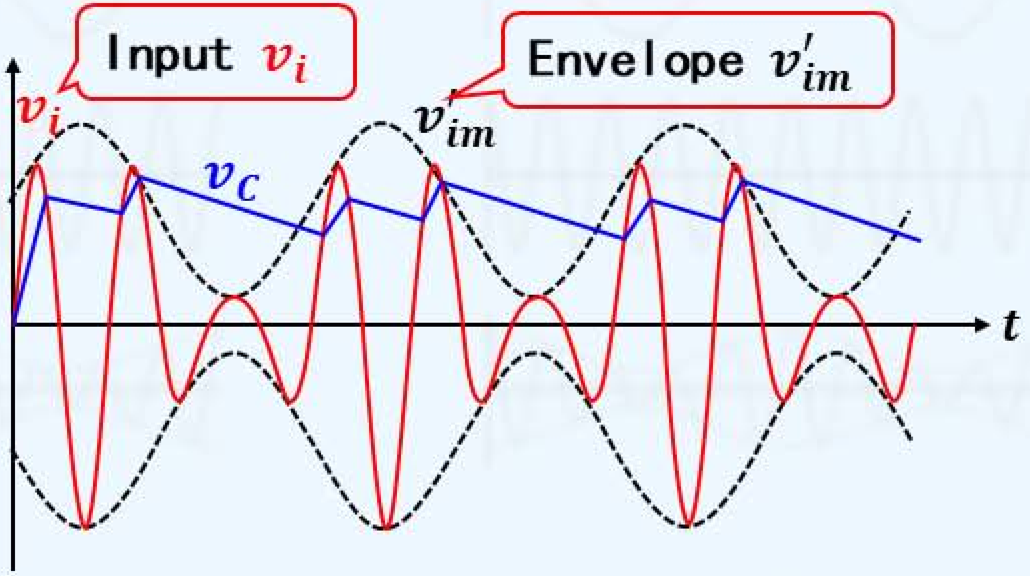
C discharge is slow

v_C cannot catch v'_{im}



Envelope Detection Distortion - Diagonal Distortion



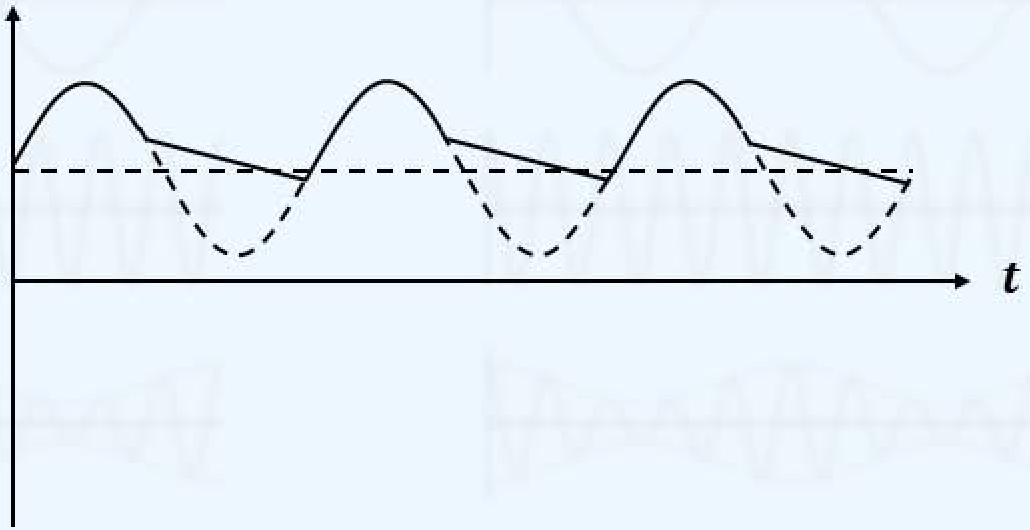


Method:

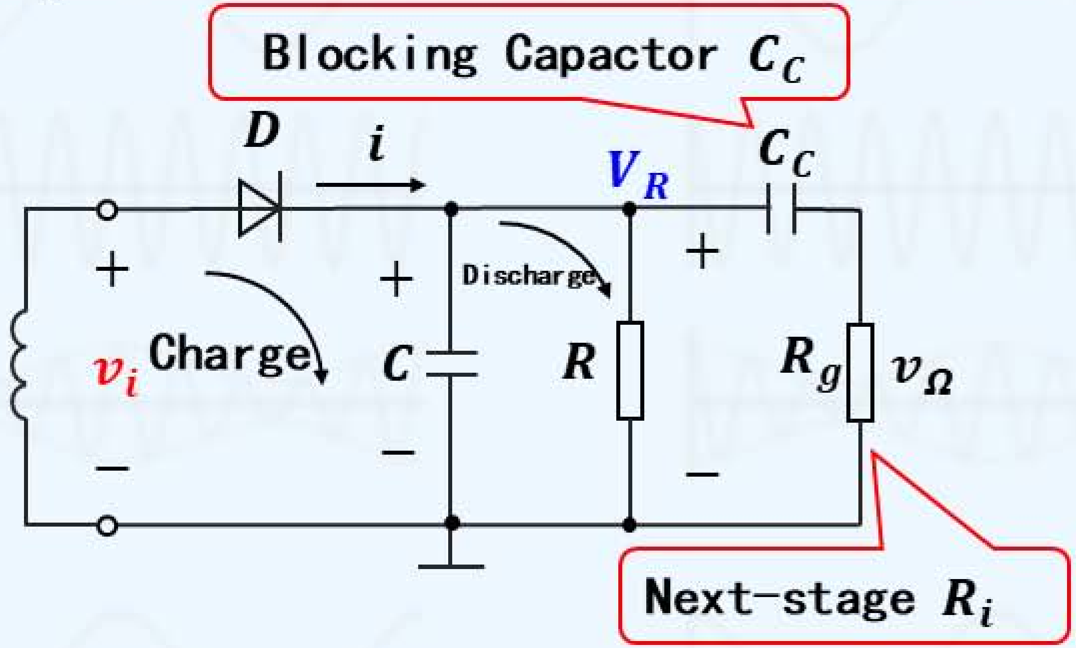
$$\frac{dv_C}{dt} > \frac{dv'_{im}}{dt}$$

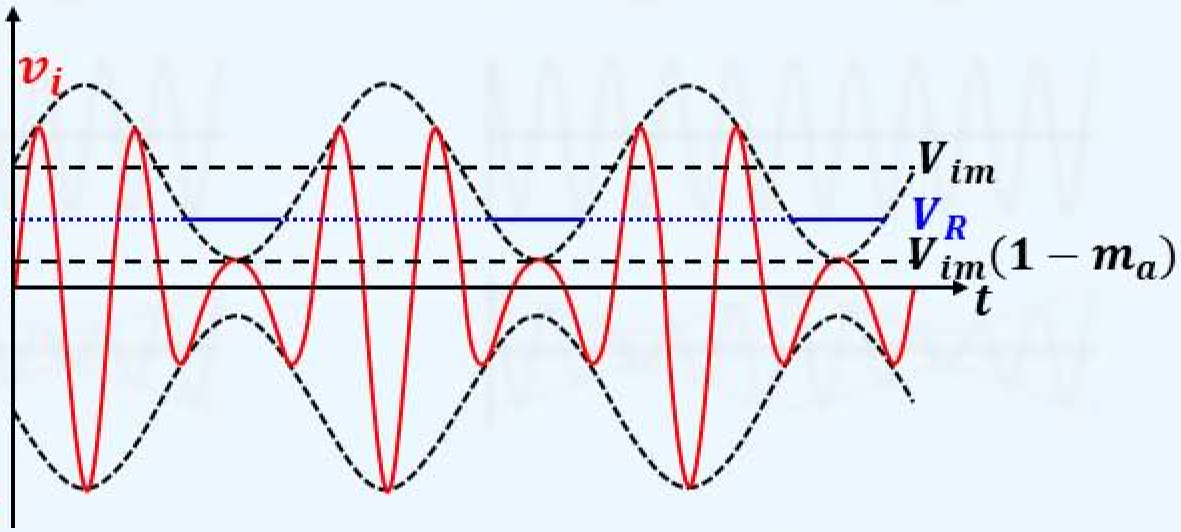
$$\Omega_{max} RC \leq \frac{\sqrt{1-m_a^2}}{m_a}$$

Engineering $\Omega_{max} RC \leq 1.5$



Envelope Detection Distortion - Negative Peak Clipping



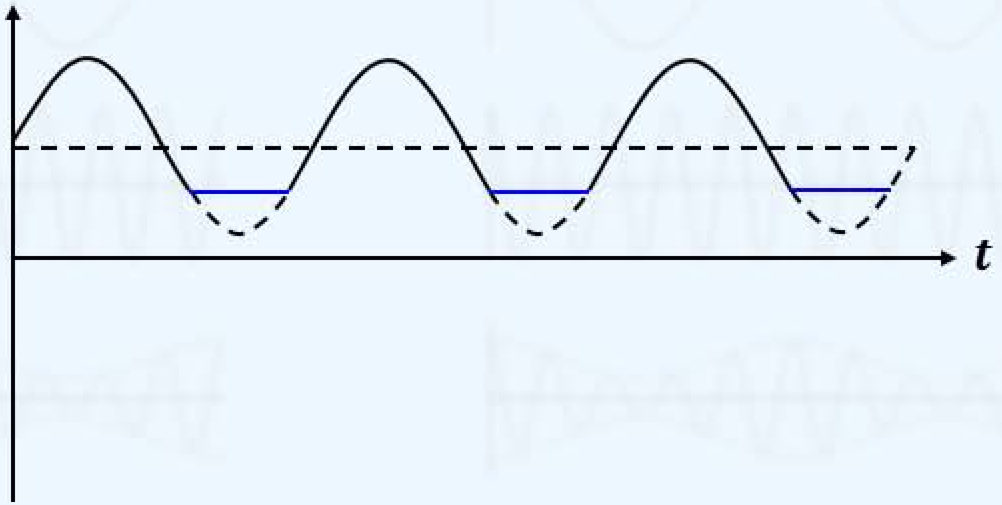


Reason:

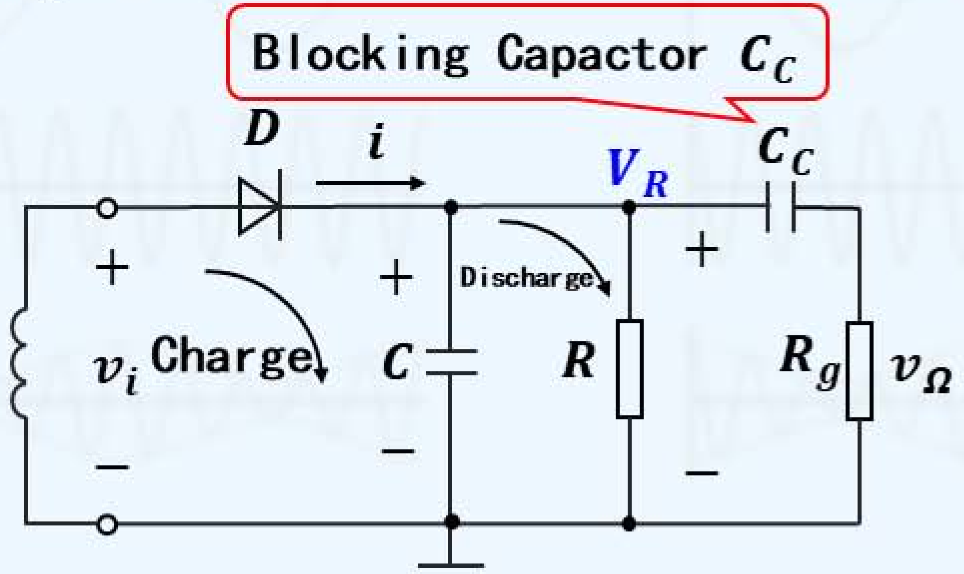
C_C ↑, voltage $\approx V_{im}$

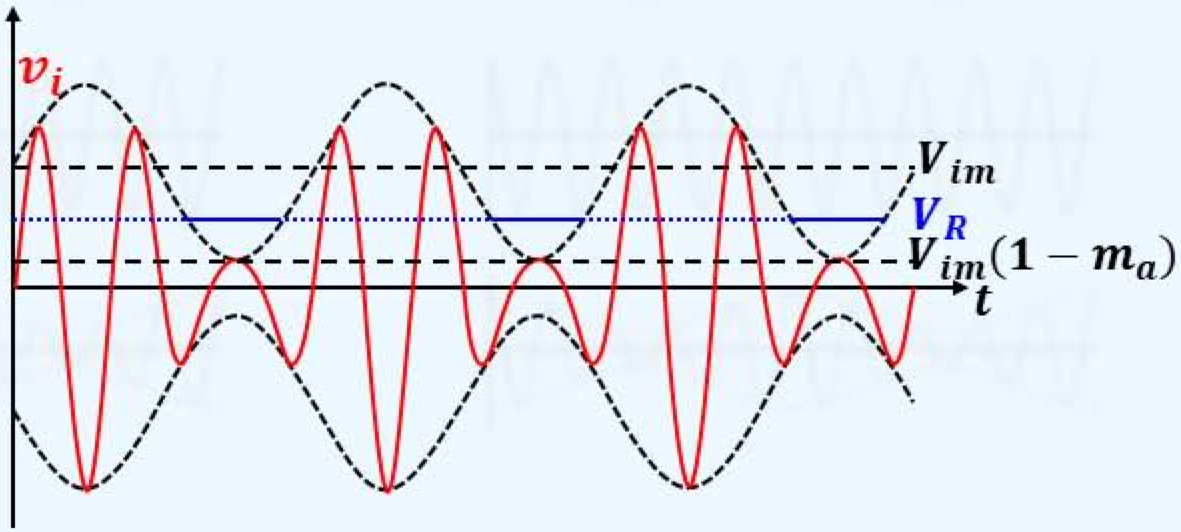
$$V_R = \frac{R}{R+R_g} V_{im}$$

$$V_R > V_{im}(1-m_a)$$



Envelope Detection Distortion - Negative Peak Clipping





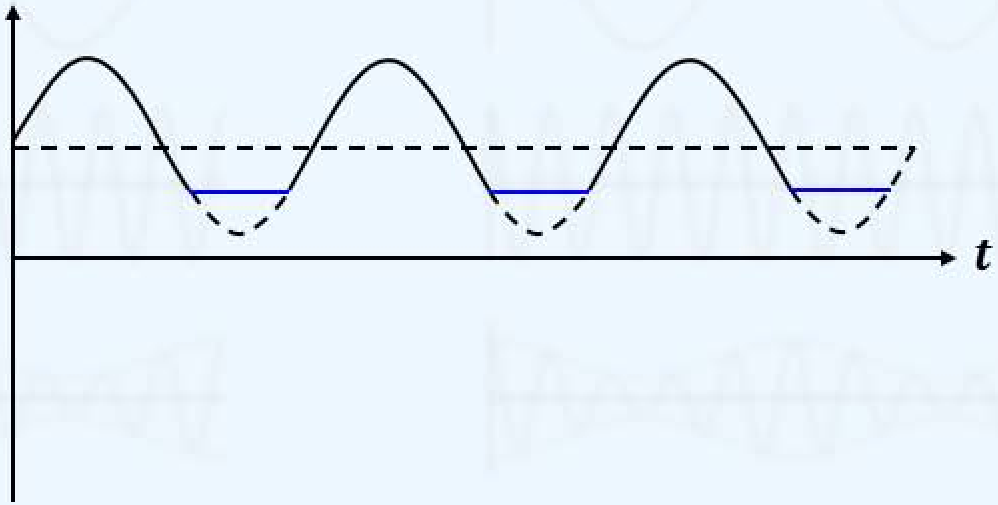
Method:

$$V_{im}(1\text{-}m_a) > V_R = \frac{R}{R+R_g}V_{im}$$

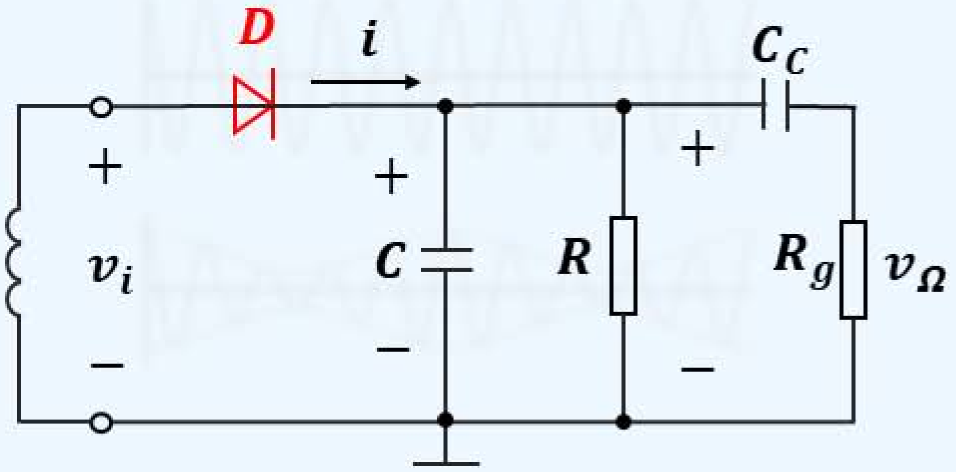
$$m_a < \frac{R_g}{R+R_g} = \frac{R \parallel R_g}{R} = \frac{R_\sim}{R}$$

AC Resistance

DC Resistance



Envelope Detection Distortion – Nonlinear Distortion



Reason:

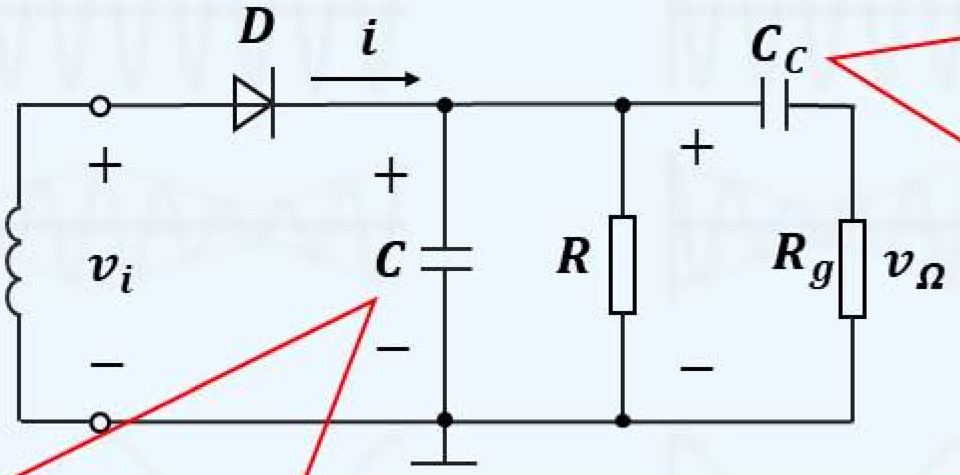
- Nonlinear Diode

Method:

- R big enough

Envelope Detection Distortion – Frequency Distortion

$C_c \approx$ several μF



Reason2: Blocking C_C influences Ω_{min}

Method:

$$\frac{1}{\Omega_{min}C_c} \ll R_g$$

Reason1: High-pass filter C influences Ω_{max}

Method:

$$\frac{1}{\Omega_{max}C} \gg R$$

$C \approx 0.01\mu F$

Summary

By C

Diagonal Distortion

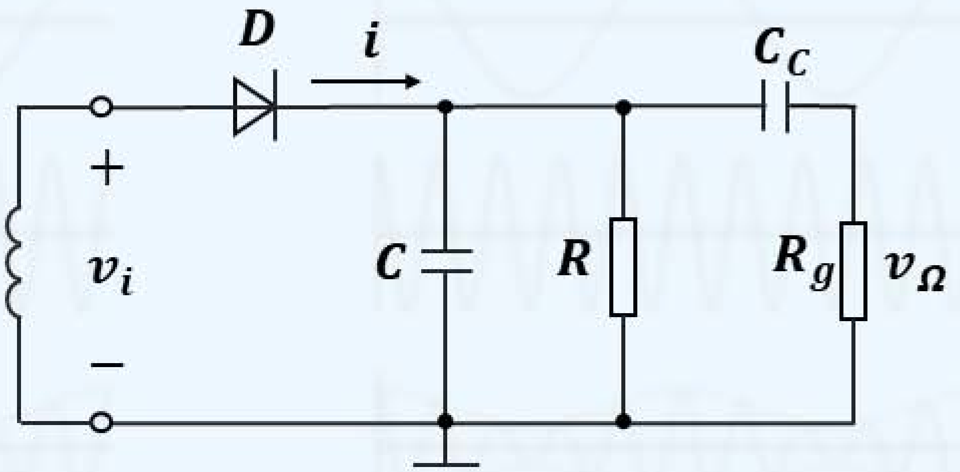
Negative Peak Clipping Distortion

Diode cut-off

By C_C

Nonlinear Distortion

Frequency Distortion



Synchronous Detection

Detection - Classification

- Detection
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    - Peak Envelope Detection
      - Series Diode
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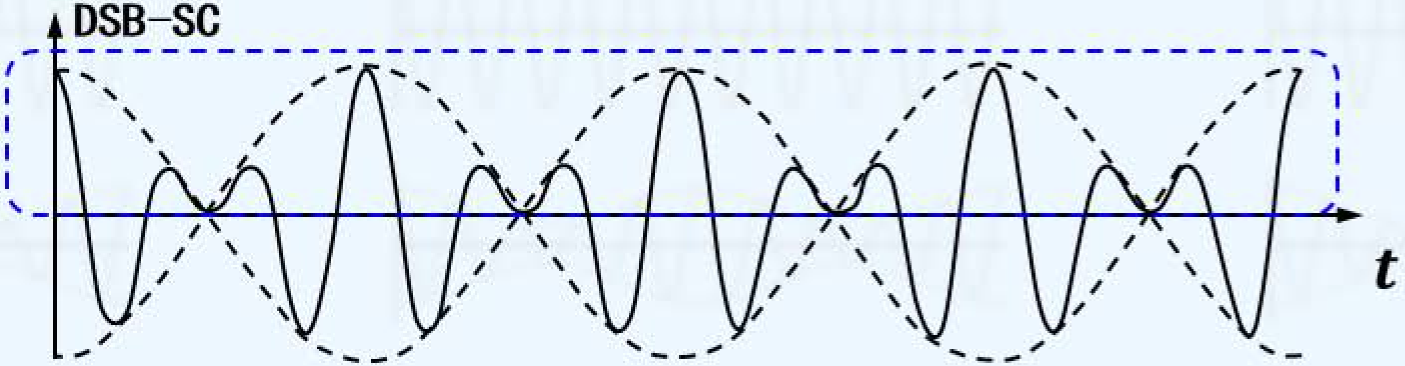
    - Multiplication
    - Superposition

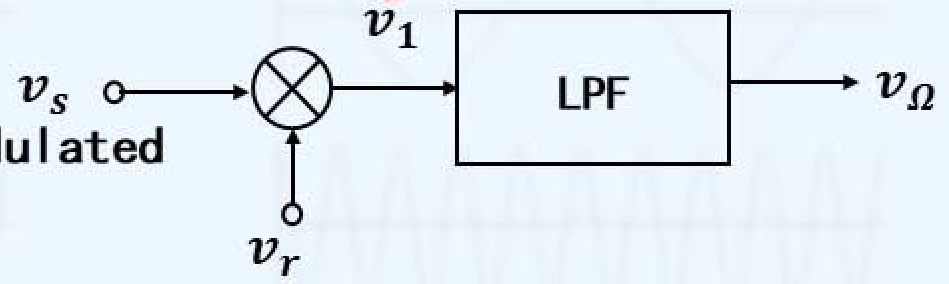


Synchronous Detection – Multiplication

$$
\begin{aligned}
v_1 &= V_s(\cos\Omega t\cos\omega_0 t)V_0\cos\omega_0 t \\
&= V_sV_0\cos\Omega t\,(\cos\omega_0 t)^2 \\
&= V_sV_0\cos\Omega t\cdot\frac{1}{2}(1+\cos 2\omega_0 t) \\
&= \frac{1}{2}V_sV_0\cos\Omega t+\frac{1}{2}V_sV_0\cos\Omega t\cos 2\omega_0 t \\
&= \frac{1}{2}V_sV_0\cos\Omega t+\frac{1}{4}V_sV_0\cos(2\omega_0-\Omega)t+\frac{1}{4}V_sV_0\cos(2\omega_0+\Omega)t
\end{aligned}
$$

(DSB-SC):

$v_s = V_s\cos\Omega t\cos\omega_0 t$

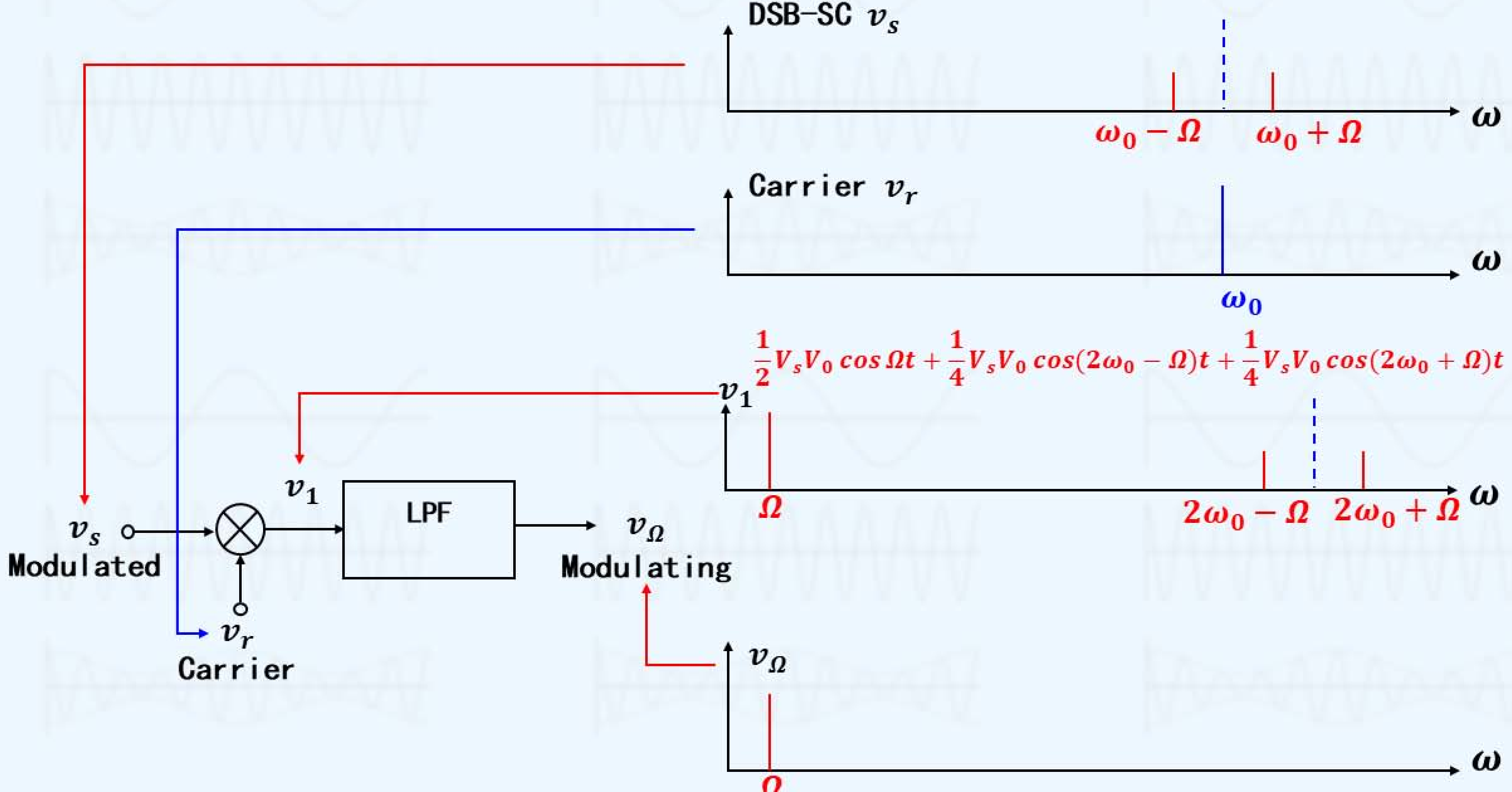


$= \frac{1}{2}V_sV_0\cos\Omega t$

$v_r = V_0\cos\omega_0 t$

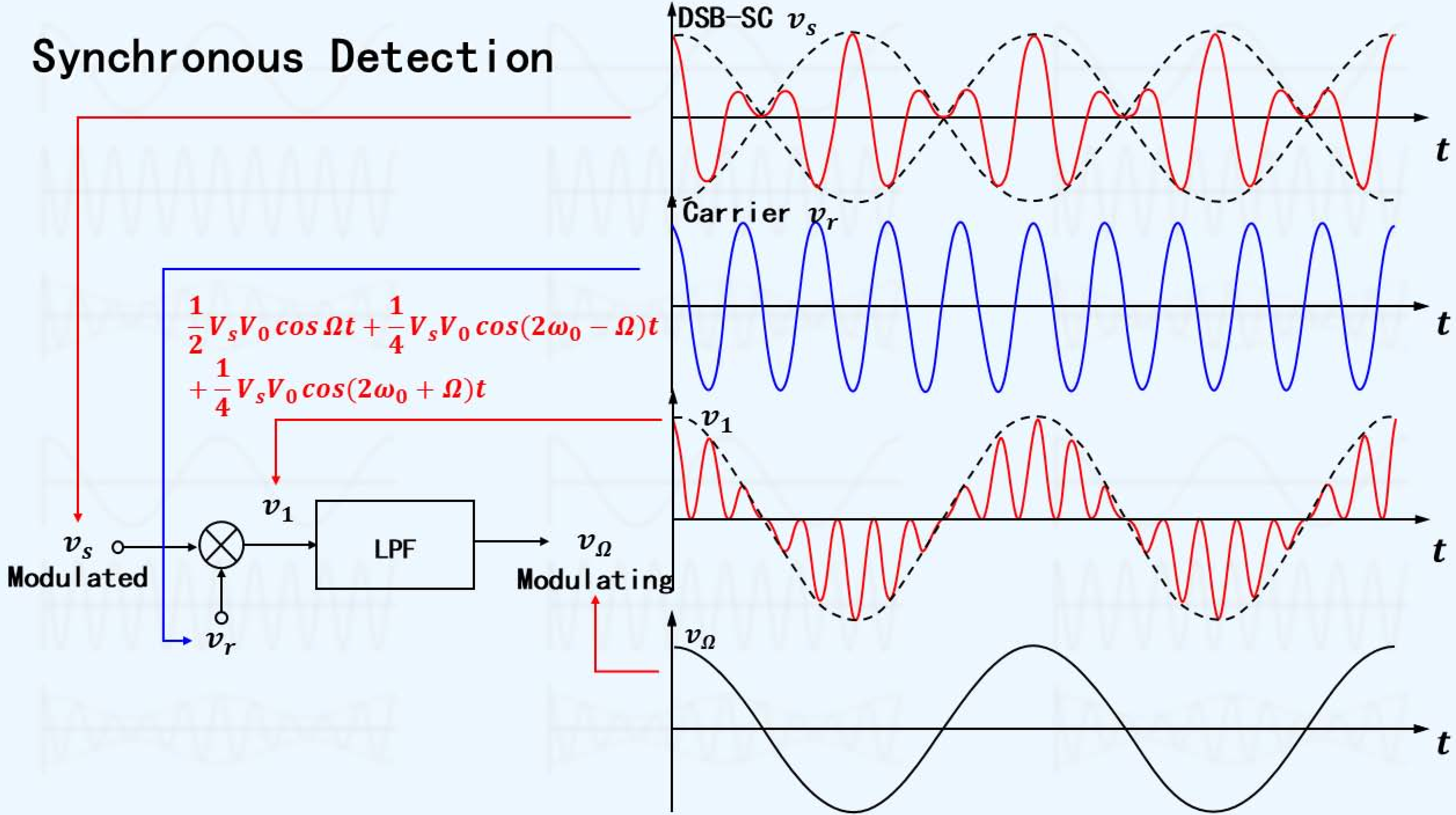
Synchronous

Synchronous Detection - Multiplication



Synchronous Detection

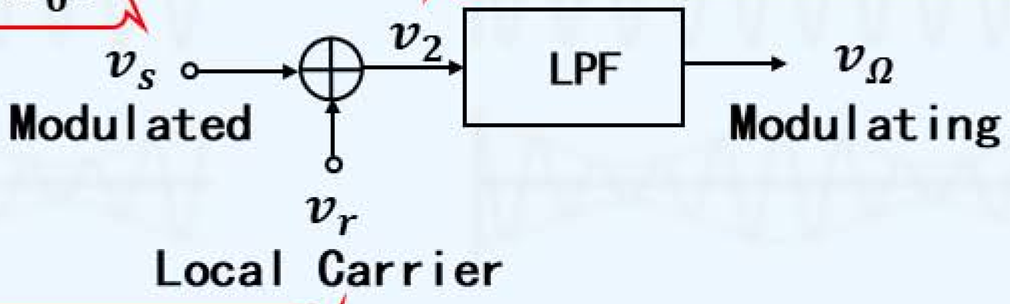
$$\frac{1}{2}V_sV_0\cos\Omega t+\frac{1}{4}V_sV_0\cos(2\omega_0-\Omega)t+\frac{1}{4}V_sV_0\cos(2\omega_0+\Omega)t$$



Synchronous Detection – Superposition

$$v_2 = v_s + v_r = V_r\left(1 + \boxed{\frac{V_s}{V_r}}\cos\Omega t\right)\cos\omega_0 t$$

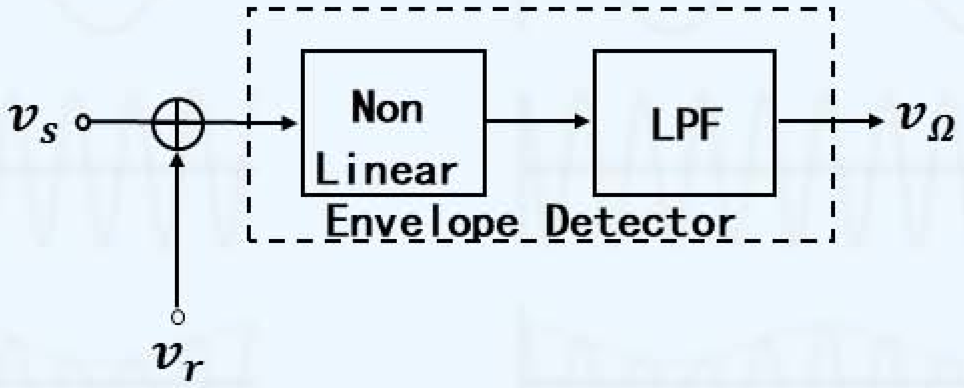
$$v_s = V_s \cos\Omega t \cos\omega_0 t$$

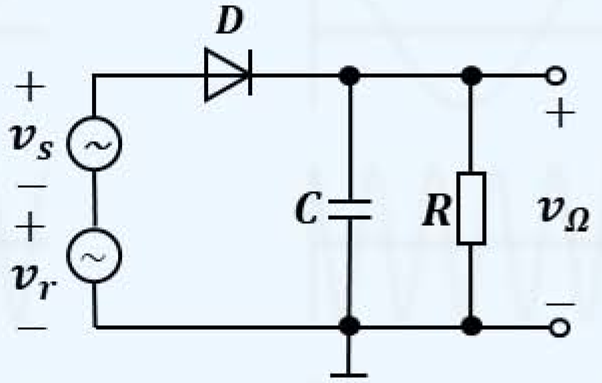


$$v_r = V_0 \cos\omega_0 t$$

If $V_s < V_r$, $m_a = \frac{V_s}{V_r} < 1$

$\Rightarrow$ Using envelope detection





Synchronous Detection using Diode

Summary

- Detection
  - Envelope Detection
    - AM
    - Square-law Detection
    - Peak Envelope Detection
      - Series Diode
      - Parallel Diode
    - Average Envelope Detection
  - Synchronous Detection
    - DSB-SC
    - SSB
    - AM?
    - Multiplication
    - Superposition