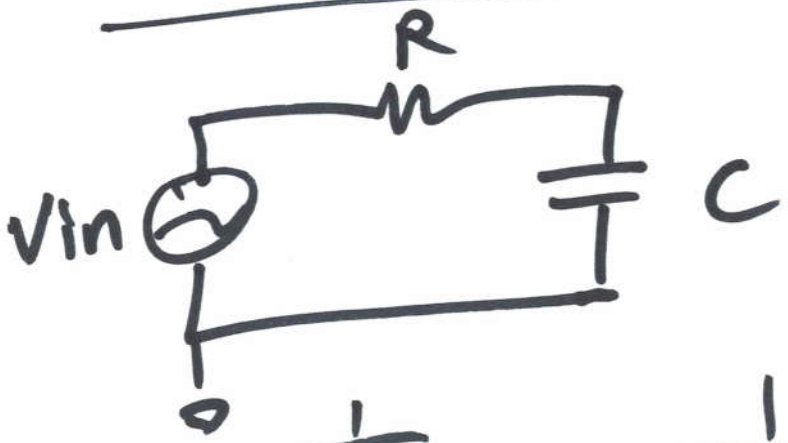
Bode Plot



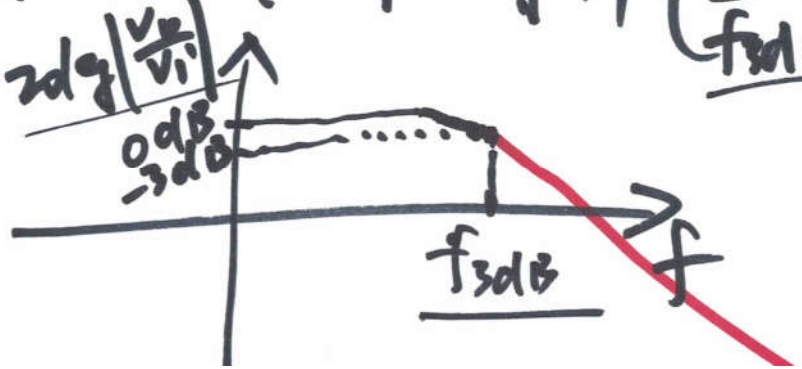
$$\frac{V_o}{V_i} = \frac{\frac{1}{j\omega C}}{R+\frac{1}{j\omega C}} = \frac{1}{1+j\omega RC}$$

$$\left|\frac{V_o}{V_i}\right| = \frac{1}{\sqrt{1^2+(\omega RC)^2}} = \frac{1}{\sqrt{1+\left(\frac{f}{\frac{1}{2\pi RC}}\right)^2}}$$

$$\frac{1}{2\pi RC} = f_{3dB} \qquad \left|\frac{V_o}{V_i}\right| = \frac{1}{\sqrt{1+\left(\frac{f}{f_{3dB}}\right)^2}}$$

$\frac{1}{\sqrt{2}} = 0.707$

$20\log 0.707 = -3dB$



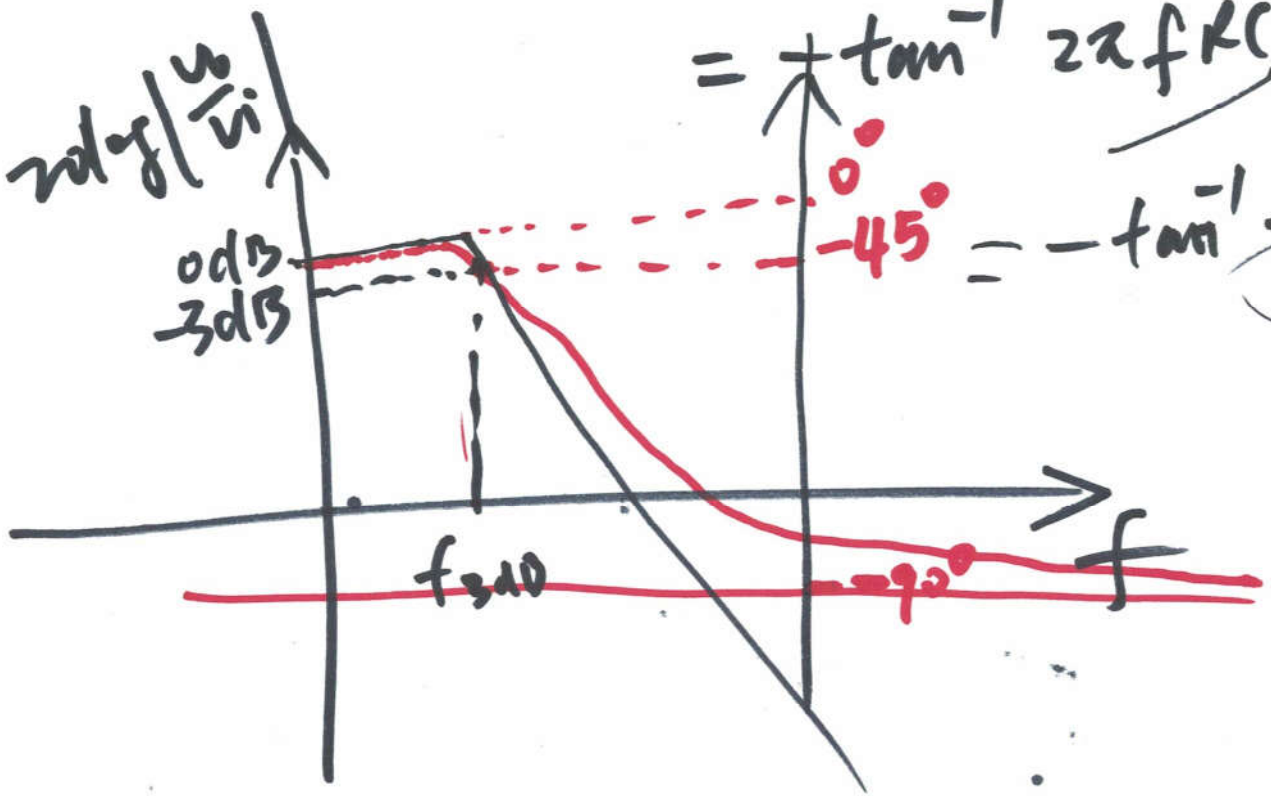
$$\frac{V_o}{V_i} = \frac{1+0j}{1+j\omega RC}$$

$$\Delta\theta = \angle V_o - \angle V_i = \tan^{-1}\frac{0}{1} - \tan^{-1}\frac{\omega RC}{1}$$

$$= -\tan^{-1}\omega RC$$

$$= -\tan^{-1} 2\pi f RC = -\tan^{-1}\frac{f}{f_{3dB}}$$

$$= -\tan^{-1}\frac{f}{1/2\pi RC}$$



$f = f_{3dB}, \Delta\theta = -45°$

$f \ll f_{3dB}, \Delta\theta = 0°$

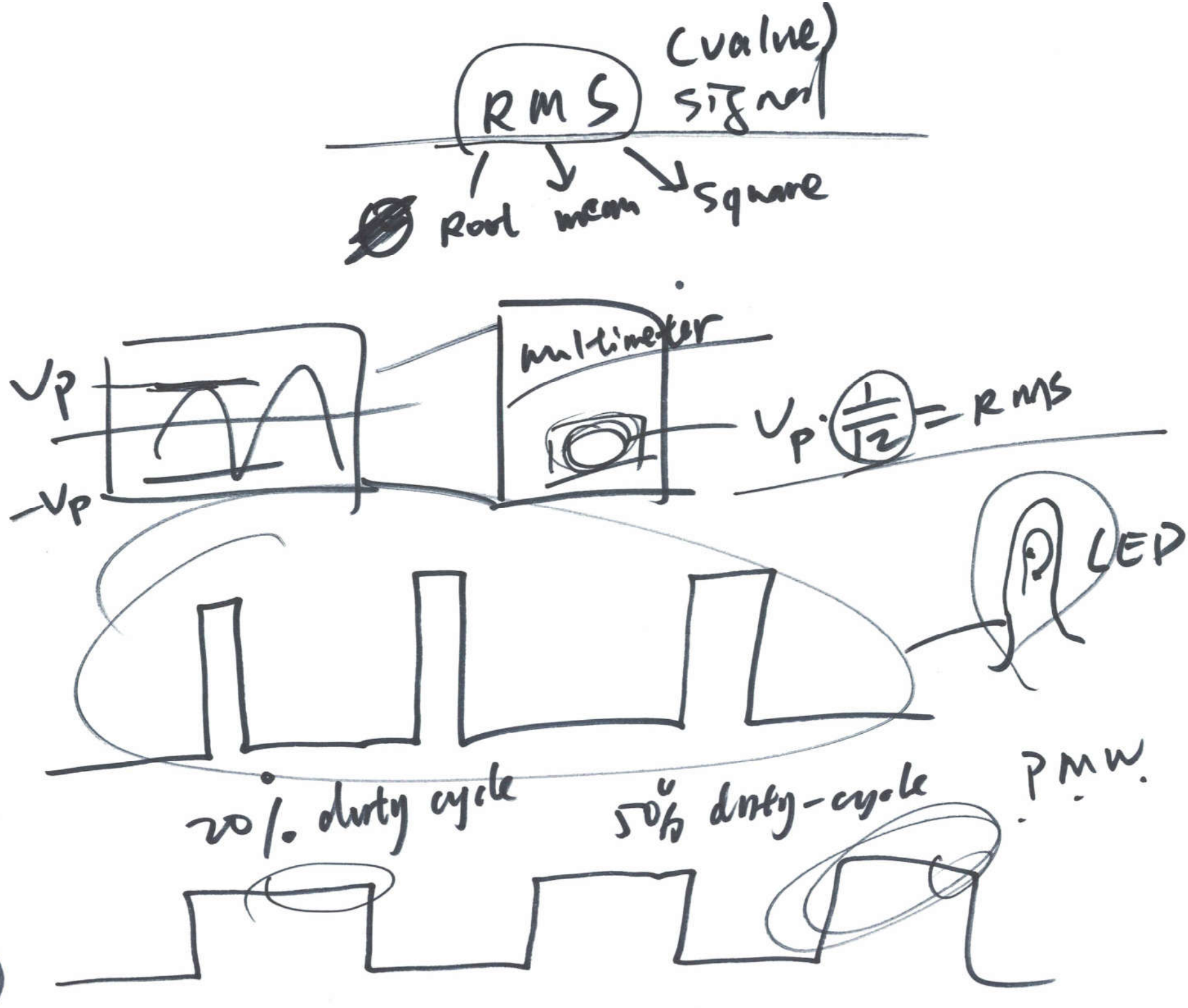
$f \gg f_{3dB}, \Delta\theta = -90°$

$$\frac{1}{2\pi RC}$$

$$= \frac{1}{6.28 \cdot 10\text{kΩ} \cdot 100\text{n}}$$

$$= 159\text{Hz}$$

(3)


RMS
(value)
signal
Root mean Square
multimeter
V_p
$-V_p$
$V_p \cdot \frac{1}{\sqrt{2}} = RMS$
LED
20% duty cycle
50% duty-cycle
PMW.

signal: $V_p \cdot \sin(2\pi f t)$

$$RMS = \sqrt{\frac{1}{T}\int_0^T (V_p \sin 2\pi f t)^2 dt} = \frac{V_p}{\sqrt{2}} \sin 2\pi f t$$

$$= V_p \sqrt{\frac{1}{T}\int_0^T \sin^2 2\pi f t \, dt}$$

$$= V_p \sqrt{\frac{1}{T}\int_0^T \frac{1-\cos 4\pi f t}{2} dt}$$

$$= V_p \sqrt{\frac{1}{T}\left(\frac{T}{2} - \frac{1}{2}(-\sin 4\pi f t)\right)_0^T}$$

$$\sin x = \frac{1-\cos 2x}{2}$$

$$\cos 2x = 1 - 2\sin^2 x$$

$$\cos 2x = \cos^2 x - \sin^2 x$$

$$\cos(x+x) = \cos 2x$$

$$= \cos x \cdot \cos x - \sin x \cdot \sin x$$

$$= \cos^2 x - \sin^2 x$$

$$= 1 - \sin^2 x - \sin^2 x$$

$$= 1 - 2\sin^2 x$$

Valid

$$= V_p \sqrt{\frac{1}{2} + \frac{1}{2}\sin(4\pi f t)}$$

$$= \frac{V_p}{\sqrt{2}}$$