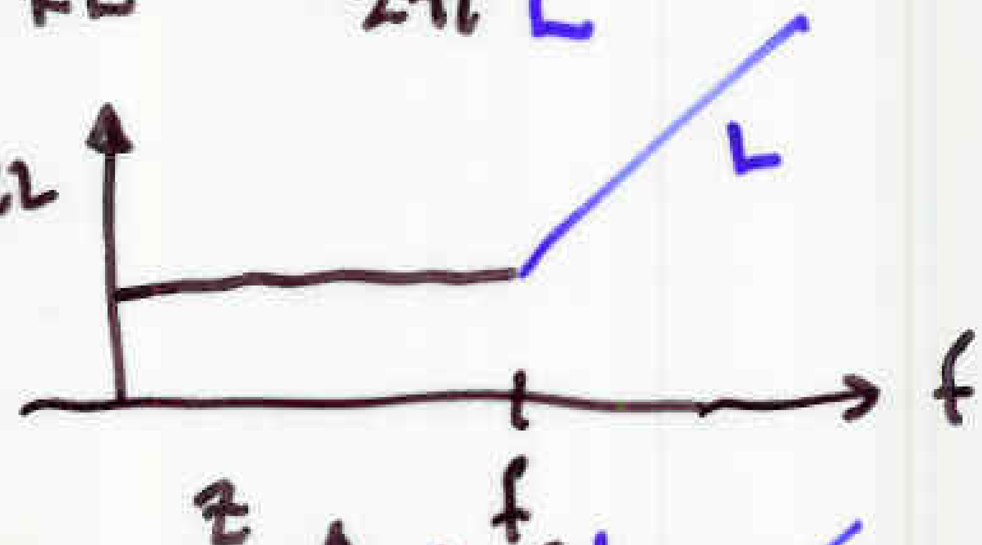
# Series RLC

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

$Z_C$ series with $R$

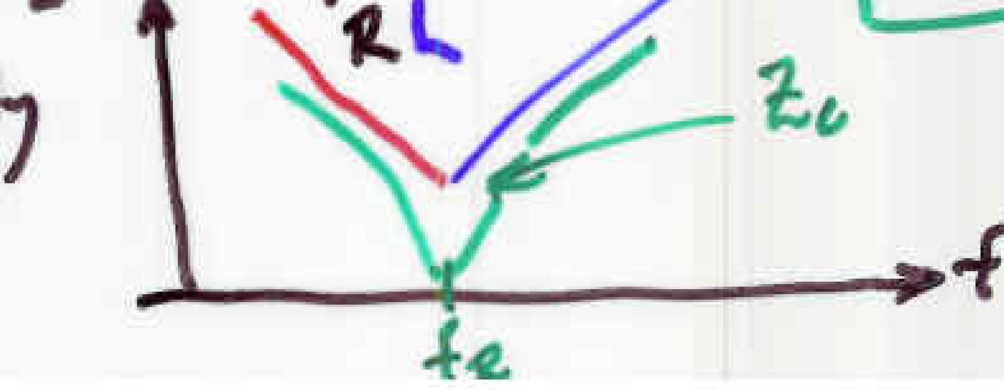

$$f_{RL} = \frac{R}{2\pi L}$$

$Z_L$ series with $R$

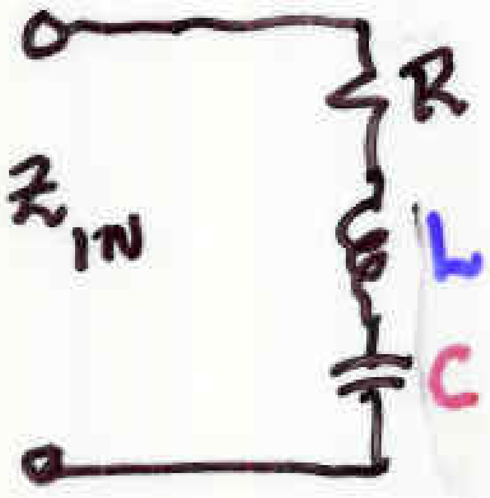


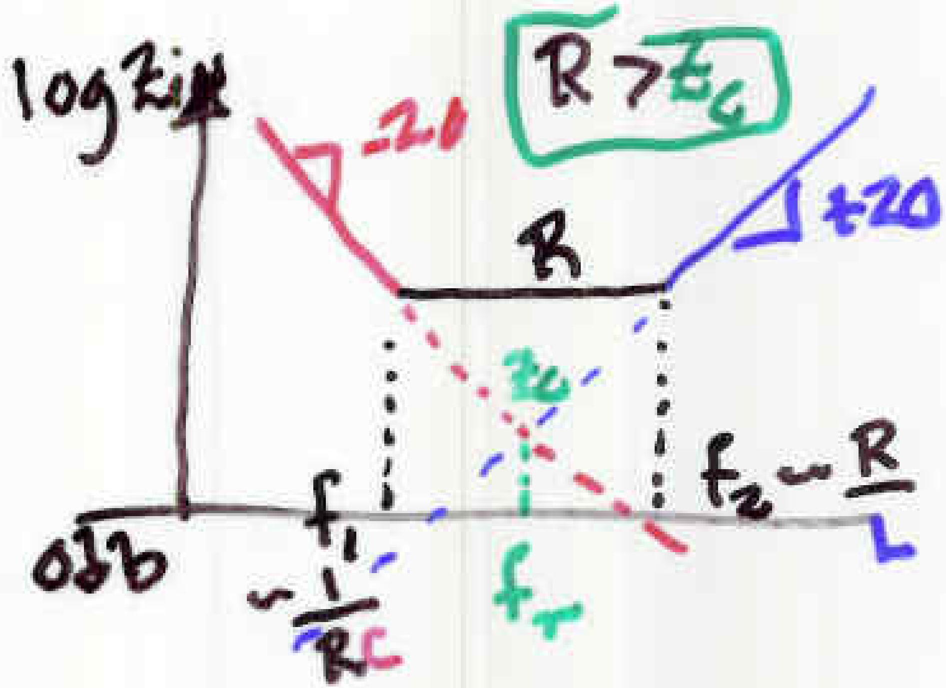

$\boxed{R\ L\ Z_0}$

Finally
R-L-C



Series RLC




$$f_1 = \frac{1}{2\pi R C} \qquad f_2 = \frac{R}{2\pi L}$$

$f_R = ?$ $\qquad \left|\frac{1}{\omega C}\right| = |\omega L|$ @ $\omega_R$

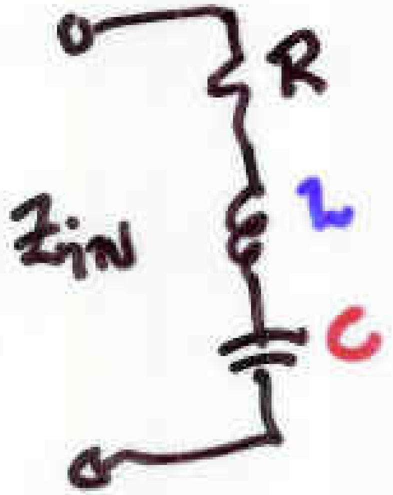
$$\omega_R = \frac{1}{\sqrt{LC}}$$

$$f_R = \frac{1}{2\pi\sqrt{LC}}$$

$$Z_C = Z_L \text{ @ } \omega_R = \sqrt{\frac{L}{C}} \equiv Z_c$$

Above <u>case for R > $Z_c$</u>

Case: $R\ L\ Z_c \equiv \sqrt{\frac{L}{C}}$





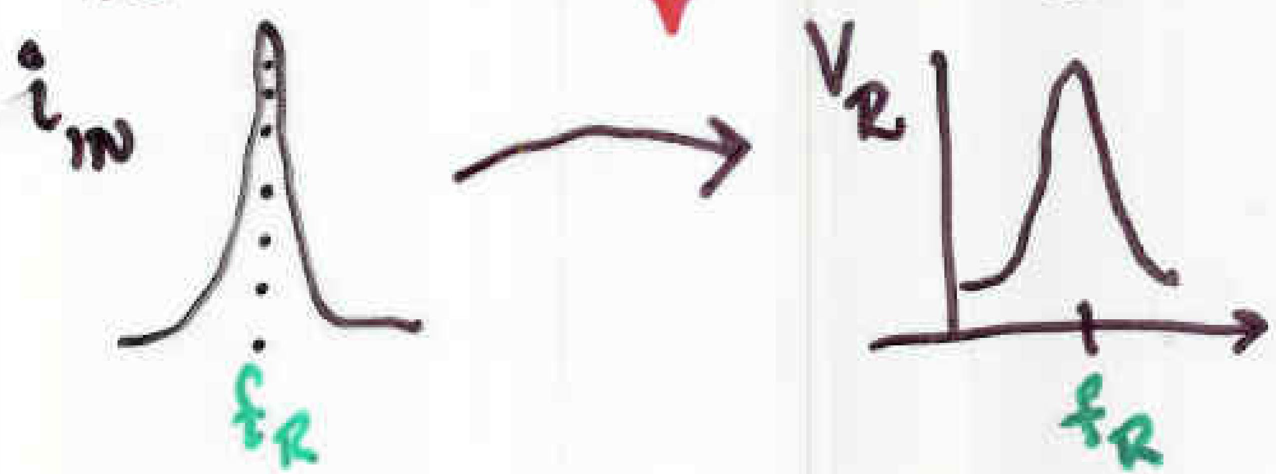
Resonance: $Z_L$ cancled by $Z_C$

$Q$ = Deviation from asymptote @ $f_r$

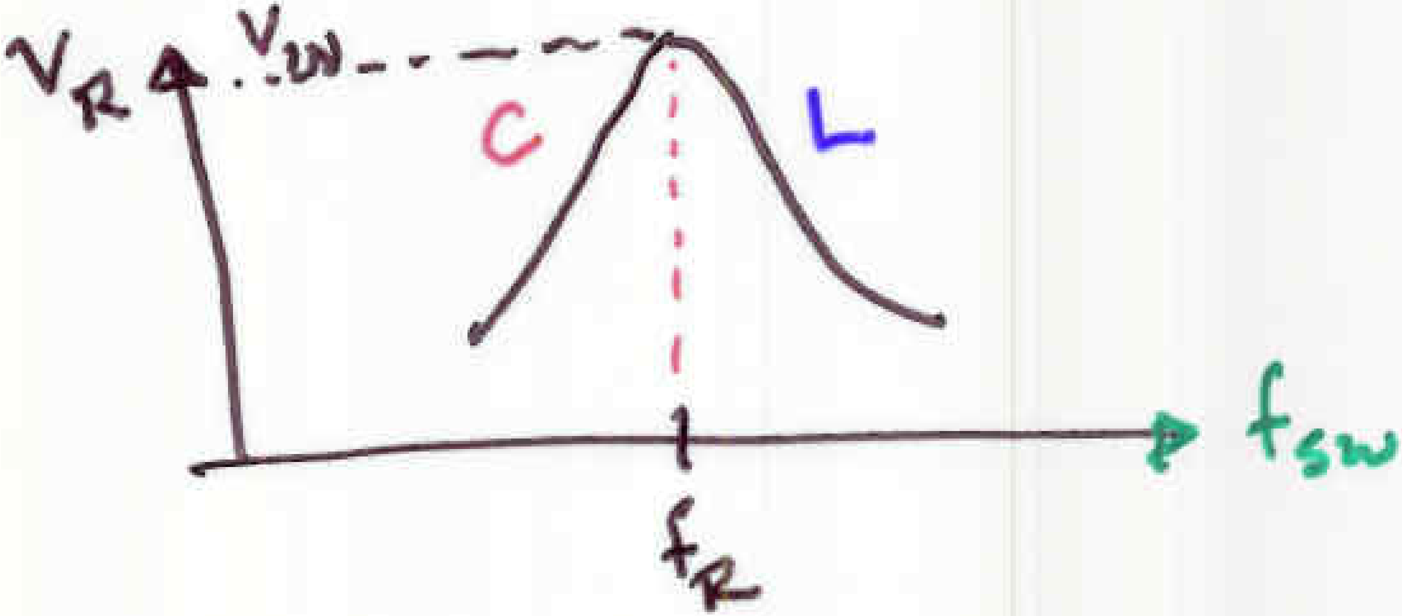
$= \frac{Z_C}{R}$

$Q(db) = Z_o(\underset{\Omega}{db}) - R(\underset{\Omega}{db})$

If $Z_{in}$ "Q's" down then $i_{in}(t)$?



# Resonant Buck



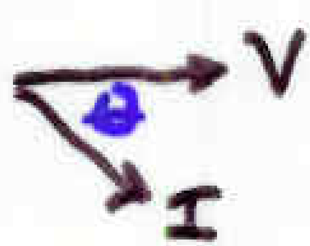

$f_{sw} = f_R$ $\quad V_R = V_{IN}$

$f_{sw} \neq f_R$ $\quad \underbrace{V_R < V_{IN}}_{\text{Buck}}$

$f < f_R$: Capacitive


ZVS for FET

$f > f_R$: Inductive




ZCS for FET

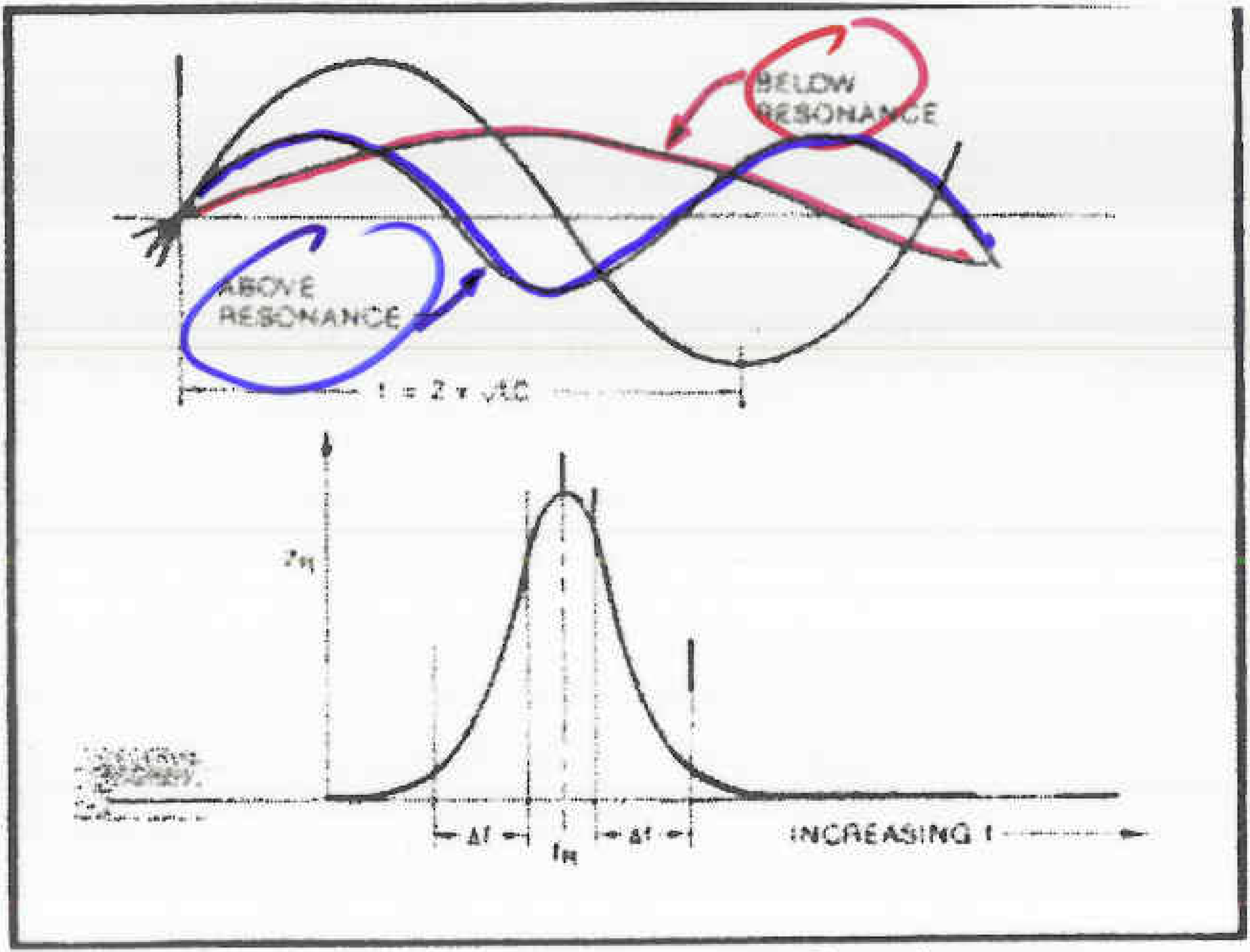



*Fig. 11 - Variable Frequency Continuous Resonance*

1. SERIES OR PARALLEL LOADED?
2. FIXED OR VARIABLE FREQUENCY?
3. CONTINUOUS / DISCONTINUOUS RESONANCE?
4. ZERO CURRENT OR VOLTAGE SWITCHING?
5. HALF OR FULL CYCLE CONDUCTION?

*Fig. 8 - Classifying Resonant Converters*

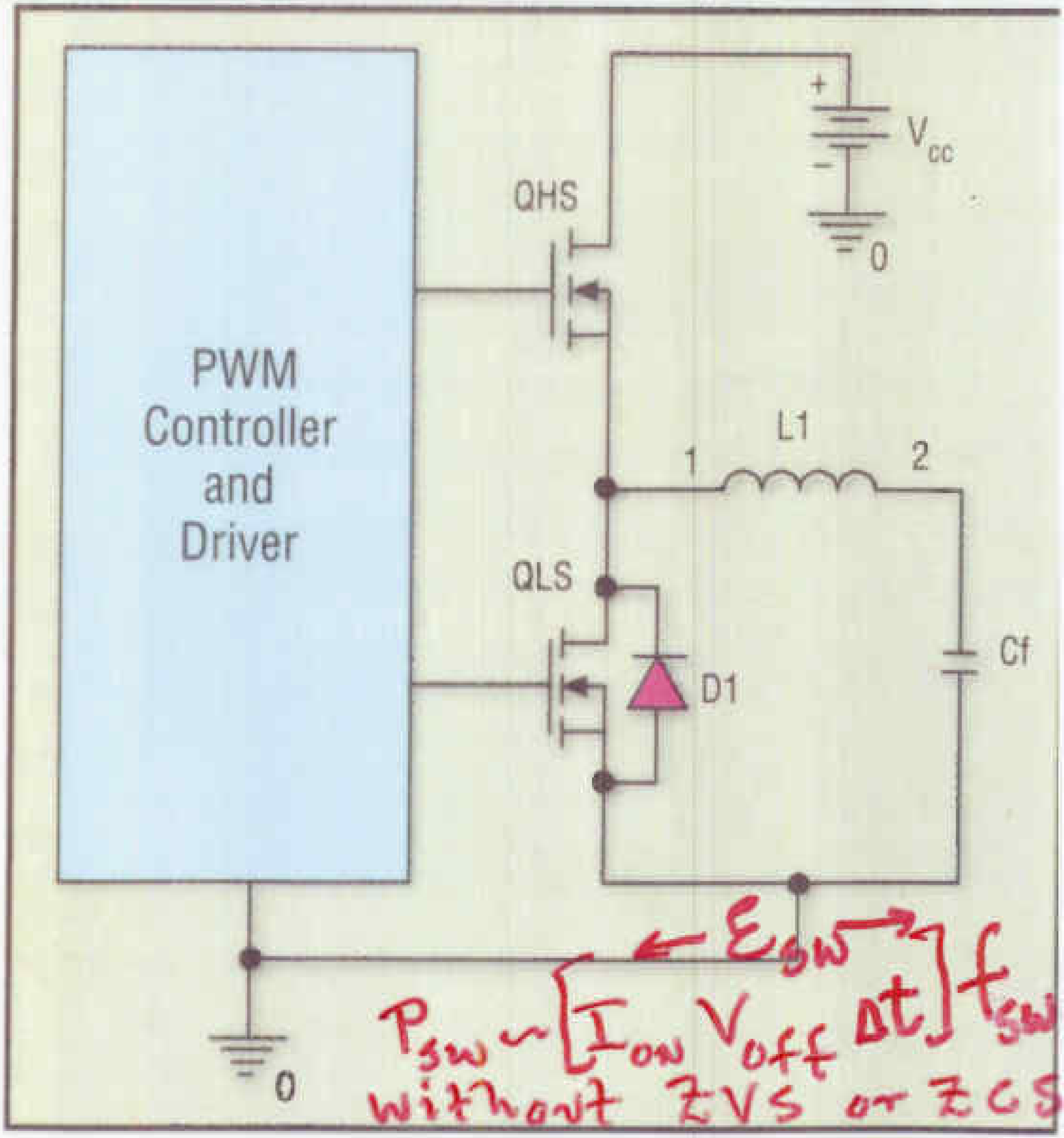



**Fig. 1.** *The classical synchronous buck converter uses two switching MOSFETs: the high-side (control) device, QHS, and the low-side synchronous rectifier, QLS.*

| | |
|---|---|
| 5 to 20 kHz | -AUDIBLE NOISE<br>-SLOW BIPOLAR SWITCHES<br>-LARGE L's AND C's |
| 20 to 100 kHz | -ABOVE AUDIBLE RANGE<br>-FAST BIPOLAR TRANSISTOR<br>-MAGNETICS BECOME IMPORTANT<br>-SMALL SIZES |
| 100 to 500 kHz | -POWER MOSFET SWITCHES<br>-LOSSES IN L's AND C's<br>-DIODE RECOVERY TIME<br>-RFI AND EMI<br>-PACKAGING PROBLEMS |

*Fig. 2 - Power Supply Switching Frequencies*

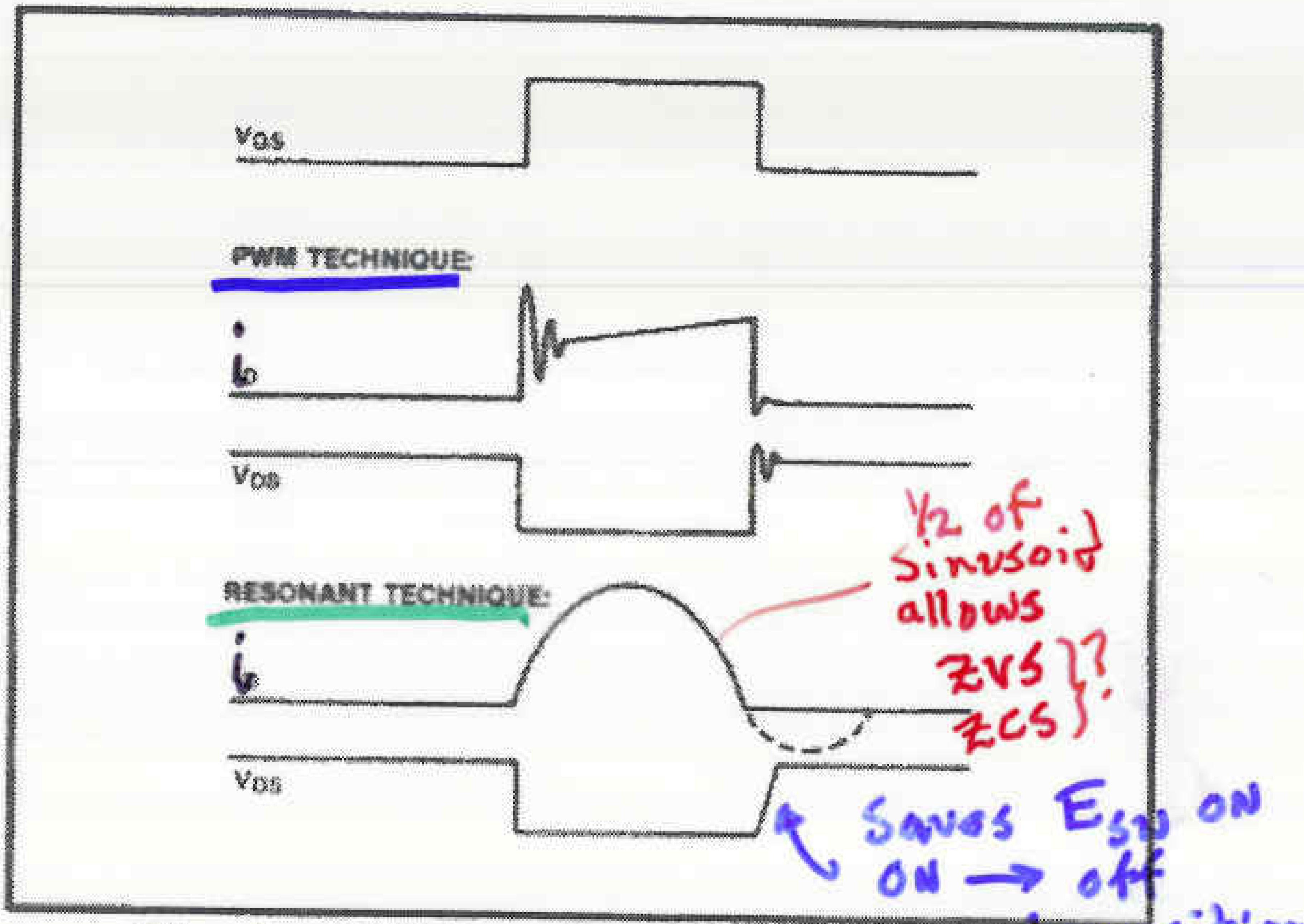



*Fig. 5 - PWM vs. Resonant Switching*