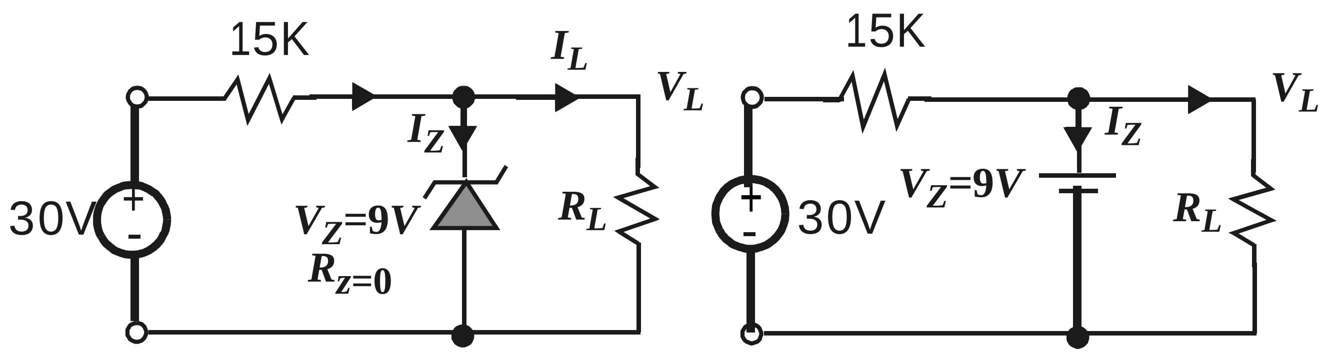
# Lecture 13

- More on Zener regulation
- Limiter/clipper circuits
- Clamping and peak detection circuits
- Half-wave rectifiers

# Zener Example

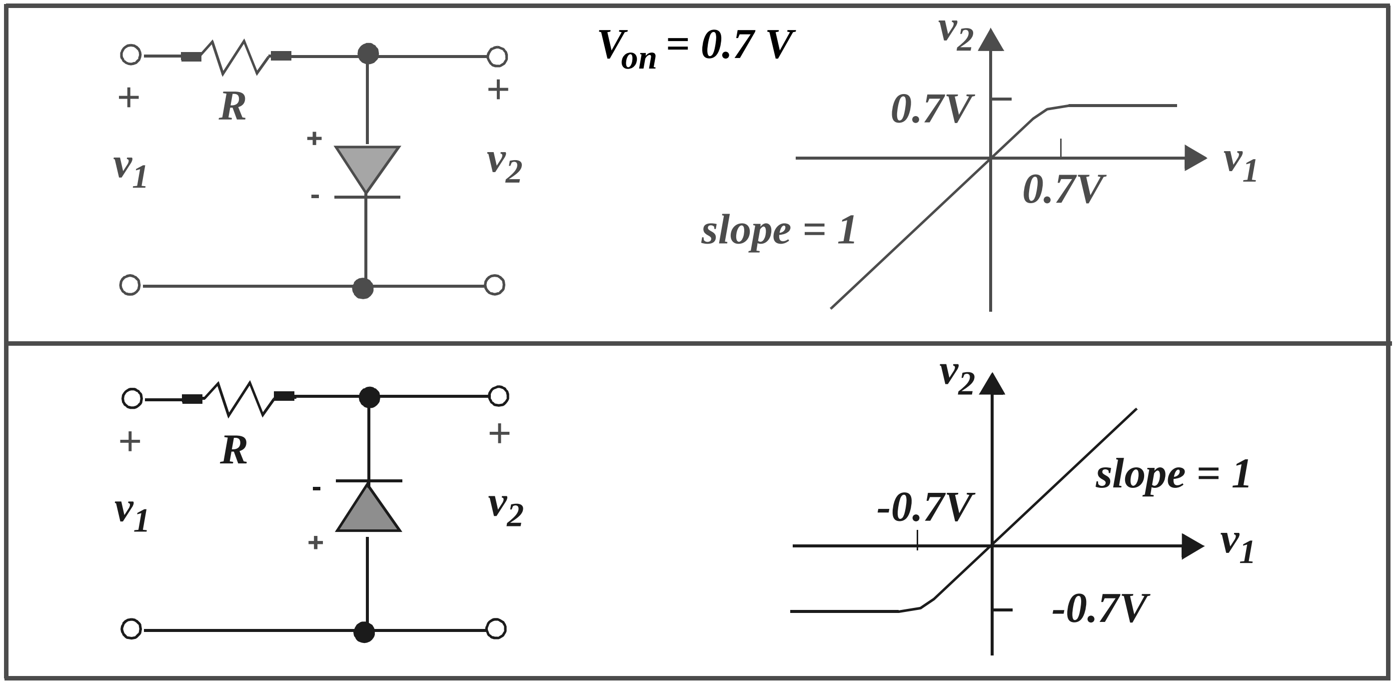



Find the maximum load current and the corresponding load resistance to maintain a regulated output

# Limiter or Clipper Circuits

Used in signal processing circuits;  Limits voltage between IPs of Op-Amp.

Provides $v_{out} \propto v_{in}$ up to a certain value(s), beyond which voltage is clipped off.



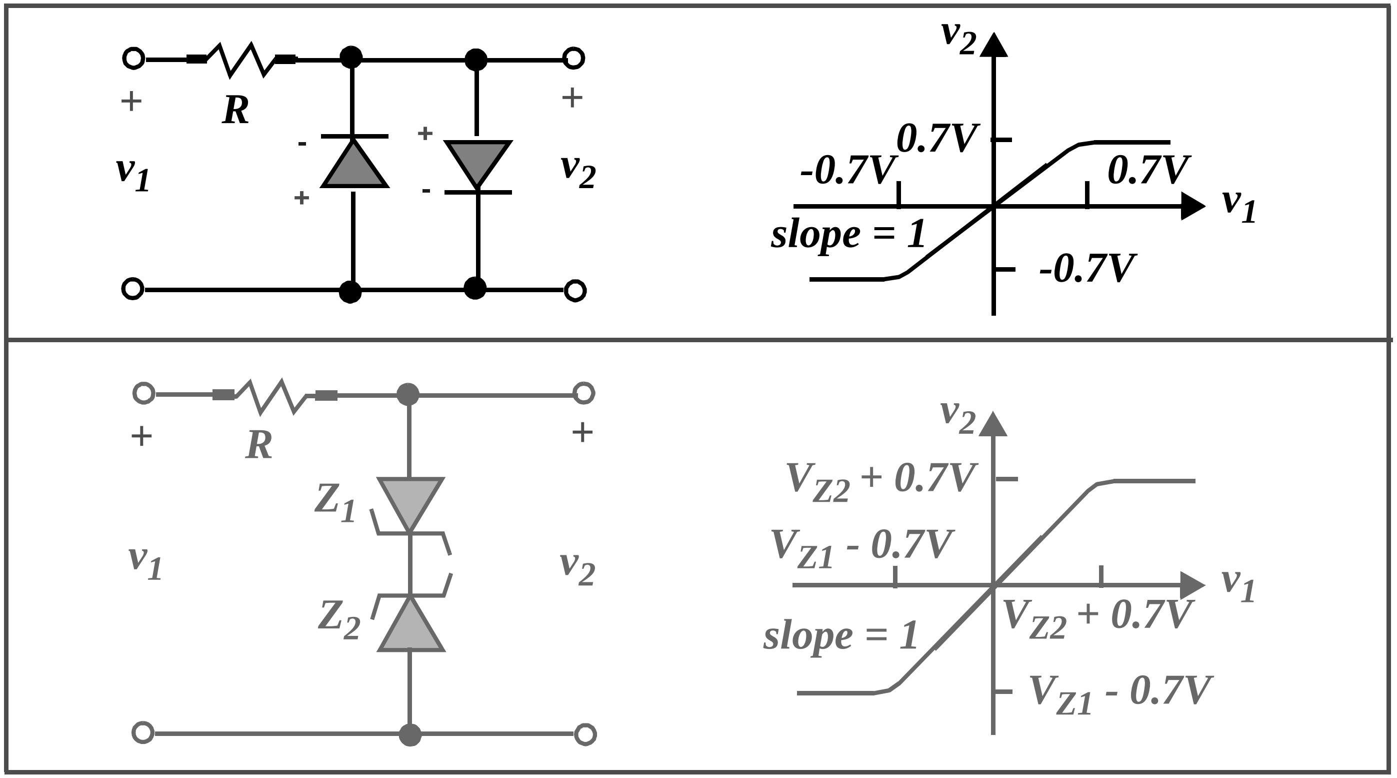

# Limiter or Clipper Circuits

Used in signal processing circuits;

Limits voltage between two inputs of Op-Amp.

Provides $v_{out} \propto v_{in}$ up to a certain value(s), beyond which voltage is clipped

off.

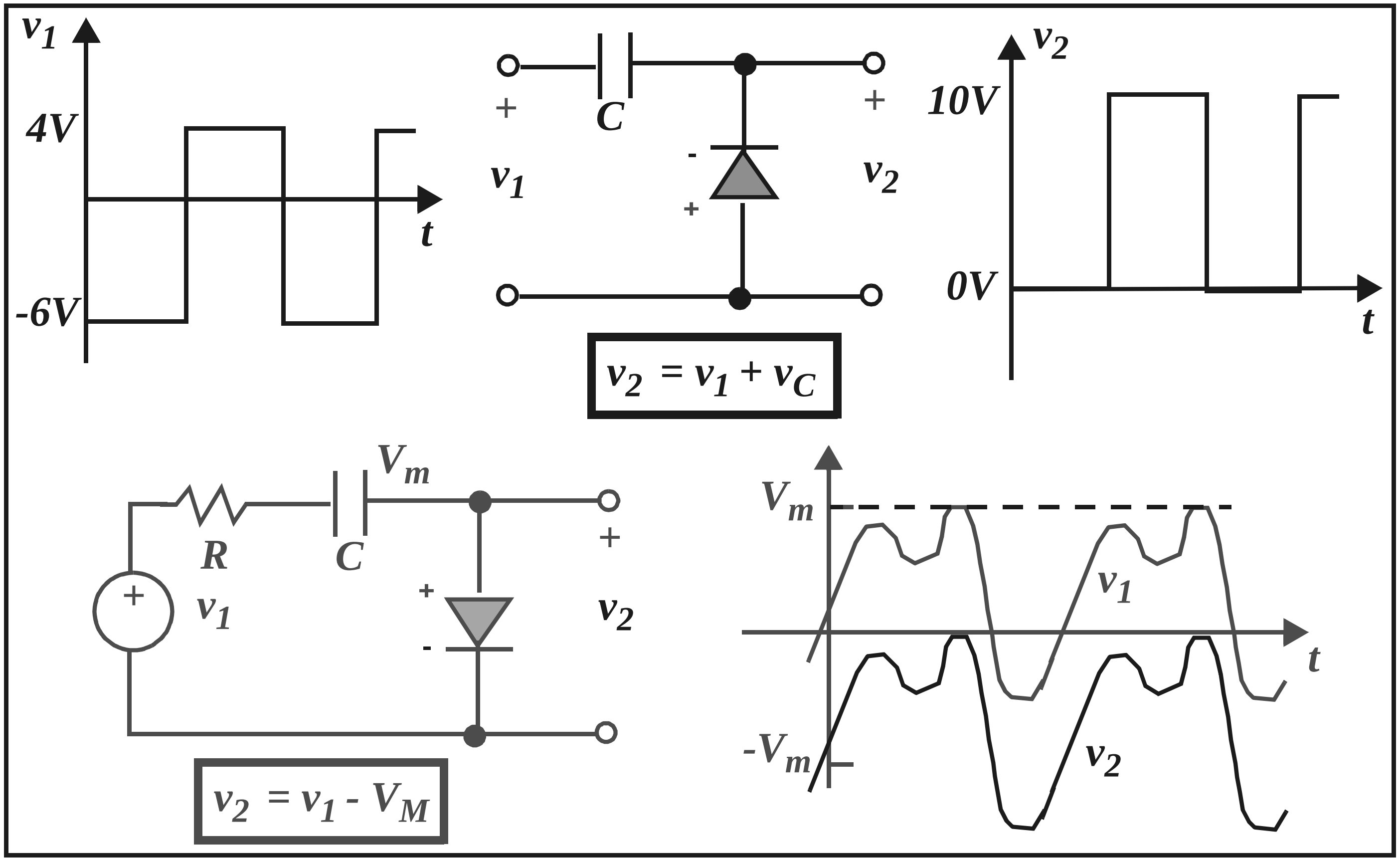



## Clamping Circuits

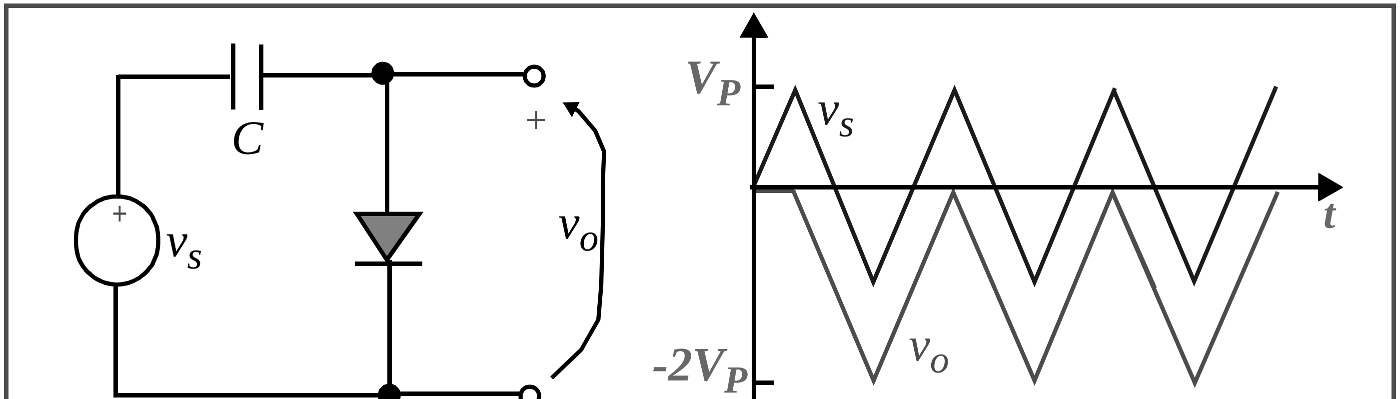
In TV receivers, peak values of certain signals must be held clamped to pre-determined levels

Provides $v_{out} \propto v_{in}$ but clamps $v_{out}$ to a certain value.

In clamping, the variable component of $v_{in}$ is transmitted and the dc value is restored.



# More Diode Clamping Circuits




$v_o = v_s - V_P$

$v_s$ increases (> 0), diode turns on, $v_o$ = 0, C charges up, $v_C = v_s$.

$v_s$ decreases from peak, diode turns off, $v_o = v_s - V_P$.

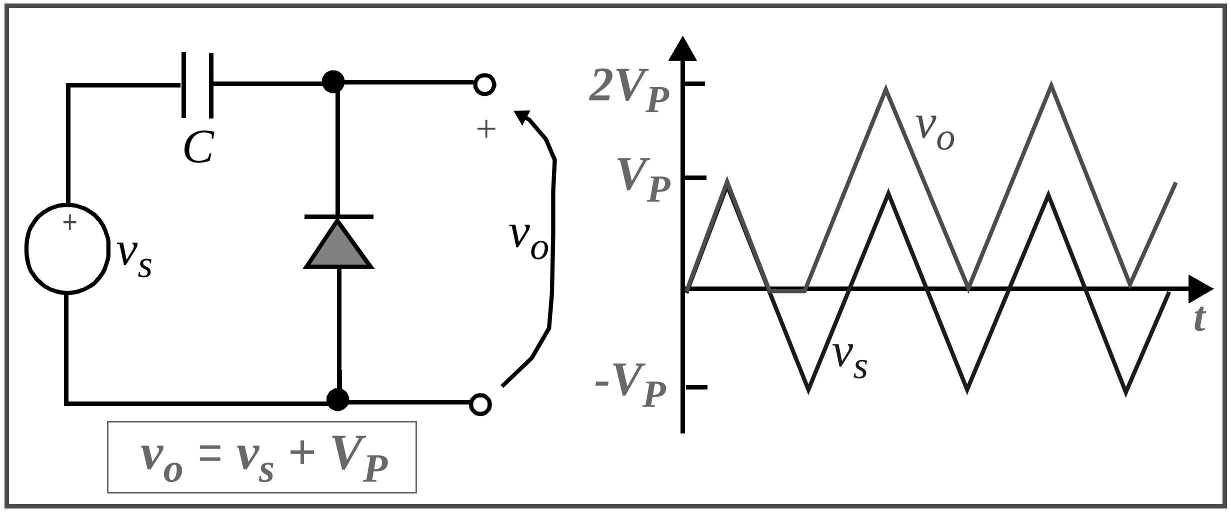
No discharge path and $v_C = V_P$. Waveform peak clamped to 0.

# More Diode Clamping Circuits

Here, initial transient lasts for 3/4 cycle.

When $v_s > 0$, diode is reverse biased initially, $v_o = v_s$.

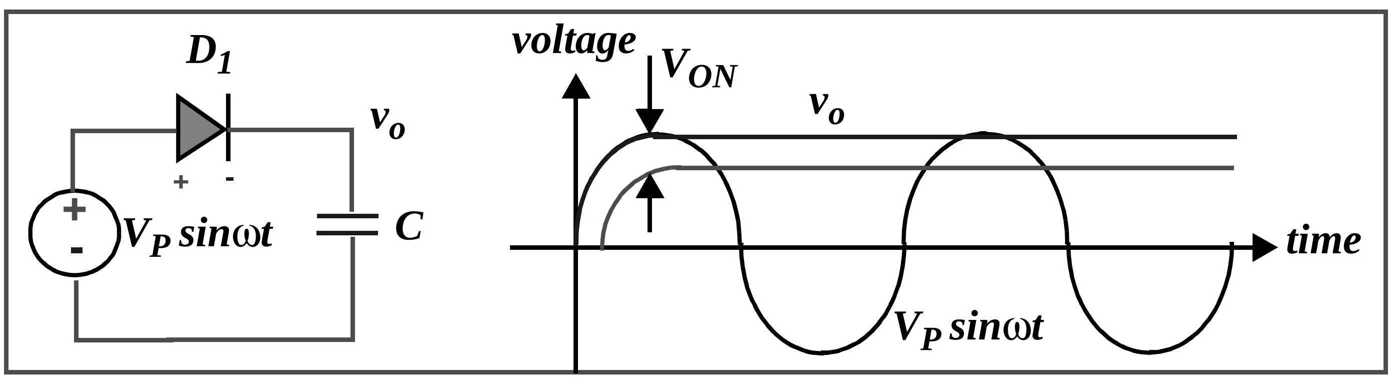
However, when $v_s < 0$ but increasing, diode turns on, $v_C = -V_P$.




After initial transient for 3/4 cycle, $v_o = V_P + v_s$.

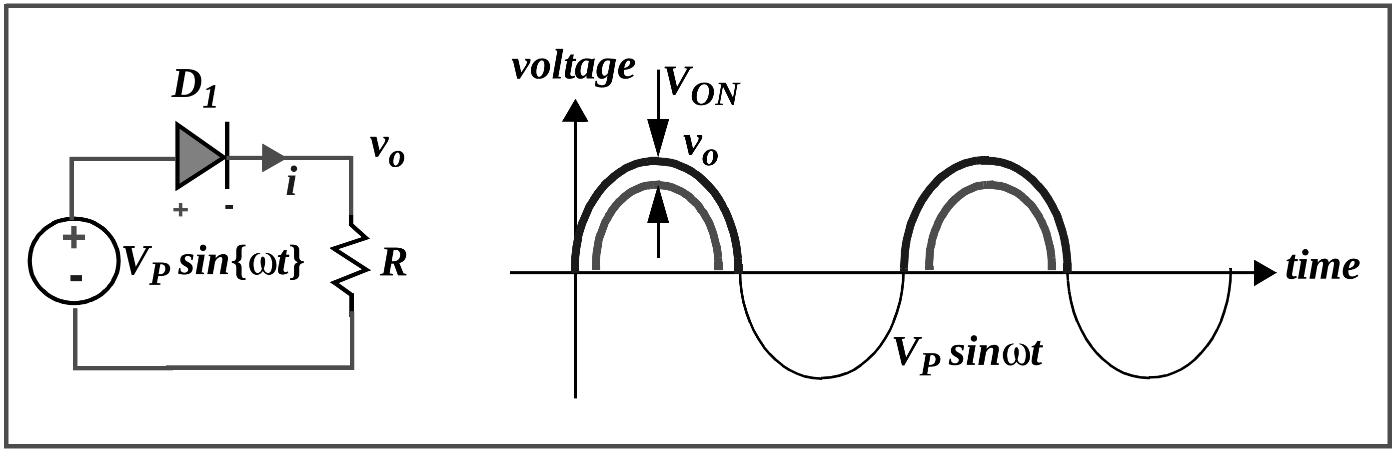
Waveform minimum value clamped to zero.

# Peak Detector Circuit



# Half-Wave Rectifier Circuits

In rectifying circuits, the variable component of $v_s$ is rejected and the dc value is transmitted.

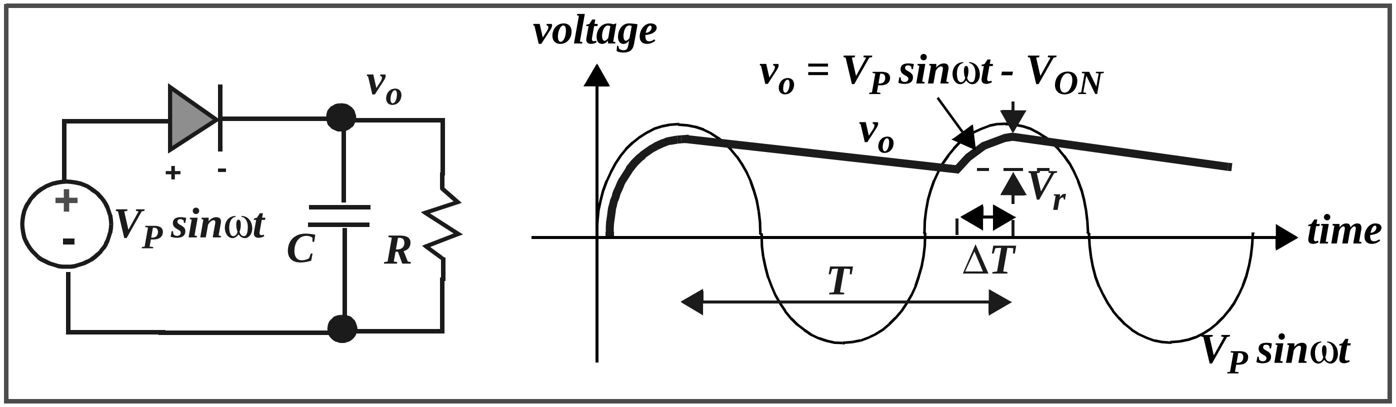



$$i = \frac{V_P \sin(\omega t)}{R} \quad \text{for } 0 \le \omega t \le \pi \qquad \text{and} \qquad i = 0 \text{ for } \pi \le \omega t \le 2\pi.$$

$$\boxed{I_{DC} = \frac{1}{2\pi}\int_0^{2\pi} i \cdot d(\omega t) = \frac{1}{2\pi}\int_0^{\pi} \frac{V_P \sin(\omega t)}{R} \cdot d(\omega t) = \frac{V_P}{\pi R} = \frac{I_P}{\pi}}.$$

Explain the effect of $V_{ON}$ on $v_o$ for the R and C loads.

## Case of RC Load




Ripple voltage $V_r = (V_P - V_{ON}) - \left((V_P - V_{ON}) \cdot \exp\left(-\frac{T - \Delta T}{RC}\right)\right)$.

$V_r \approx (V_P - V_{ON})\left(\frac{T}{RC}\right) \cdot \left(1 - \frac{\Delta T}{T}\right) \approx \left(\frac{V_P - V_{ON}}{R}\right)\frac{T}{C}$ for $\Delta T \ll T$.

Need to find the conduction interval $\Delta T$. Put $t' = T - \Delta T$.

$$(V_P - V_{ON}) \cdot \exp\left(-\frac{T - \Delta T}{RC}\right) = V_P \cos\omega(T - \Delta T) - V_{ON}.$$

$$(V_P - V_{ON}) \cdot \left(1 - \frac{T}{RC}\right) = V_P \cos\{\omega \cdot \Delta T\} - V_{ON}.$$

$$(V_P - V_{ON}) \cdot \left(1 - \frac{T}{RC}\right) = V_P\left(1 - \frac{(\omega \cdot \Delta T)^2}{2}\right) - V_{ON}$$

. Solve for $\Delta T$.

$$\Delta T \approx \frac{1}{\omega}\sqrt{\frac{2}{V_P} \cdot T\frac{V_P - V_{ON}}{RC}} = \frac{1}{\omega}\sqrt{\frac{2V_r}{V_P}}$$

. 

$$\theta_c = \omega \cdot \Delta T = \sqrt{\frac{2V_r}{V_P}}$$

in radians.

Explain diode current, surge current and peak-inverse-voltage (PIV) rating.