Application Specific Circuits

Section 06

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- Converters
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  - Analog/Digital
- Protection Circuits
  - Voltage/Current Limiter
  - Reverse Polarity
  - ESD Protection

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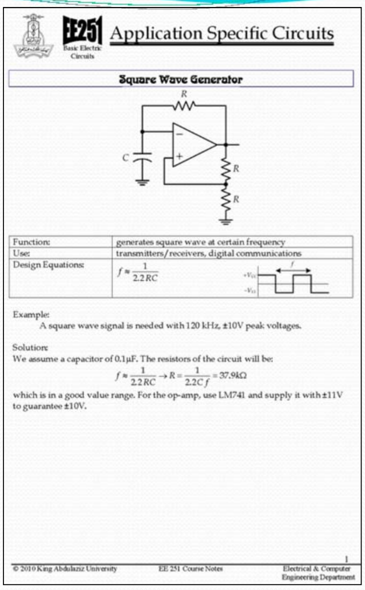
  - Integrators, Differentiator
  - Transfer Functions
- Filters
  - Low/High Pass Filters
  - Band Pass/Stop Filters

Format

1. Circuits Schematic
2. Function
3. Usage
4. Design Equations
5. Design Example



EE251 Basic Electric Circuits — Application Specific Circuits

Square Wave Generator

Function:	generates square wave at certain frequency
Use:	transmitters/receivers, digital communications
Design Equations:	$f \approx \frac{1}{2.2RC}$

Example:

A square wave signal is needed with 120 kHz, ±10V peak voltages.

Solution:

We assume a capacitor of 0.1μF. The resistors of the circuit will be:

$$f \approx \frac{1}{2.2RC} \rightarrow R = \frac{1}{2.2Cf} = 37.9k\Omega$$

which is in a good value range. For the op-amp, use LM741 and supply it with ±11V to guarantee ±10V.

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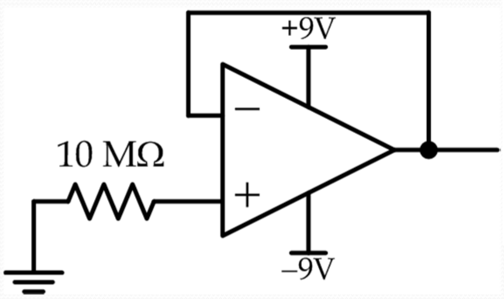
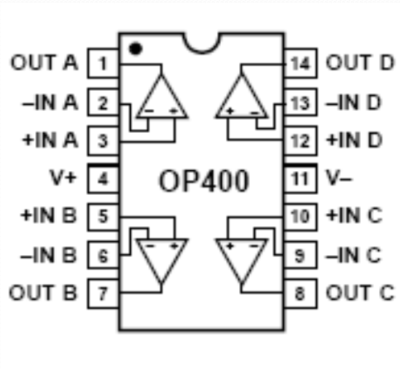
Note!!

- Some are Conceptual Designs
- Consider Ready-Made IC's available
- Or even PCBs

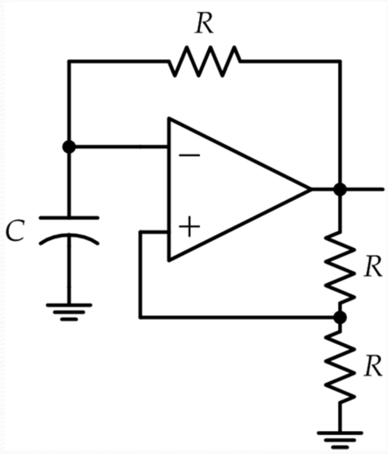
Op-Amp

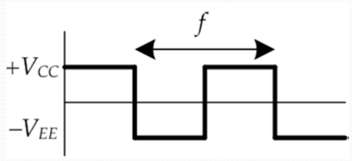
- Needs Dual Power Supply
- Multiple op-amps in one IC





(1) Square Wave Generator





$$f \approx \frac{1}{2.2\,RC}$$

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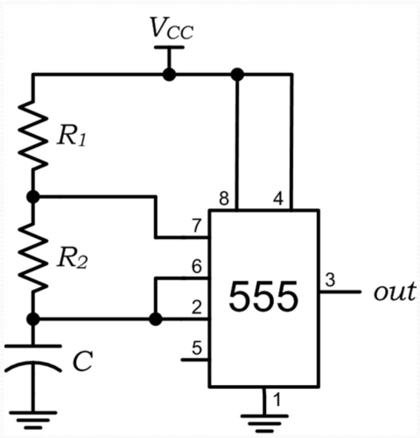
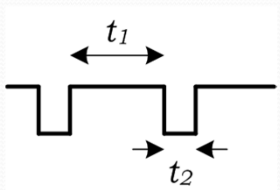
(2) Pulse Generator





$$t_1 = \ln 2 \times (R_1 + R_2) \times C$$
$$t_2 = \ln 2 \times R_2 \times C$$

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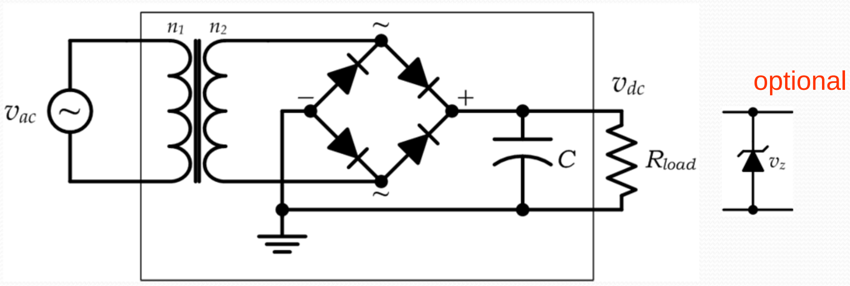
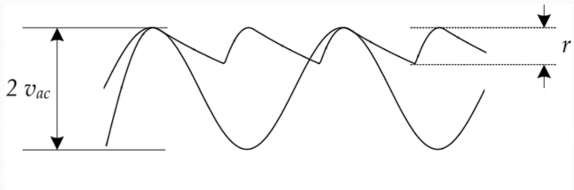
(3) AC/DC Converter



$$v_{dc} = v_{ac}\frac{n_2}{n_1} - 2 \cdot V_D$$

$$r \approx \frac{v_{dc}}{2 \cdot f \cdot C \cdot R_{load}}$$



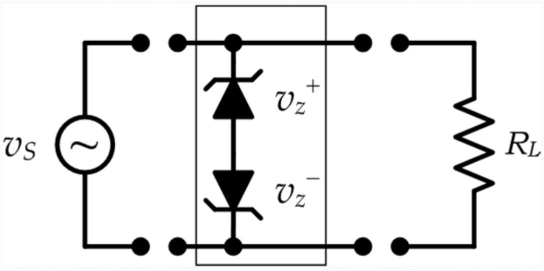
Example

- design an AC/DC converter to:
  - Produce 8.4 VDC
  - Ripples 1%
  - Diodes available V_D=0.6V
  - Maximum load expected 2kΩ

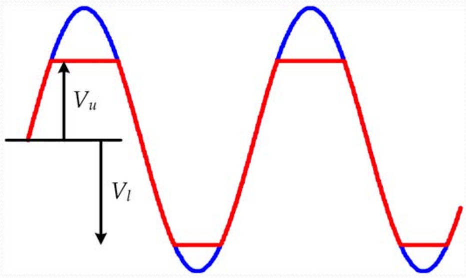
$$v_{dc} = v_{ac}\frac{n_2}{n_1} - 2 \cdot V_D$$

$$r \approx \frac{v_{dc}}{2 \cdot f \cdot C \cdot R_{load}}$$

Clipping Protection

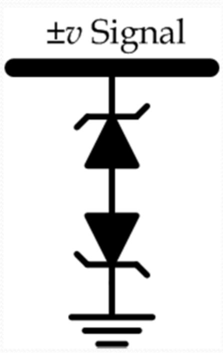


$$V_u = v_z^+ + v_f^-$$
$$V_l = v_z^- + v_f^+$$

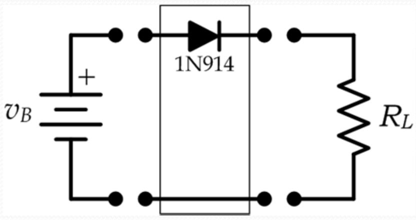


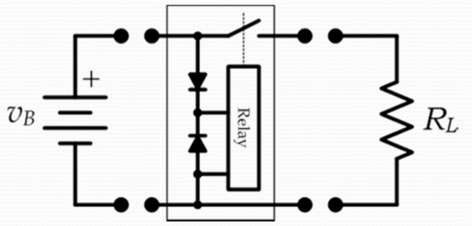
ESD Protection

- Simple Parallel Discharging Zener Diode
- Special Diodes for High speed Lines

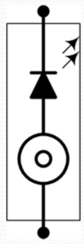


Reverse Polarity Protection



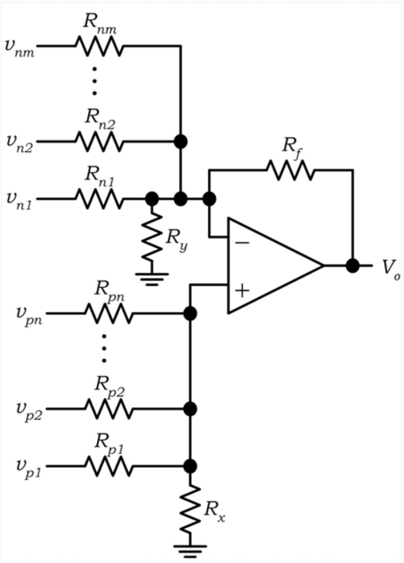


$$I_L \approx \frac{v_B}{R_L}$$



optional

General Adder (Mixer)



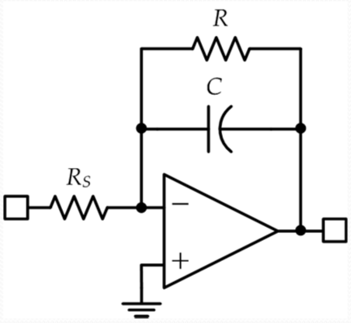
$$V_o = \sum_{i=1}^{n} A_i v_{pi} - \sum_{i=1}^{m} B_i v_{ni}$$

$$A_i = \frac{R_f}{R_{pi}}, B_i = \frac{R_f}{R_{ni}}$$

$$Let \quad A = \sum A_i, B = \sum B_i, C = A - B - 1$$

$$\begin{cases} C \geq 0 & R_x = \infty & R_y = \dfrac{R_f}{C} \\ C < 0 & R_x = -\dfrac{R_f}{C} & R_y = \infty \end{cases}$$

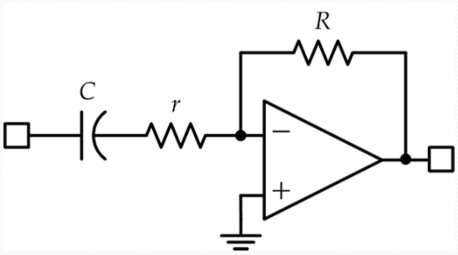
Integrator



$$v_o = \begin{cases} -\dfrac{R}{R_S} & f \le f_0 \\ -\dfrac{1}{R_S C}\displaystyle\int v_s(t)\,dt & f > f_0 \end{cases}$$

$$f_0 = \frac{1}{2\pi RC}$$

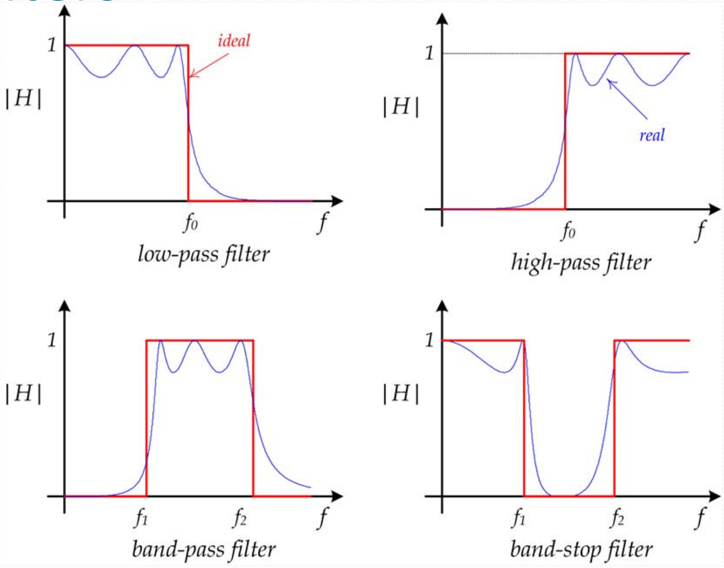
Differentiator



$$v_o = \begin{cases} -RC\dfrac{d}{dt}v_s(t) & f \le f_0 \\ -\dfrac{R}{r} & f > f_0 \end{cases}$$

$$f_0 = \frac{1}{2\pi rC}$$

Filters



Process Check

- What circuits did you face in your field?
- Do you need more details?
- Where to find more Designs?