

Application Specific Circuits

Section 06

Contents



- Generators
 - Square, Sine, Triangle, Pulse Generators
- Converters
 - AC/DC
 - Analog/Digital
- Protection Circuits
 - Voltage/Current Limiter
 - Reverse Polarity
 - ESD Protection



Contents

- Math Circuits
 - General adders (mixers)
 - Integrators, Differentiator
 - Transfer Functions
- Filters
 - Low/High Pass Filters
 - Band Pass/Stop Filters

Electrical & Computer Engineering

King Abdulaziz University

Slide 145

Format

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

EE251 Application Specific Circuits

Square Wave Generator

The circuit diagram shows a square wave generator. It consists of an operational amplifier (op-amp) with its non-inverting input connected to ground through a capacitor C. The inverting input is connected to the output through a resistor R. The output is connected back to the inverting input through another resistor R. A feedback loop is formed by a resistor R and a capacitor C connecting the output back to the inverting input.

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

Example:
A square wave signal is needed with 120 kHz, $\pm 10V$ peak voltages.

Solution:
We assume a capacitor of $0.1\mu F$. The resistors of the circuit will be:
$$f = \frac{1}{2.2RC} \rightarrow R = \frac{1}{2.2Cf} = 37.94\Omega$$

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

© 2010 King Abdulaziz University EE 251 Course Notes Electrical & Computer Engineering Department

Electrical & Computer Engineering

King Abdulaziz University

Slide 146

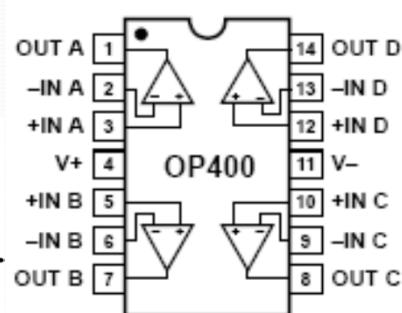
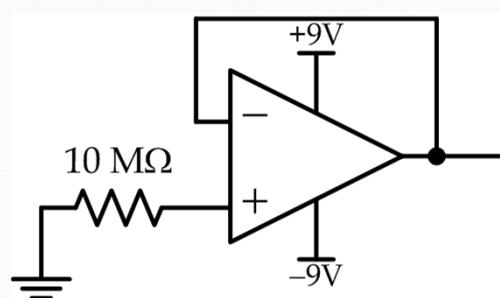
Note!!



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

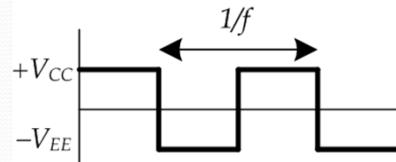
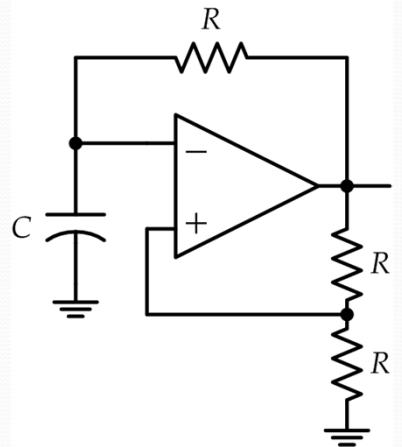
Op-Amp

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





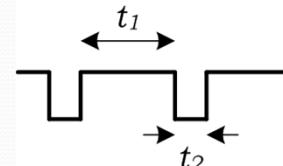
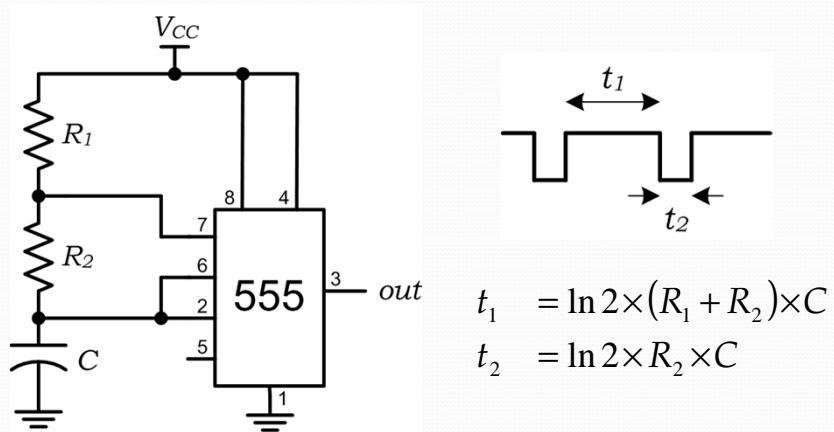
(1) Square Wave Generator



$$f \approx \frac{1}{2.2 RC} \text{ Hz}$$



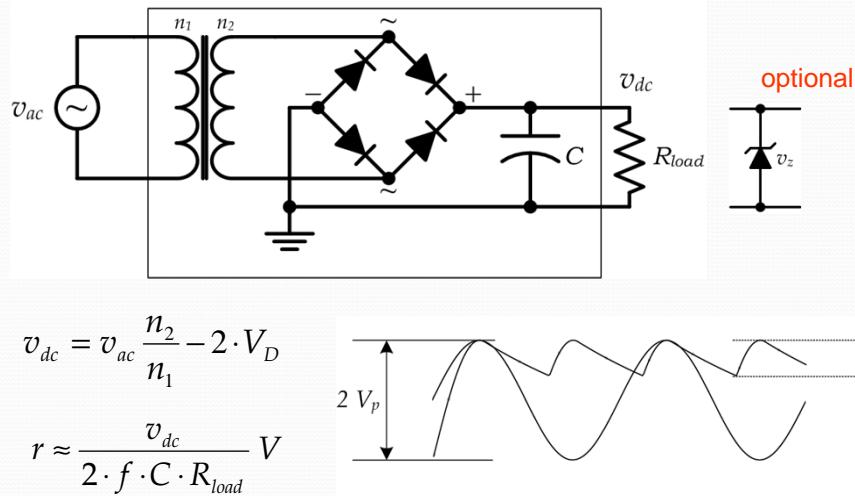
(2) Pulse Generator



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

$$t_2 = \ln 2 \times R_2 \times C$$

(3) AC/DC Converter



Electrical & Computer Engineering

King Abdulaziz University

Slide 151

Example



- Design an AC/DC converter to:
 - Produce 8.4 VDC
 - From the mains supply of 220Vrms
 - With Ripples of 1%
 - Diodes available $V_D=0.6V$
 - Maximum load expected $2k\Omega$

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

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

Electrical & Computer Engineering

King Abdulaziz University

Slide 152



Solution

$$v_{dc} = 8.4 \text{ V}$$

$$V_D = 0.6 \text{ V}$$

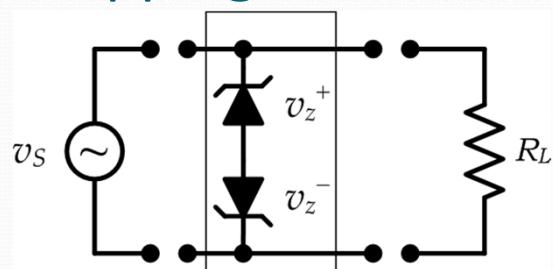
$$V_p = \sqrt{2} \times 220 = 311 \text{ V} \quad \rightarrow \quad \frac{n_2}{n_1} = 0.031 \approx \frac{1}{32}$$

$$r = 8.4 \times \frac{1}{100} = 84 \text{ mV} \quad C = 417 \mu\text{F}$$

$$R_{load} = 2 \text{ k}\Omega$$

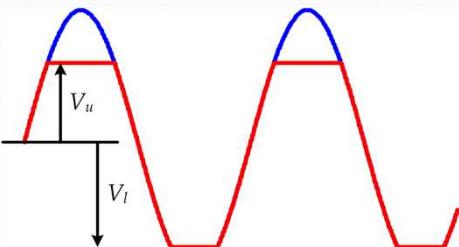
$$f = 60 \text{ Hz}$$

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

+ve Signal Only



±v Signal

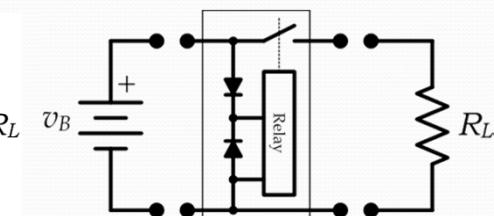
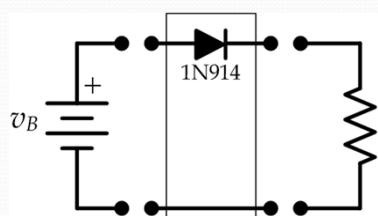


Electrical & Computer Engineering

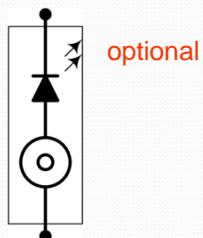
King Abdulaziz University

Slide 155

Reverse Polarity Protection



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



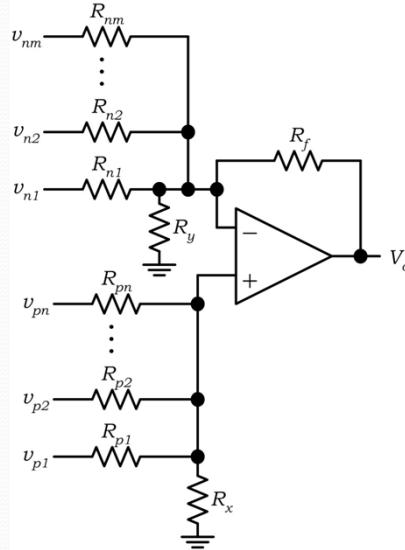
Electrical & Computer Engineering

King Abdulaziz University

Slide 156



General Adder (Mixer)



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

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

$$\text{Let } A = \sum A_i, B = \sum B_i, C = A - B - 1$$

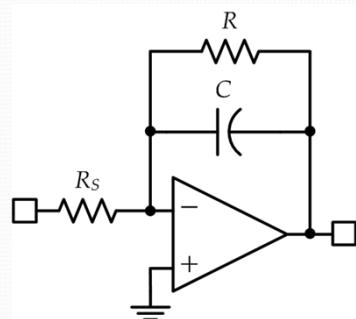
$$\begin{cases} C \geq 0 & R_x = \infty & R_y = \frac{R_f}{C} \\ C < 0 & R_x = -\frac{R_f}{C} & R_y = \infty \end{cases}$$

Electrical & Computer Engineering

King Abdulaziz University

Slide 157

Integrator



$$v_o = \begin{cases} -\frac{R}{R_s} \times v_s(t) & f \leq f_0 \\ -\frac{1}{R_s C} \int v_s(t) dt & f > f_0 \end{cases}$$

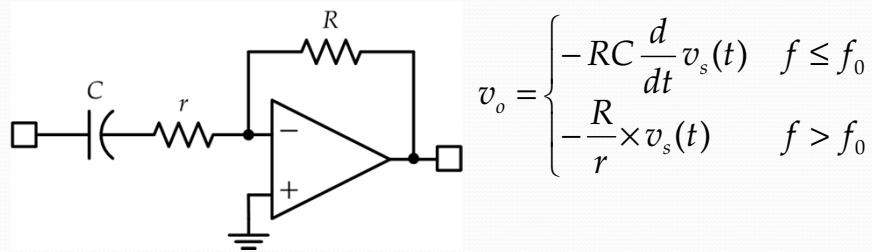
$$f_0 = \frac{1}{2\pi RC} \quad \text{Hz}$$

Electrical & Computer Engineering

King Abdulaziz University

Slide 158

Differentiator



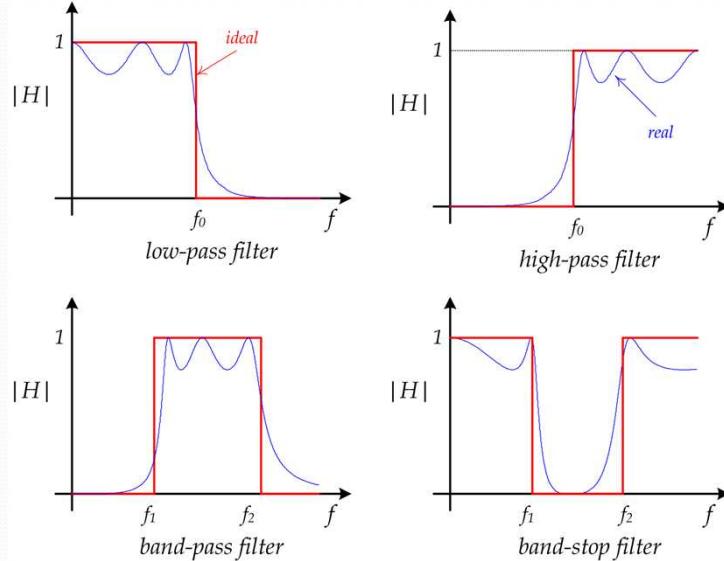
$$f_0 = \frac{1}{2\pi r C} \quad \text{Hz}$$

Electrical & Computer Engineering

King Abdulaziz University

Slide 159

Filters



Electrical & Computer Engineering

King Abdulaziz University

Slide 160



Process Check

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