WAVESHAPING CIRCUITS

Major virtue of electronic circuits ⇒ the ease of ⇓

Controlled ⇒ Voltage ★ current waveforms

◆ Some of the basic waveshaping functions ⇓

radar pulse – train generator

![Diagram showing waveshaping functions](image-url)
**Clipping**

- Removing \(\Rightarrow\) undesired portion of a signal
- The waveshape function performed by the circuit components arranging

![Circuit Diagram](image)

**Figure 3.34** A clipping circuit.

- Consisting \(\Rightarrow\) diode \& resistance \& voltage source
- Input signal \(\Rightarrow\) \(V_1\) \(\Rightarrow\) varies with time
- Output signal \(\Rightarrow\) \(V_D\) \& \(V_R\)
- The sum of the voltage around the loop = zero

\[
\begin{align*}
\nu_D + \nu_R &= \nu_1 - V \\
\nu_R &= \nu_1 - V - \nu_D \\
\nu_D &= \nu_1 - V - \nu_R
\end{align*}
\]
The behavior of the circuit depends on the state of the diode switch (S)

(S) closed when \( v_D + v_R = v_1 - V \)

positive Fig-b then \( v_D = 0 \)

and

\( v_R = v_1 - V \)

(S) open \( v_D \) negative

and

\( v_R = 0 \) clipping the signal

the battery shifts signal down

and

the diode cuts signal off
Common type of clipping

\[ v_2 = v_1 \quad \Rightarrow \quad v_2 \propto v_1 \Rightarrow \text{up to } V \]

**Figure 3.35** Clipping characteristic and circuit.

- (a) Desired transfer characteristic \( v_2 \) versus \( v_1 \)
- (b) Diode circuit

The *bias* voltage set \( \Rightarrow \) so that

- \( D_A \Rightarrow \) conducts \( \Rightarrow \) \( v_1 > V_A \)
- \( D_B \Rightarrow \) conducts \( \Rightarrow \) \( v_1 < -V_B \)

\[ V_R = |v_2 - v_1| \]

When

- \( -V_B < v_1 < V_A \)

\( D_A \not\Rightarrow D_B \Rightarrow \) don't conduct

\[ V_2 = v_1 = v_o \]
A sinewave \( v_1 = 20 \sin \omega t \) V is applied to the circuit of Fig. 3.36a. Draw the transfer characteristic and predict the output voltage \( v_2 \).

In this circuit the first diode and the 10-V battery provide clipping for voltages greater than +10 V. With \( V_B = 0 \), the second diode provides clipping of all negative voltages or rectification. The transfer characteristic and the resulting output are as shown in Fig. 3.36b.

**Clamping**

- Provide satisfactory pictures ⇒ TV receivers
- The peak values ⇒ of ⇒ \( v(t) \) ⇒ clamped at predetermined levels
- In passing through amplifiers ⇒ dc reference level ⇒ lost ★ clamper ⇒ return ⇒ signal to its original form
R \Rightarrow \text{small} \Rightarrow C \text{charge up to } +V_m \text{ of } v_1

When \Rightarrow +v_1 \text{ change to } -v_1 \Rightarrow V_c = V_m \Rightarrow \text{diode prevents current flow in opposite direction}

V_2 = v_1 - V_m

Signal form \Rightarrow \text{unaffected}

dc = V_m \Rightarrow \text{positive peak} \Rightarrow \text{clamped at zero}

If V_m \Rightarrow \text{changes} \Rightarrow V_c \Rightarrow \text{changes} \Rightarrow v_2 \text{ again } \Rightarrow \text{touches the axis}

If D \Rightarrow \text{reversed} \Rightarrow -V_m \Rightarrow \text{clamped at zero}

If B \Rightarrow \text{in series with D} \Rightarrow \text{the reference of } v_2 \Rightarrow V_B
Clamping rectifying related waveshaping function combination D C

Rectifier
Variable component rejected dc value transmitted

Clamper
Variable component transmitted dc value rejected

Homework P.P 3 – 10

Example 11

Design a circuit that will clamp the minimum point of any periodic signal to \(-5\) V.

By Eq. 3-48, the output is to be

\[ v_2 = v_1 + (V_{\text{min}} - 5) \]

Therefore, the capacitor must charge up to the voltage \(v_C = V_{\text{min}} - 5\) with the polarity shown in Fig. 3.38.

When the input signal is negative with a magnitude greater than 5 V, current must flow through the diode, which must be connected as shown.

Figure 3.38 Designing a clamping circuit.
Differentiating

![Circuit](image)

(a) Circuit

![Waveforms](image)

(b) Waveforms

**Figure 3.39** Differentiating circuit.

- **Circuit (a)** provides \( v_2 \) derivative of \( v_1 \)
- \( v_2 \propto \) to the capacitor charging current \( \propto \) in response to a step of \( \propto \) rectangular wave \( \propto v_1 \)
- **Linear circuit transforms** \( \propto \) rectangular wave \( \propto \) into \( \propto \) series of short pulse \( \propto \) if
- **RC small** \( \propto \) compared to \( \propto T \propto \) the period of the input wave

**General operation**

- Applying Kirchhoff's voltage law \( \propto \) to the left-hand loop

\[
v_1 = v_C + v_R \approx v_C
\]
\( v_R \) small compared to \( v_C \)

\[
i_C = C \frac{dv_c}{dt}
\]

\[
\therefore \quad v_2 = v_R = Ri = RC \frac{dv_c}{dt} \simeq RC \frac{dv_1}{dt}
\]

\( v_2 \propto \text{to the derivative} \Rightarrow v_1 \)

**Integrating**

*If differentiating is possible \( \Rightarrow \text{integrating is also} \)*

![Circuit](image)

**Figure 3.40** Integrating circuit.
Square wave of $V$ applied long enough for cyclic operation to be established

RC little greater than $1/2 \, T$ of the square wave

C charged * discharged on alternate $1/2 \, T \Rightarrow v_2 \Rightarrow$ shown in Fig. b

If $RC \Rightarrow$ large compared to $T$

Only straight portion of the exponential $\Rightarrow$ appears

\[ v_2 \Rightarrow \text{sawtooth wave} \propto \text{time} \]

In general

\[ v_1 = v_R + v_C \cong v_R = iR \]

If $v_C \Rightarrow$ small $\Rightarrow$ compared to $v_R \Rightarrow RC > T$


\[ v_2 = \frac{1}{C} \int idt \approx \frac{1}{RC} \int v_1 dt \]

\[ V_2 \propto \int v_1 \]

**Op Amp Integrator**

- General feedback network \( \Rightarrow \) contains C ☘️ L ☘️ R

![Op Amp Integrator Diagram](image)

- C \( \Rightarrow \) feedback element

\[ V_1 \approx 0 \]

\[ n \Rightarrow \text{at ground potential} \]

\[ I_1 \approx 0 \]

- The sum of the I into n
\[
\frac{v_1}{R_1} + C \frac{dv_o}{dt} = 0
\]

or
\[
dv_o = -\frac{v_1}{R_1C} dt
\]

Integrating each term with respect to time and solving

\[
v_o = -\frac{1}{R_1C} \int v_1 dt + a \text{ constant}
\]

This \(\Rightarrow\) an integrator device \(\Rightarrow\) very useful in computing signal processing \(\Rightarrow\) signal generating

**Op Amp Differentiator**

![Op Amp Differentiator Diagram]
Differentiator device is not so useful as the integrator

**Example 12**

Predict the output voltage of the circuit shown in Fig. 3.42 where the block represents an ideal amplifier with $A$ very large.

For $A$ very large, $v_i$ is very small and representation as an integrator is accurate. Here $i = i_1 + i_2$ and

$$v_o = -\frac{1}{C} \int \left( \frac{v_1}{R_1} + \frac{v_2}{R_2} \right) dt$$

$$= -\frac{1}{CR_1} \int \left( v_1 + v_2 \frac{R_1}{R_2} \right) dt$$

$$= -\int (v_1 + 5v_2) dt$$

The output is the integral of a weighted sum.