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UNIT 1

CIRCUIT THEORY

SYLLABUS


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Q–1: Define precisely unit step and unit impulse functions. [8 Marks ESE–1987]

Sol. Unit Step Function: Unit step function is defined as

\[ u(t) = \begin{cases} 
0 & ; \ t < 0 \\
1 & ; \ t > 0 
\end{cases} \]

Note : Unit step function is discontinuous at \( t = 0 \)

Unit impulse function: Unit impulse function is defined as

\[ \delta(t) = \begin{cases} 
0 & ; \ t \neq 0 \\
\infty & ; \ t = 0 
\end{cases} \]

Note : The area of the unit impulse signal is 1

\[ \int_{-\infty}^{\infty} \delta(t) dt = 1 \]

The continuous-time unit step is the running integral of the unit impulse

\[ u(t) = \int_{-\infty}^{t} \delta(\tau) d\tau \]

\[ \Rightarrow \quad \delta(t) = \frac{du(t)}{dt} \]

i.e. unit impulse is the running derivative of the unit step function.

Q–2: Sketch the following function from \( t = 0 \) to \( t = 10 \) units, indicating all salient values at different times [12 Marks ESE–1987]

\[ 50(1-\frac{1}{2} t[u(t)-u(t-4)] \]
The graphs of function at different stages are shown below.

Let
\[ f_1(t) = u(t) - u(t-4) \]
\[ f_2(t) = 25t[u(t) - u(t-4)] \]

\[ f(t) = 50 - f_2(t) \]

Q-3: **Unit Step and Unit Impulse Functions.**

Sol. **Unit Step Function:** Unit step function is defined as
\[ u(t) = \begin{cases} 
0 & ; \ t < 0 \\
1 & ; \ t > 0 
\end{cases} \]
Note: Unit step function is discontinuous at \( t = 0 \)

**Unit impulse function:** Unit impulse function is defined as

\[
\delta(t) = \begin{cases} 
0 & ; t \neq 0 \\
\infty & ; t = 0 
\end{cases}
\]

The area of the unit impulse signal is 1

\[
\int_{-\infty}^{\infty} \delta(t) dt = 1
\]

The continuous-time unit step is the running integral of the unit impulse

\[
u(t) = \int_{-\infty}^{t} \delta(\tau) d\tau
\]

\[\Rightarrow \quad \delta(t) = \frac{du(t)}{dt}
\]

i.e. Unit impulse is the running derivative of the Unit Step Function.

**Q-4:** Considering \( i(t) \) as input and \( v(t) \) as output in the network shown in Fig., find unit step response and the unit ramp response with \( v(0) = 0 \).

**Sol.**

Applying KCL at node P

\[
i(s) = \frac{V(s)}{2} + \frac{1}{s} \Rightarrow V(s) = \frac{i(s)}{s + 0.5}
\]

For unit step input current

\[
i(s) = \frac{1}{s} \Rightarrow V(s) = \frac{1}{s(s + 0.5)} = 2 \left[ \frac{1}{s} - \frac{1}{s + 0.5} \right]
\]

Taking inverse a laplace

\[
v(t) = \mathcal{L}^{-1}[V(s)] = 2[1 - e^{-0.5t}]u(t)
\]

For unit ramp input current

\[
i(s) = \frac{1}{s^2}
\]