

Gate 2023- Instrumentation Engineering

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Question 60: In the circuit shown, the input voltage $V_{in} = 100mV$. The switch and the opamp are ideal. At time $t = 0$, the initial charge stored in the $10nF$ capacitor is $1nC$, with the polarity as indicated in the figure. The switch S is controlled using a $1KHz$ square-wave voltage signal V_s as shown. Whenever V_s is 'High', S is in position '1' and when V_s is 'Low', S is in position '2'. At $t = 20ms$, the magnitude of the voltage V_o will be

Solution: From $t = 0$ to $t = 0.5ms$

Parameter	Value	Description
V_{in}	$100mV$	Input voltage
q_{10nF}	$1nC$	Initial charge on $10nF$
q_{1nF}		Charge on $1nF$
f	$1KHz$	Frequency of V_s
T	$1ms$	Time period
V_o		Output voltage

TABLE 0
INPUT PARAMETERS

$$q_{1nF} = 100mV \times 1nF \quad (1)$$

$$= 0.1nC \quad (2)$$

From $t = 0.5ms$ to $t = 1ms$

voltage at -ve terminal of op-amp is virtually shorted so q_{1nF} is transferred to $10nF$ with reverse polarity

$$q_{10nF} = 1nC - 0.1nC \quad (3)$$

$$= 0.9nC \quad (4)$$

At $t = 20ms$,

$$q_{10nF} = 1nC - 20(0.1nC) \quad (5)$$

$$= -1nC \quad (6)$$

$$V_o = \frac{-1nC}{10nF} \quad (7)$$

$$= -100mV \quad (8)$$