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 intial 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

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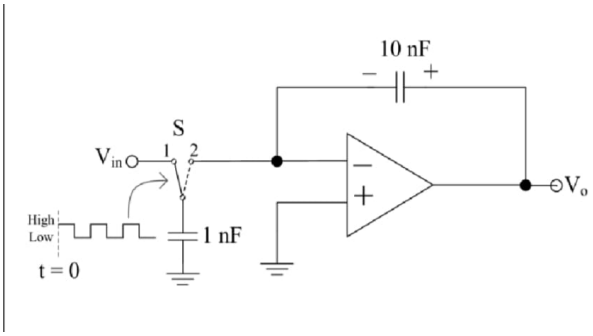

Solution: $0 < t < 0.5ms$

Parameter	Value	Description
V_{in}	$100mV$	Input voltage
q_{10nF}	$1nC$	Intial 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

$$q_{1nF} = 100mV \times 1nF \tag{1}$$
$$= 0.1nC \tag{2}$$

$0.5ms < t < 1ms$
Both the capcitors will discharge
voltage at -ve terminal of op-amp is virtually shorted so q_{1nF} is transferred to $10nF$ with reverse polarity

$$q_{10nF} = 1nC - 0.1nC \tag{3}$$
$$= 0.9nC \tag{4}$$

At $t = 20ms$,

$$q_{10nF} = 1nC - 20\,(0.1nC) \tag{5}$$
$$= -1nC \tag{6}$$
$$V_o = \frac{-1nC}{10nF} \tag{7}$$
$$= -100mV \tag{8}$$