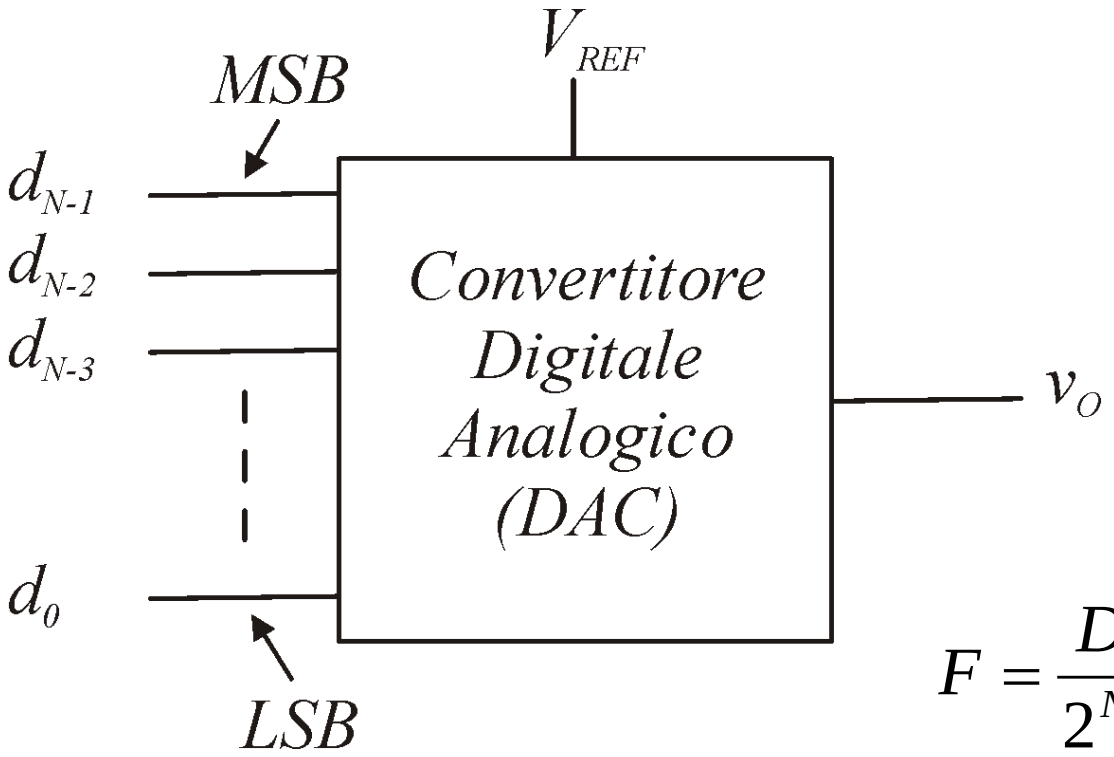
Elettronica Digitale
A.A. 2020-2021

Lezione 26/05/2021

Convertitore Digitale-Analogico (D/A o DAC)



$$v_0 = FV_{REF}$$

$$F = \frac{D}{2^N} = \frac{d_{N-1}2^{N-1} + d_{N-2}2^{N-2} + d_{N-3}2^{N-3} + \cdots + d_0 2^0}{2^N}$$

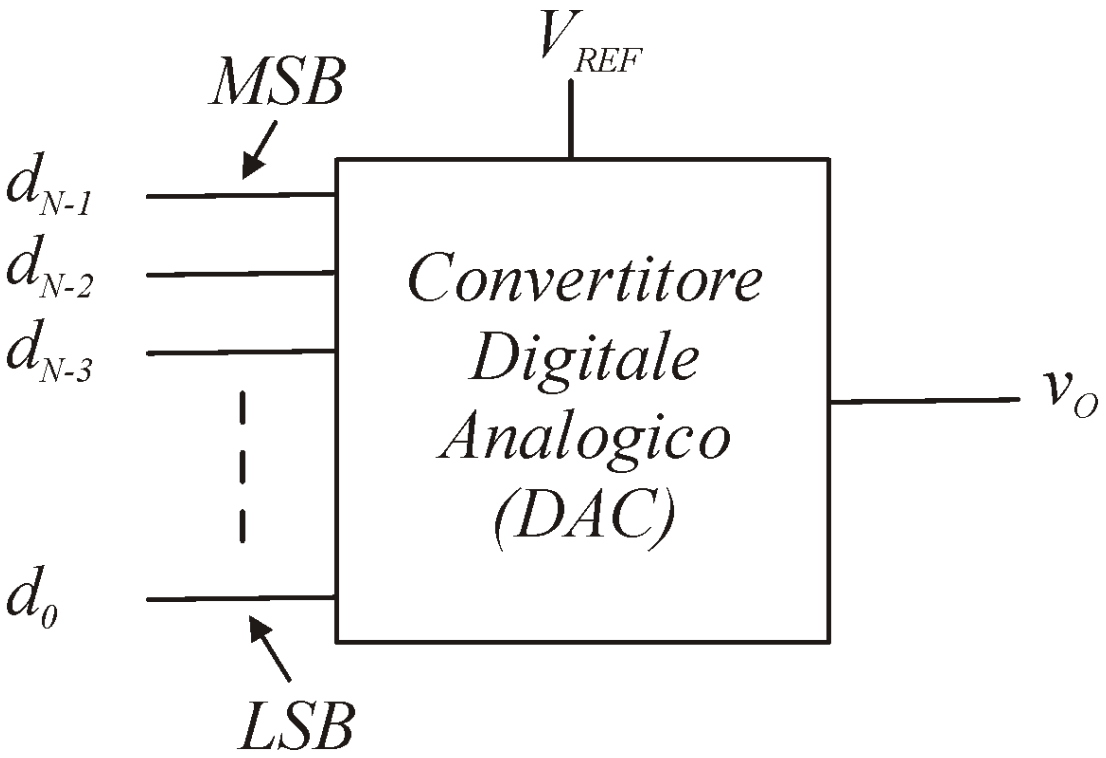
Minima variazione della tensione di uscita

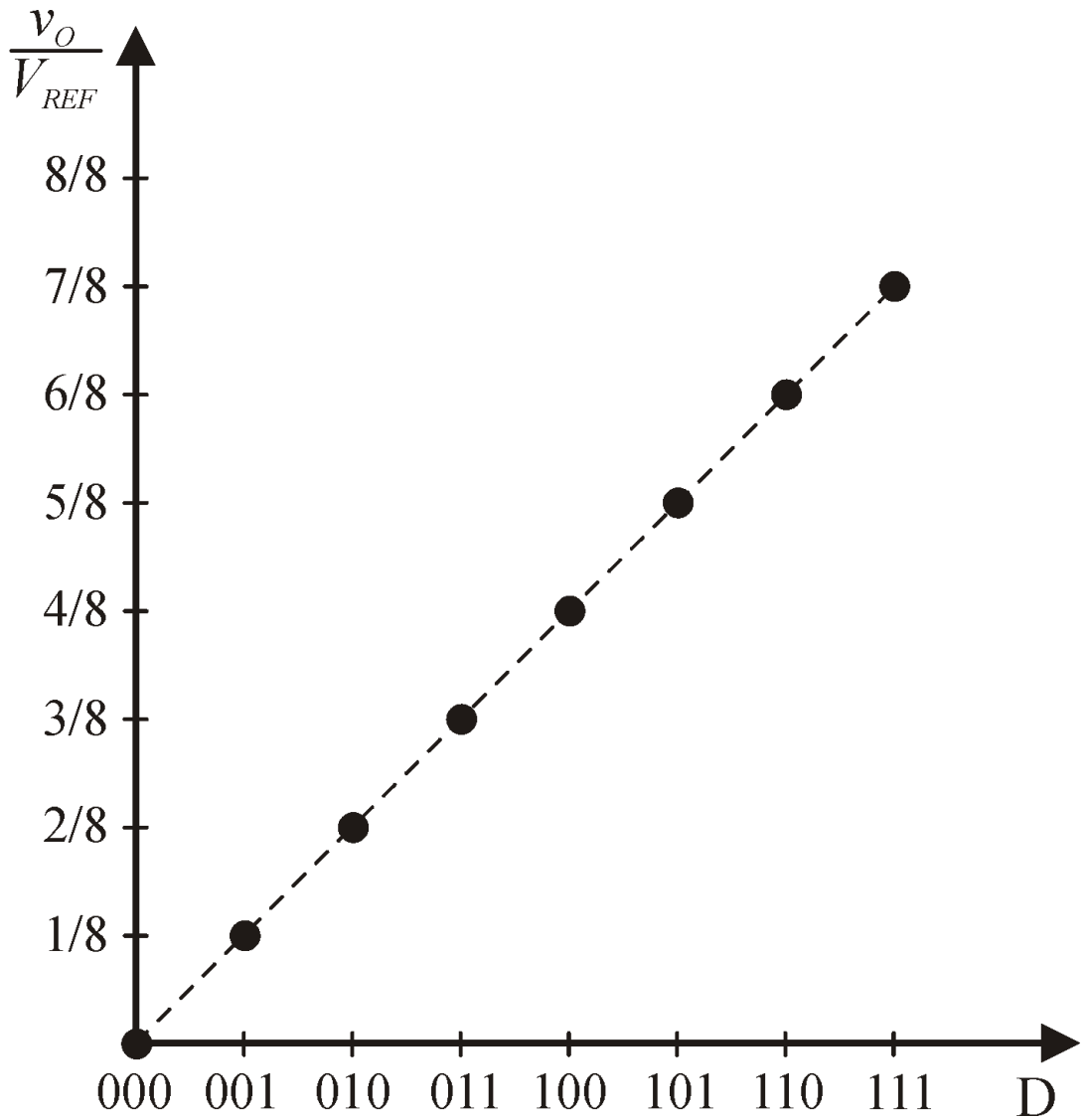
$$V_{LSB} = \frac{V_{REF}}{2^N}$$

Valore massimo della tensione di uscita (tensione di fondo scala)

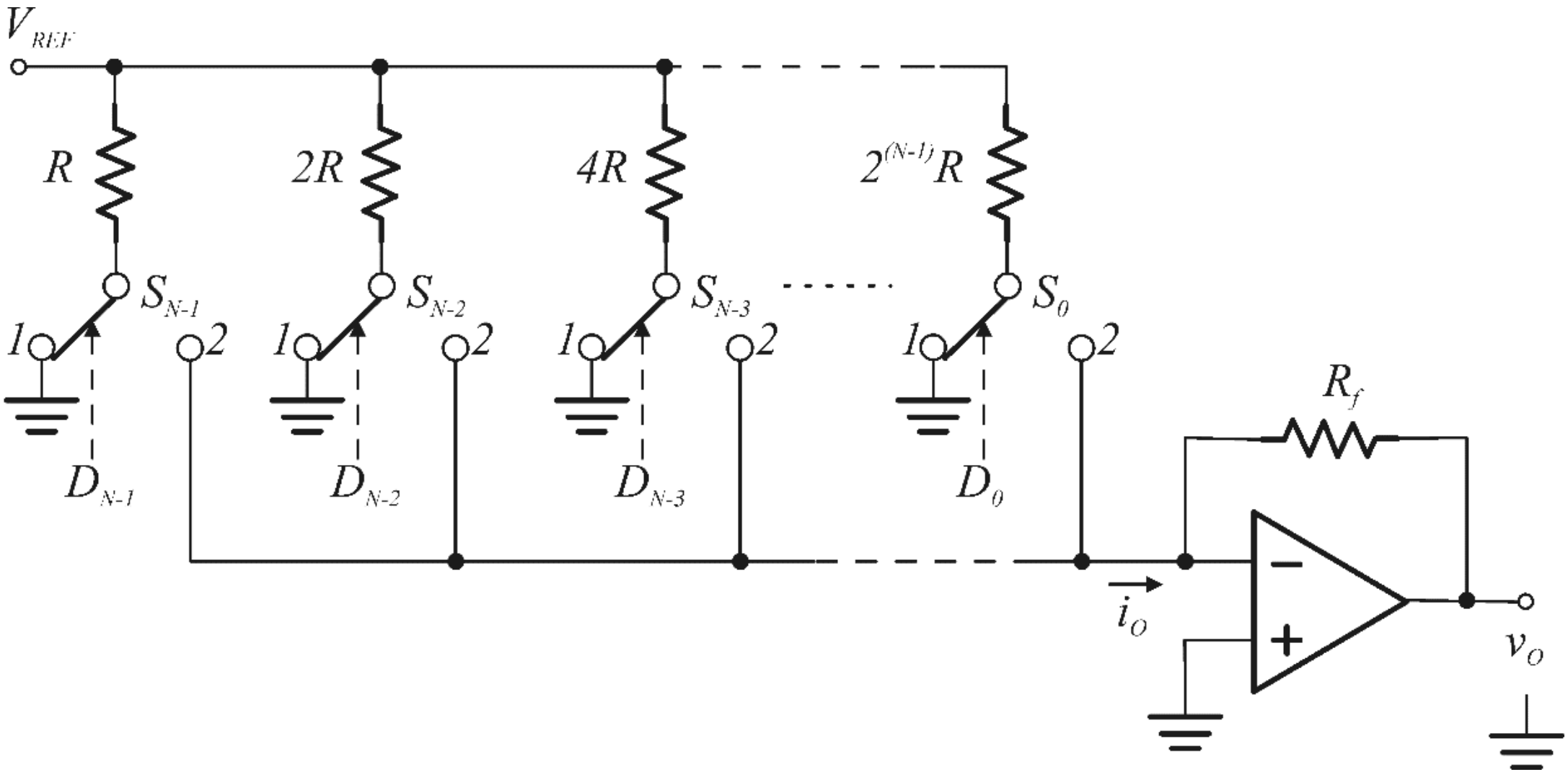
$$V_{FS} = \frac{2^N - 1}{2^N} V_{REF}$$

Convertitore Digitale-Analogico (D/A o DAC)

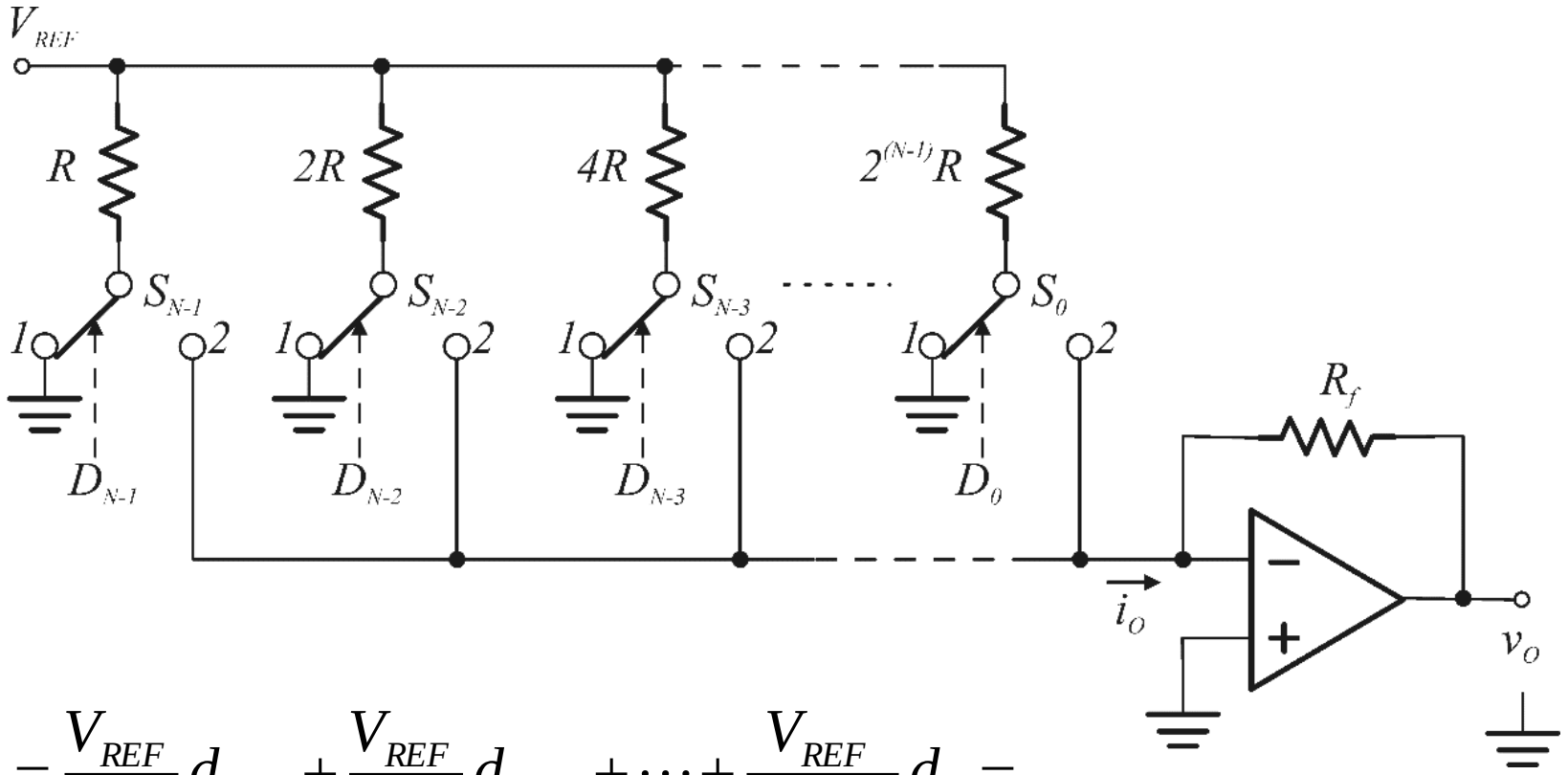




Convertitore D/A con resistori a pesi binari



Convertitore D/A con resistori a pesi binari



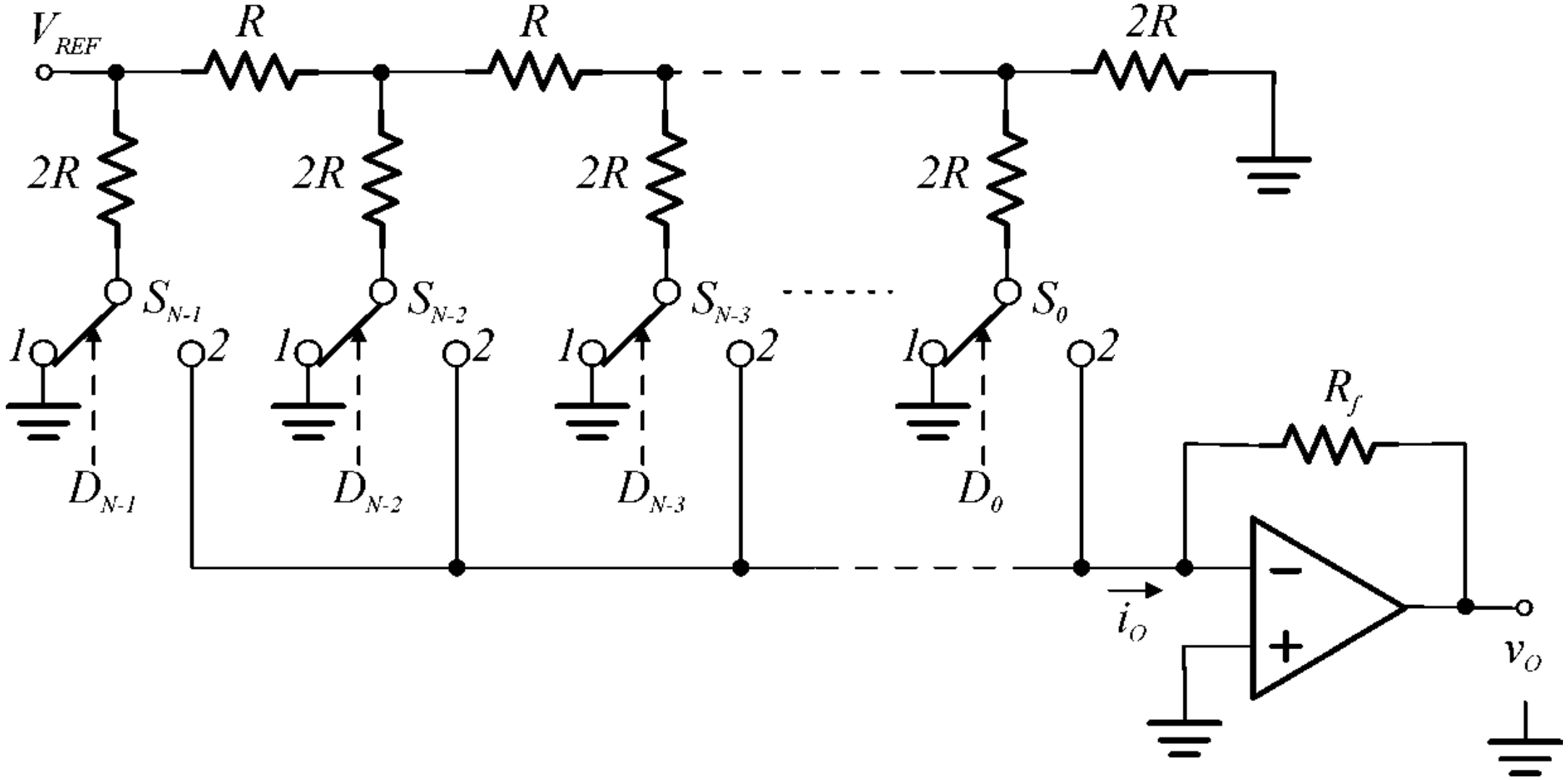
$$i_0 = \frac{V_{REF}}{R} d_{N-1} + \frac{V_{REF}}{2R} d_{N-2} + \cdots + \frac{V_{REF}}{2^{N-1}R} d_0 =$$

$$= \frac{V_{REF}}{2^{N-1}R} \left(d_{N-1} 2^{N-1} + d_{N-2} 2^{N-2} + \cdots + d_0 \right) =$$

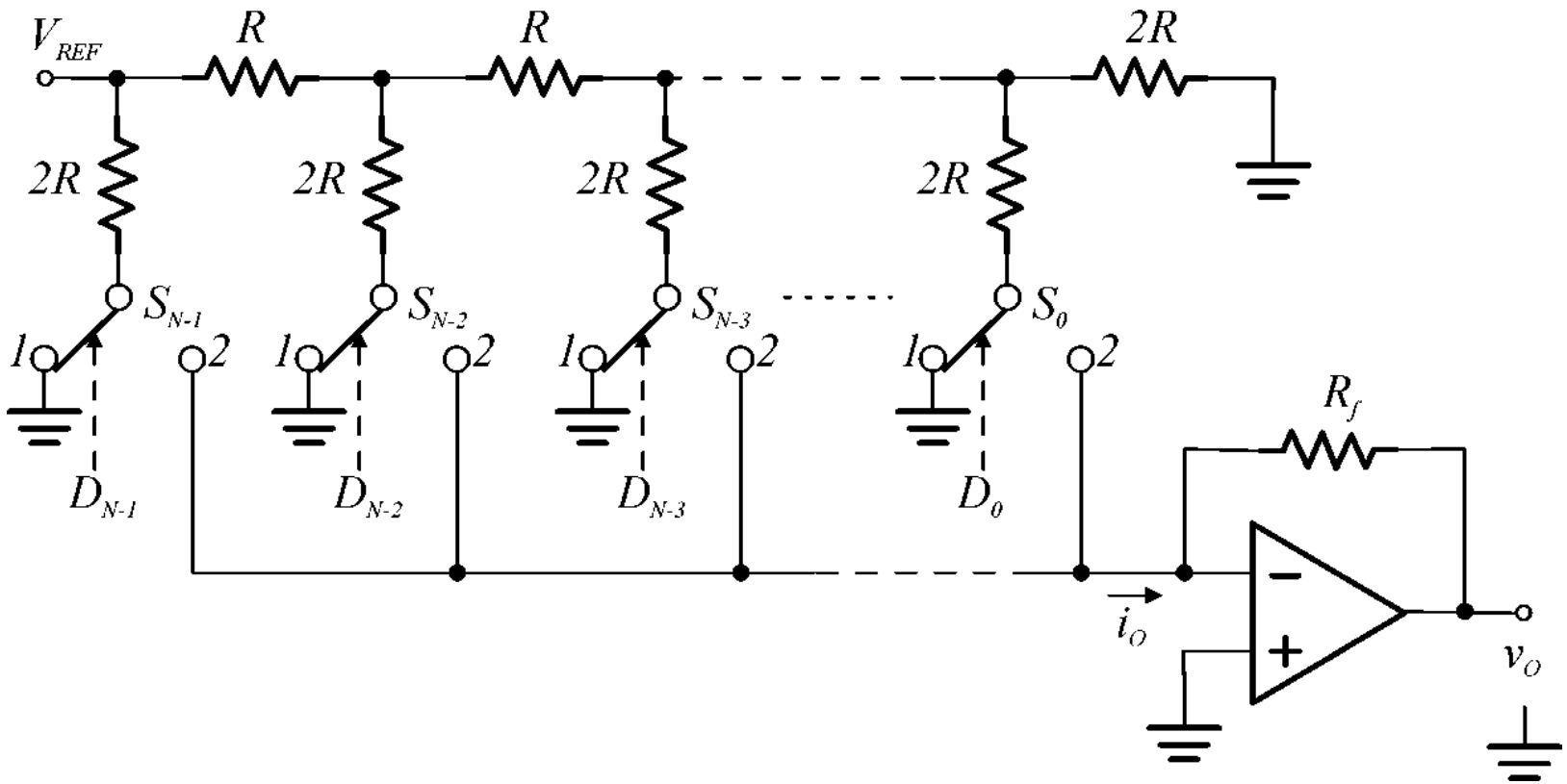
$$= \frac{V_{REF}}{2^{N-1}R} D$$

$$v_0 = -i_0 R_f = -\frac{V_{REF}}{2^{N-1}R} R_f D$$

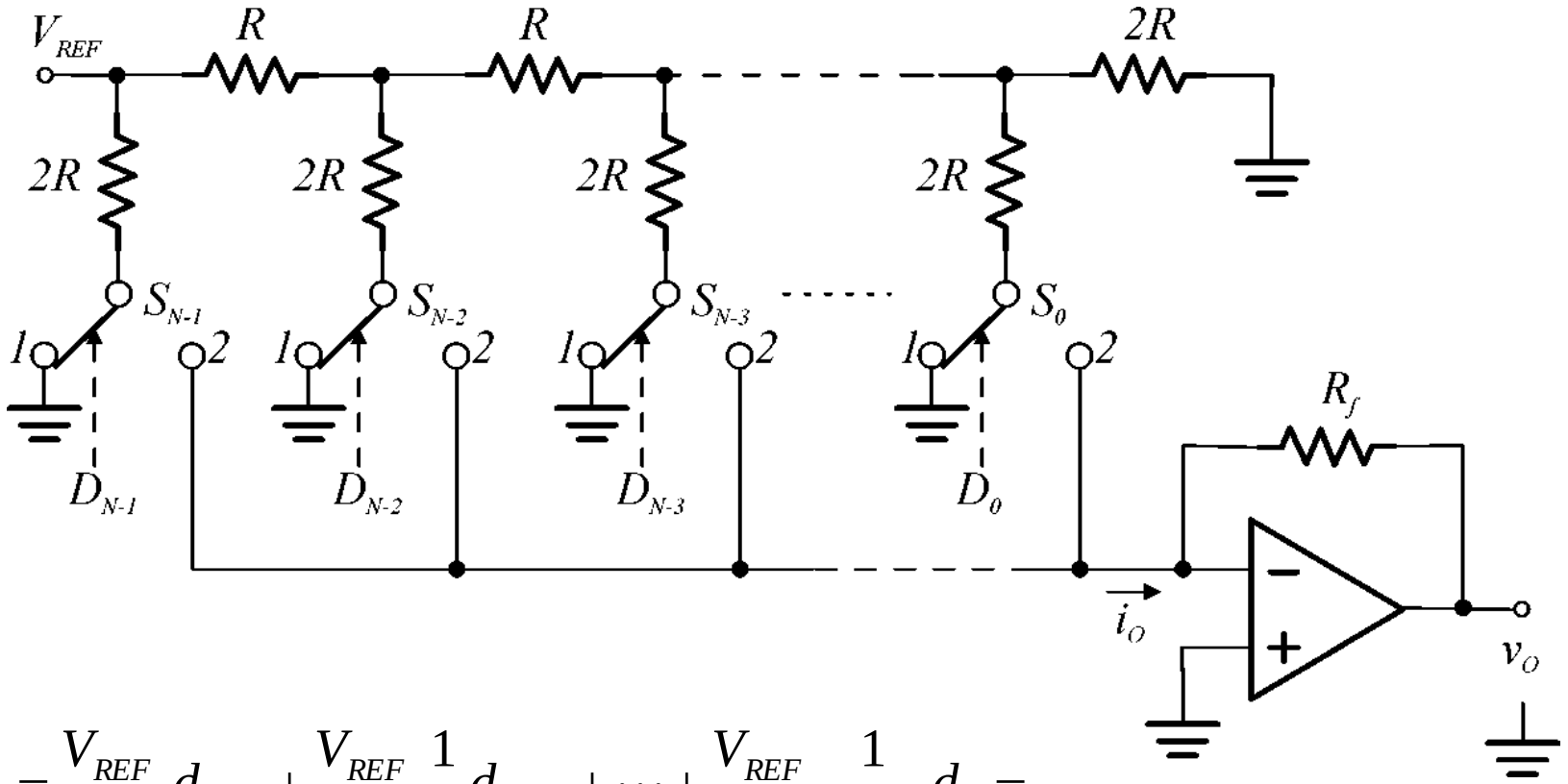
Convertitore D/A con rete a scala R-2R



Convertitore D/A con rete a scala R-2R



Convertitore D/A con rete a scala R-2R



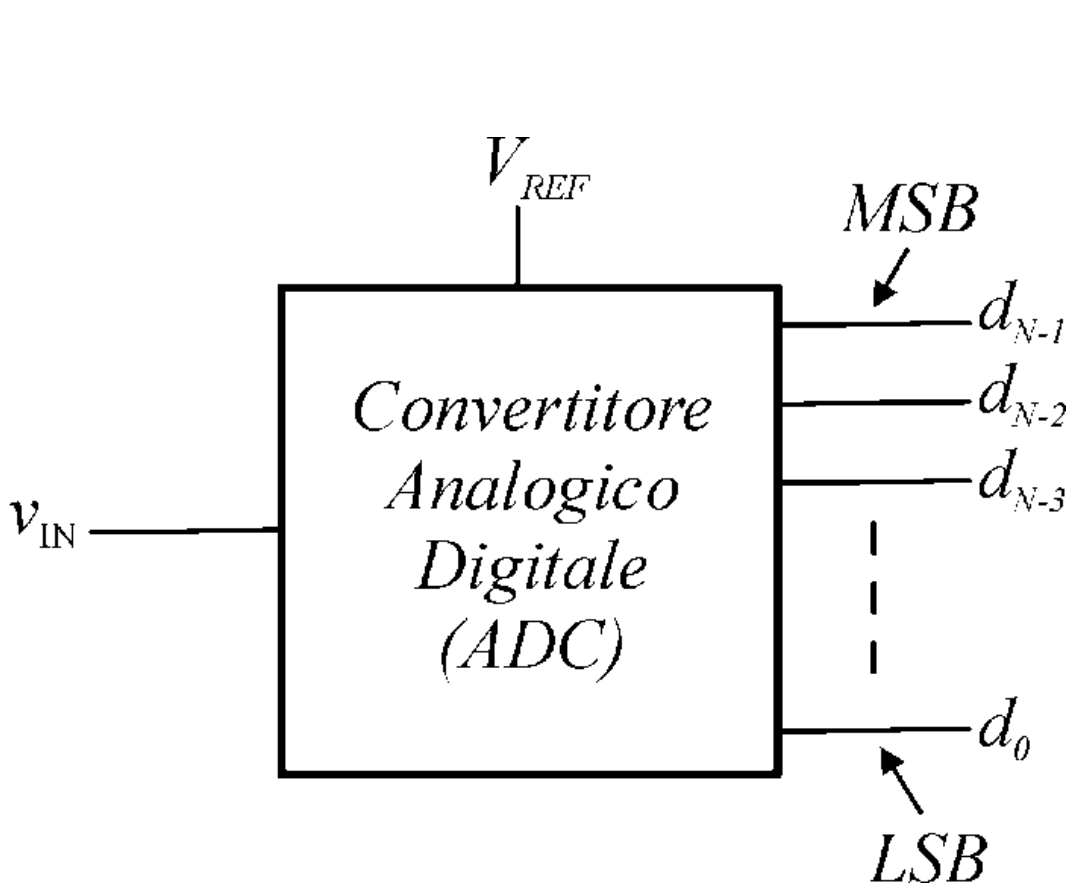
$$i_0 = \frac{V_{REF}}{2R} d_{N-1} + \frac{V_{REF}}{2R}\frac{1}{2} d_{N-2} + \cdots + \frac{V_{REF}}{2R}\frac{1}{2^{N-1}} d_0 =$$

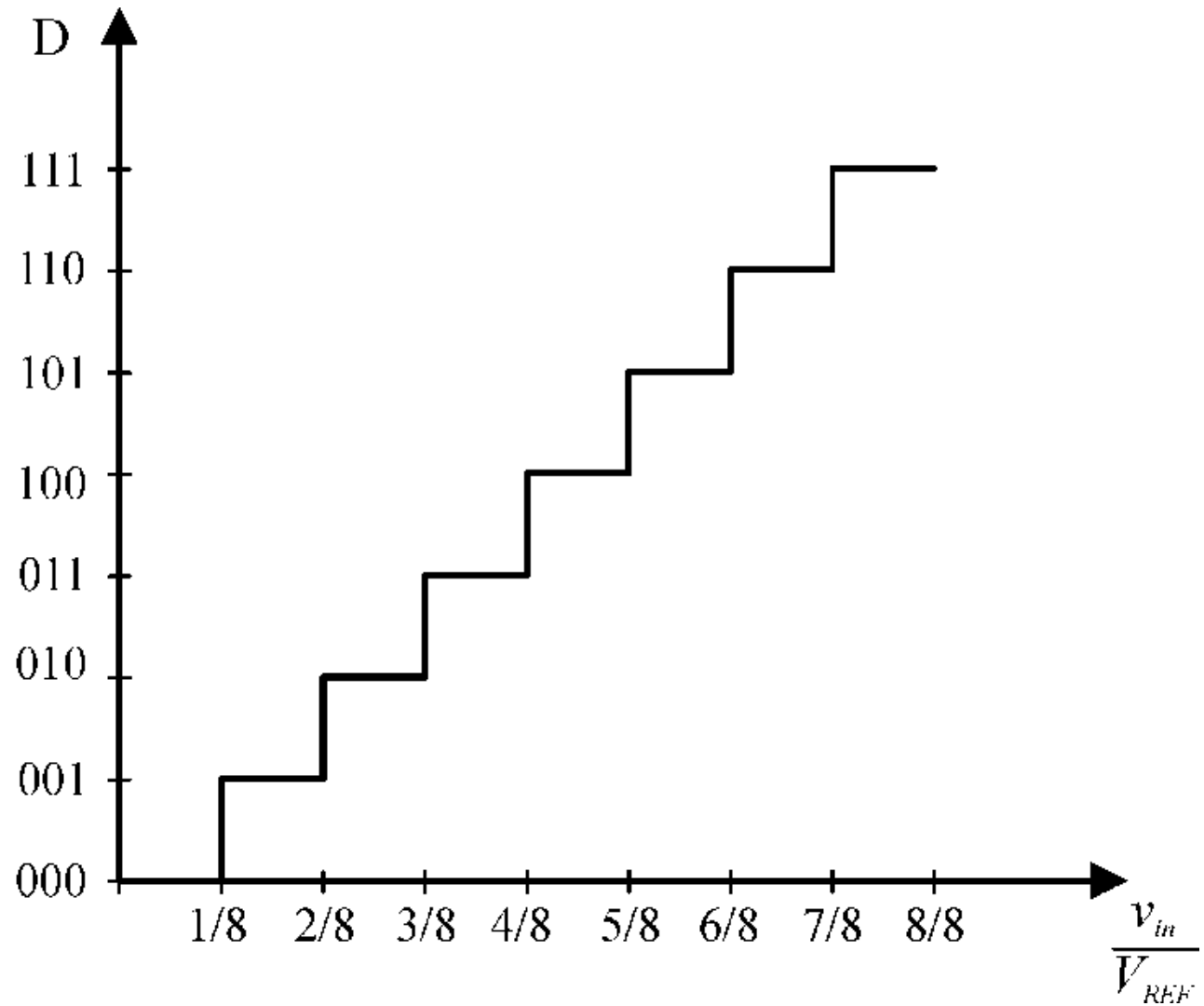
$$= \frac{V_{REF}}{2^N R}\left(d_{N-1} 2^{N-1} + d_{N-2} 2^{N-2} + \cdots + d_0\right) =$$

$$= \frac{V_{REF}}{2^N R} D$$

$$v_0 = -i_0 R_f = -\frac{V_{REF}}{2^N R} R_f D$$

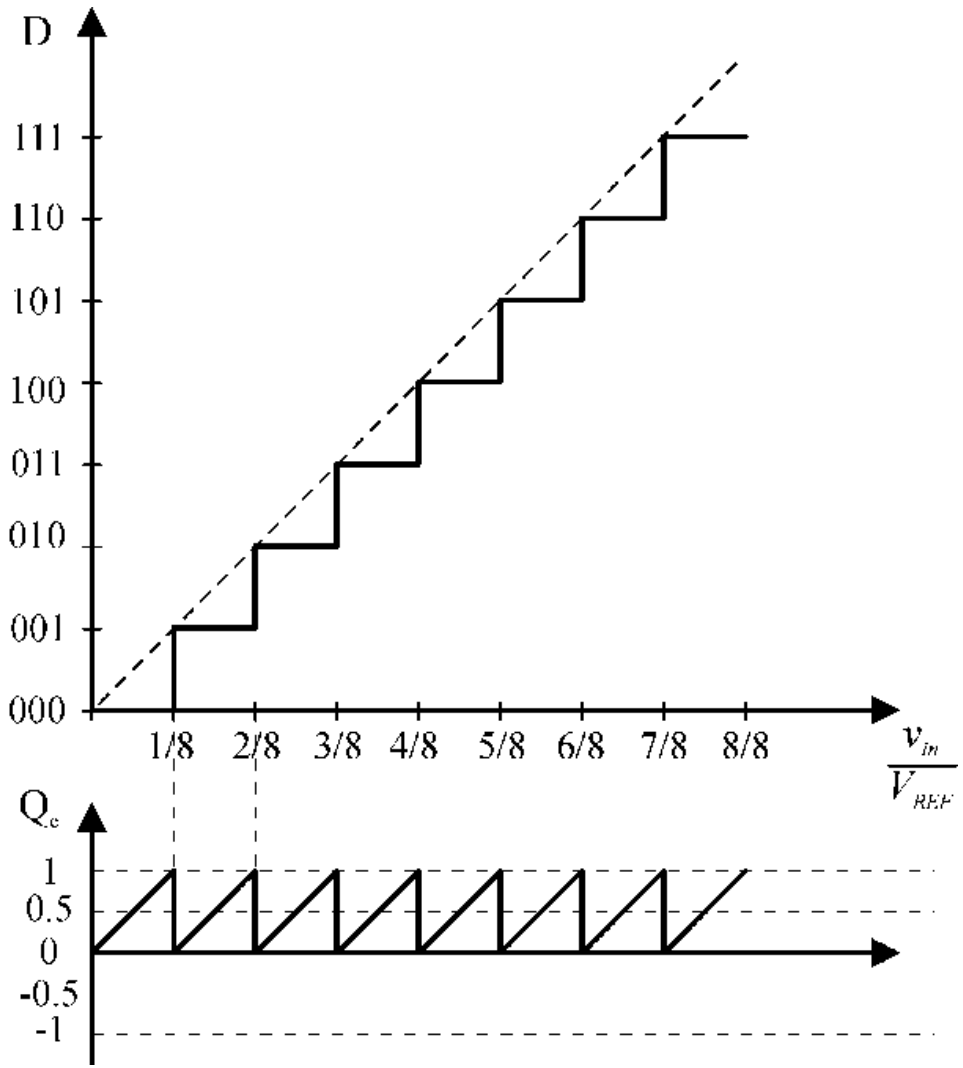
Convertitore Analogico Digitale (A/D o DAC)

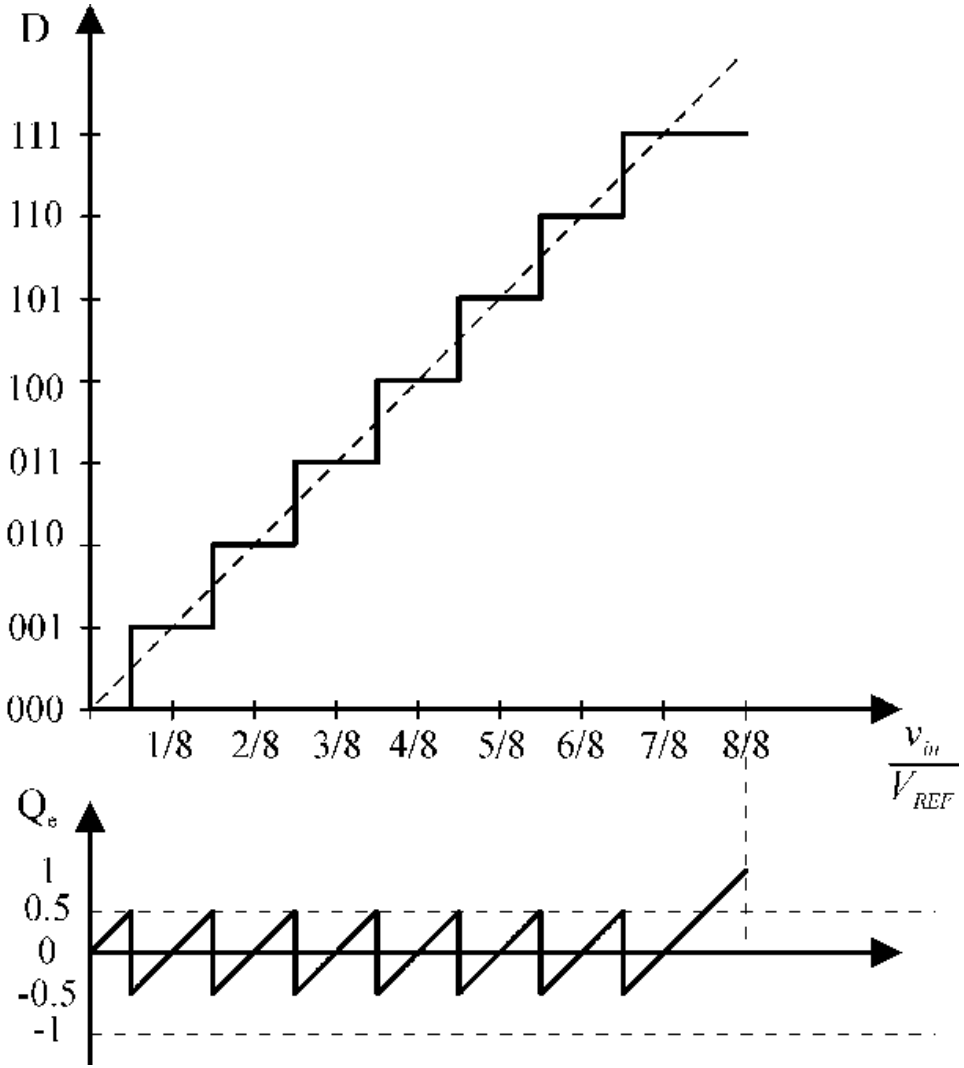




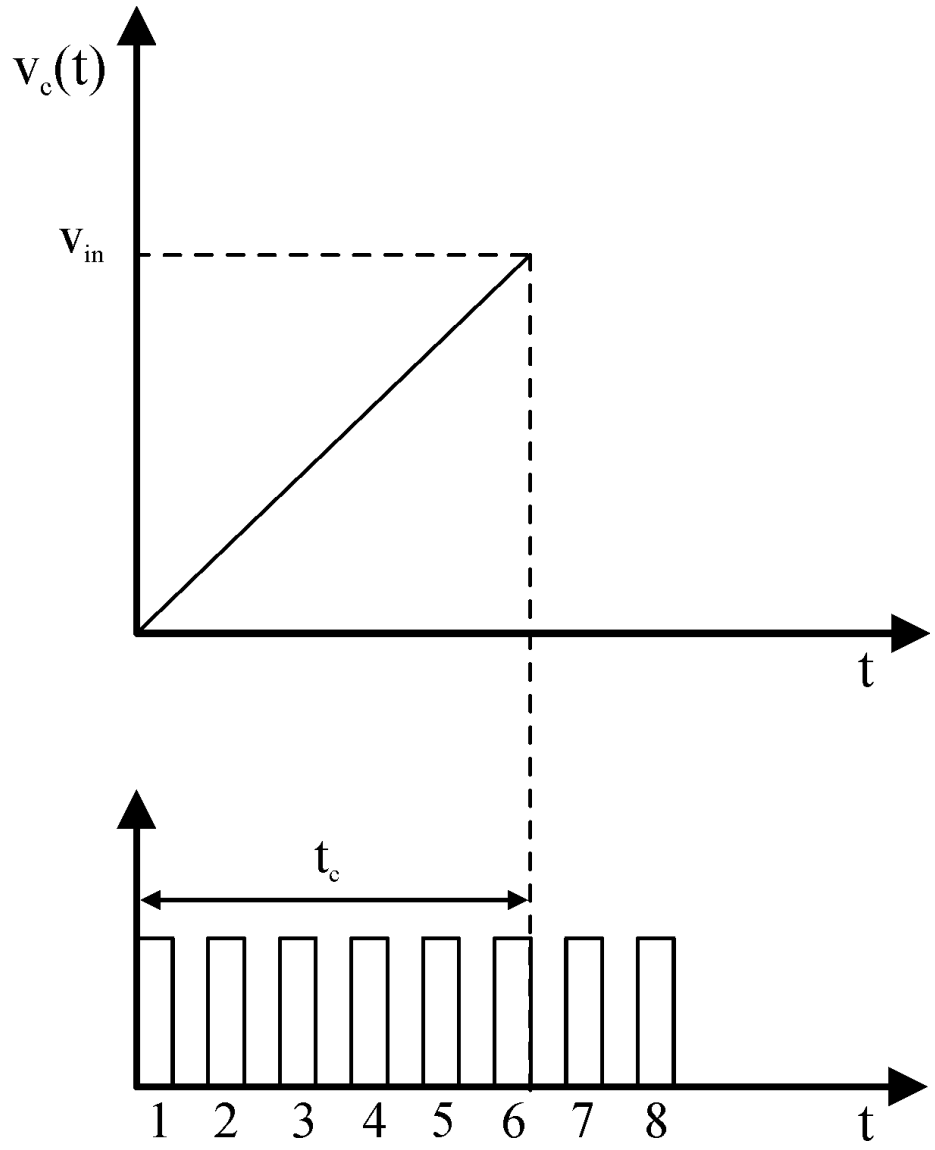
Convertitore Analogico Digitale (A/D o DAC)

Errore di quantizzazione $Q_e = v_{in} - D\frac{V_{REF}}{2^N} = v_{in} - DV_{LSB}$



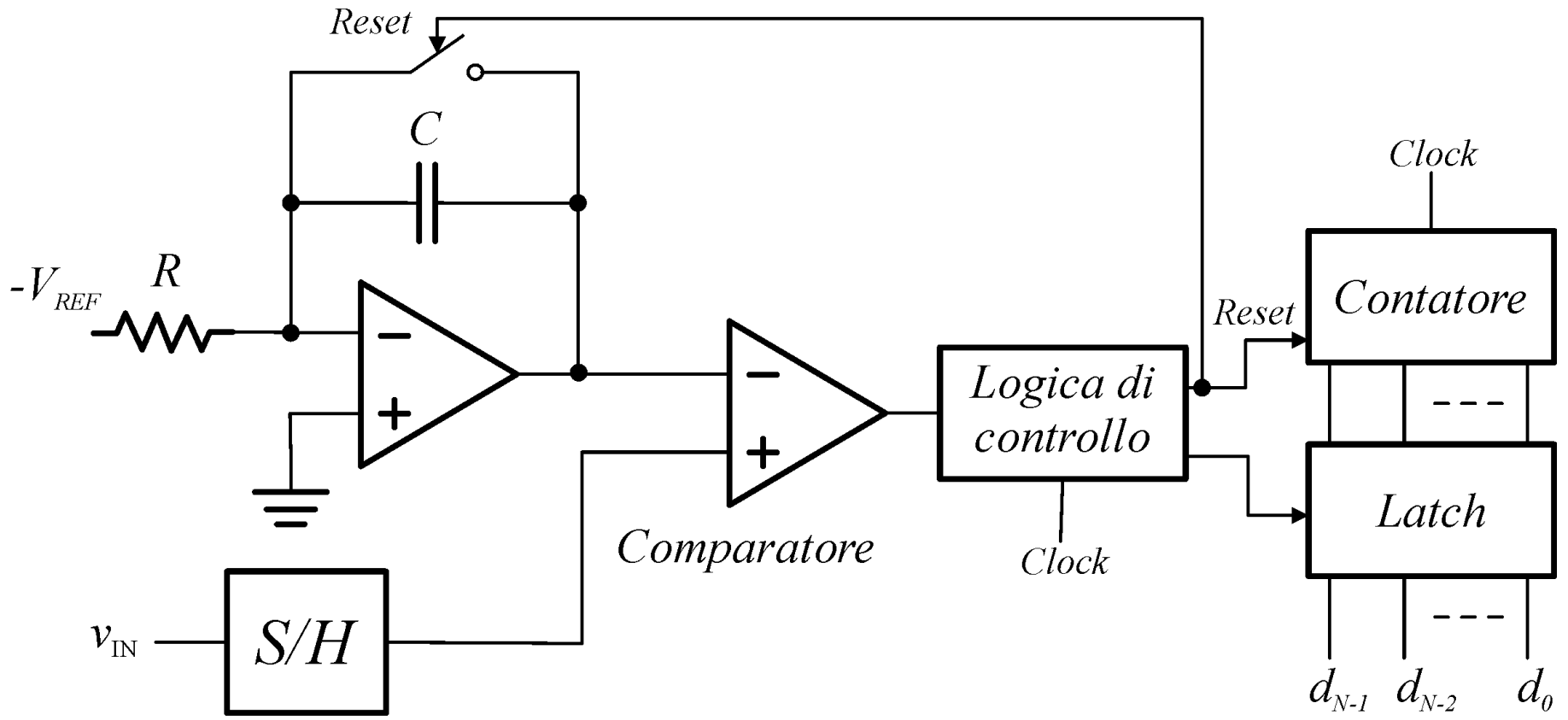


Convertitore A/D a singola rampa



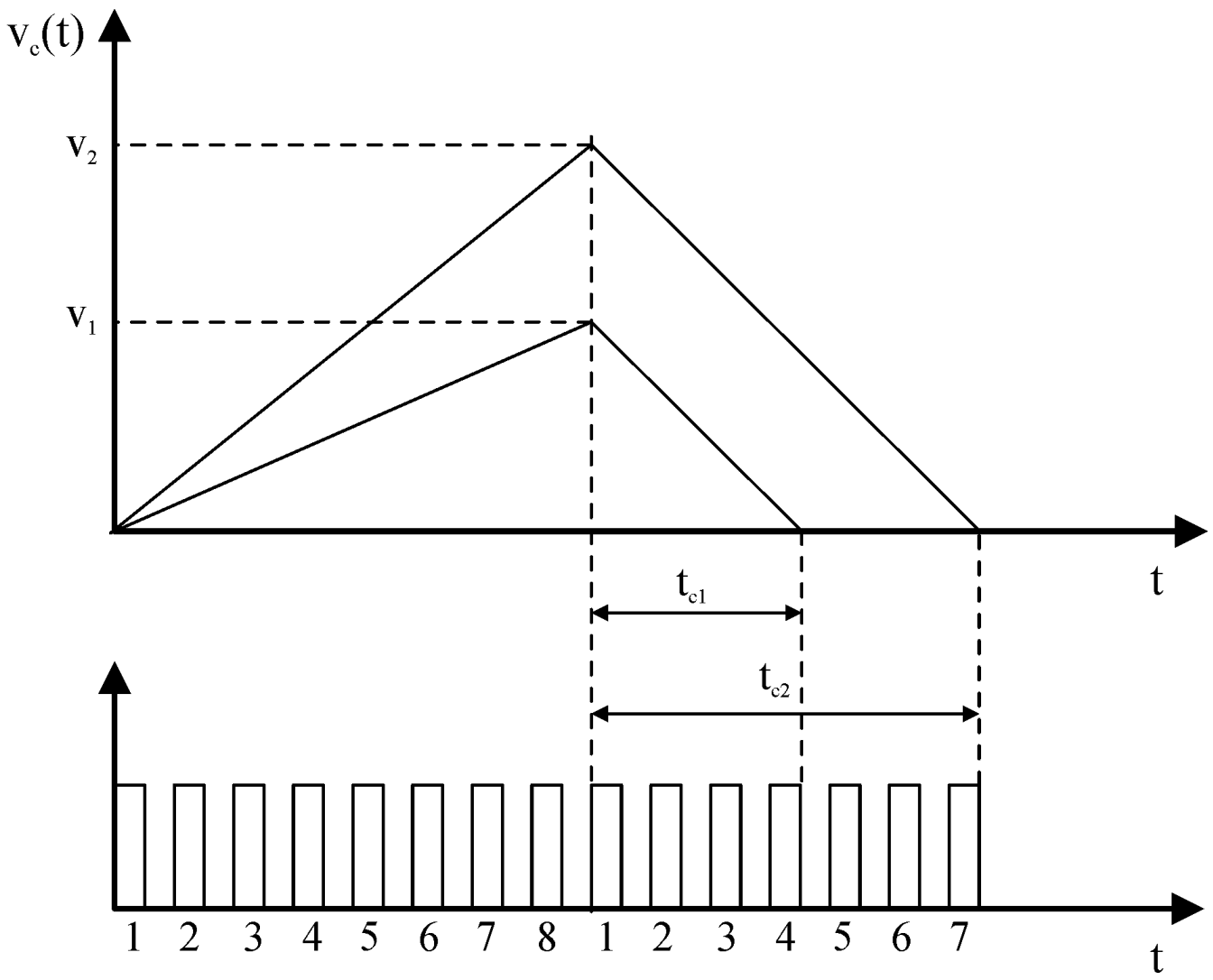
Si integra una tensione nota e costante e si misura quanto tempo occorre per ottenere in uscita dall'integratore una tensione uguale al segnale che si vuole convertire.

Convertitore A/D a singola rampa



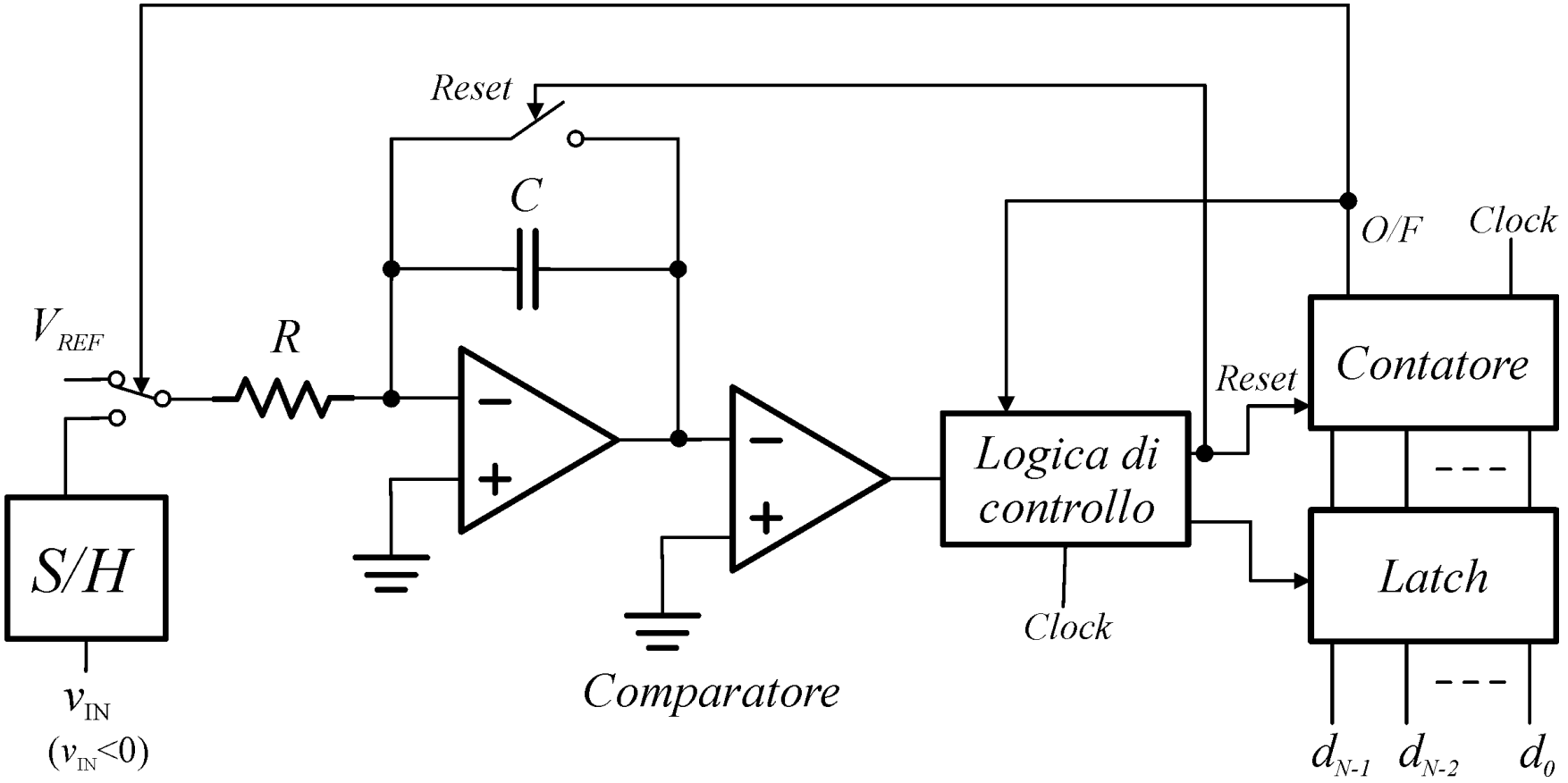
$$v_c = -\frac{1}{RC}\int_0^{t_c}\left(-V_{REF}\right)d\tau = \frac{V_{REF}}{RC}t_c = v_{IN} \quad \Rightarrow \quad t_c = DT_{ck} = v_{IN}\frac{RC}{V_{REF}} \quad \Rightarrow \quad \boxed{D = v_{IN}\frac{RC}{V_{REF}}\frac{1}{T_{ck}}}$$

Convertitore A/D a doppia rampa

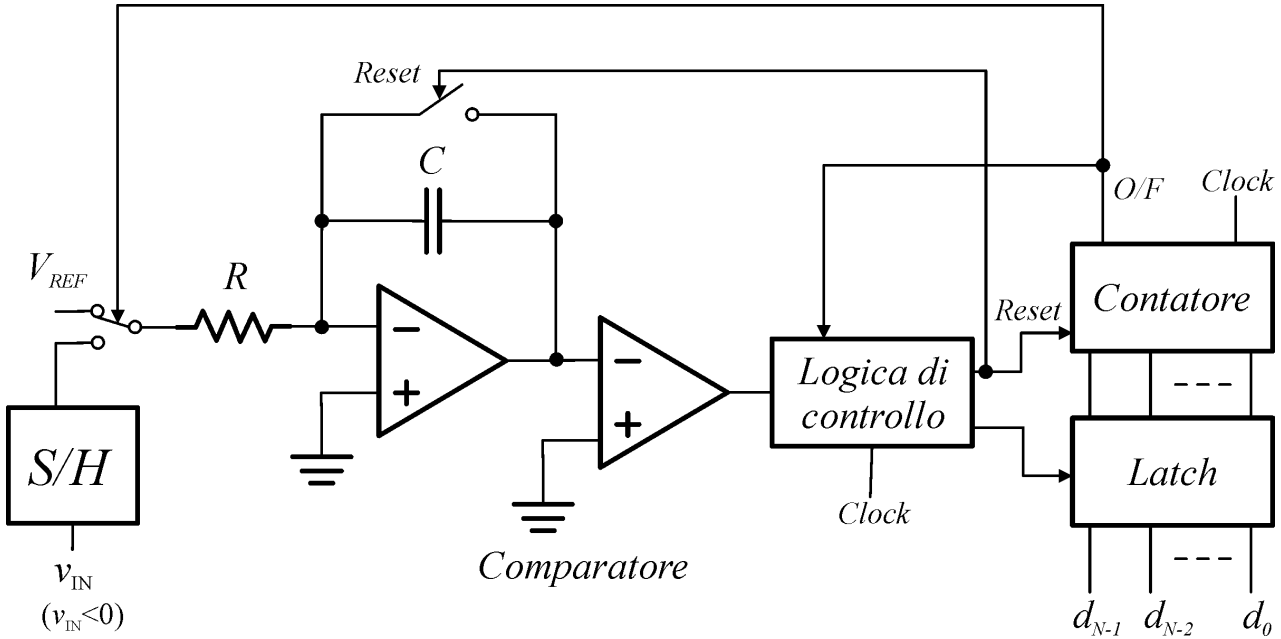


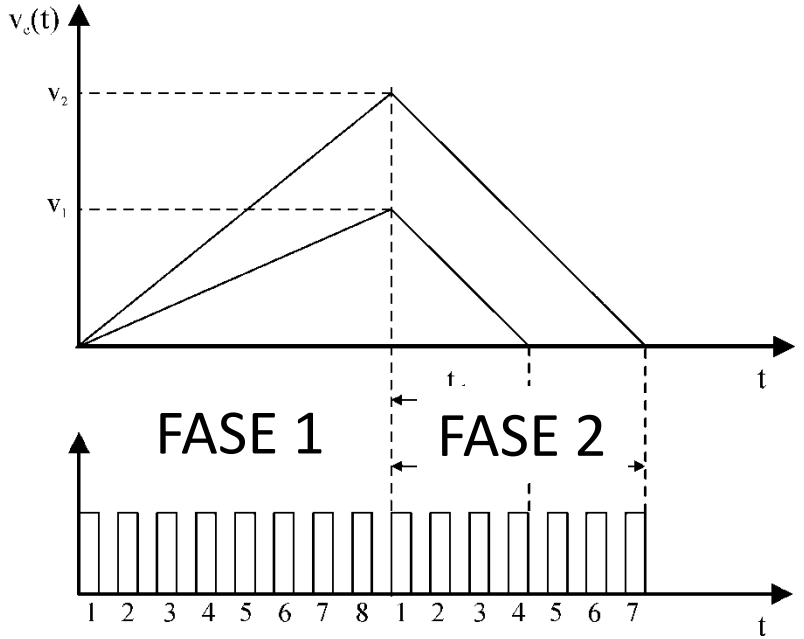
Nel convertitore a doppia rampa vengono fatte due integrazioni.
Nella prima integrazione, si parte da zero e si integra la tensione di ingresso v_{IN} per un periodo di tempo pari al fondoscala del contatore, ovvero 2^N cicli di clock.
Nella fase successiva, si integra una tensione costante V_{REF} di segno opposto alla tensione v_{IN} per un intervallo di tempo necessario per far ritornare a zero l'uscita dell'integratore.
Il conteggio eseguito nella seconda fase viene preso come risultato della conversione.

Convertitore A/D a doppia rampa



Convertitore A/D a doppia rampa





FASE 1 $$v_c = \frac{|v_{IN}|}{RC} 2^N T_{ck}$$

FASE 2 $$v_c = \frac{|v_{IN}|}{RC} 2^N T_{ck} - \frac{1}{RC} V_{REF} D T_{ck} = 0$$

$$D = \frac{|v_{IN}|}{RC} \frac{2^N T_{ck}}{V_{REF} T_{ck}} RC$$

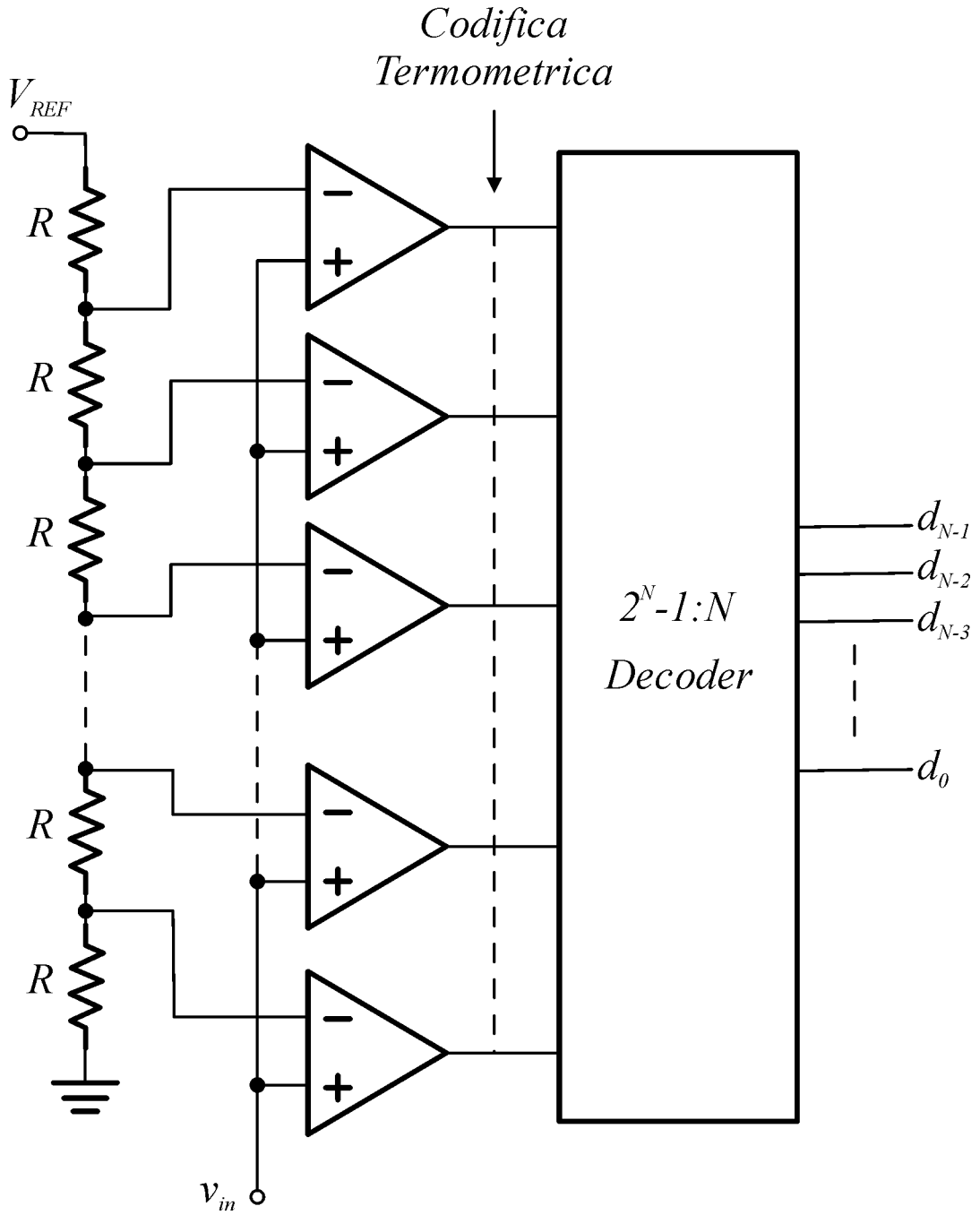
$$D = |v_{IN}| \frac{2^N}{V_{REF}}$$

Convertitore A/D flash

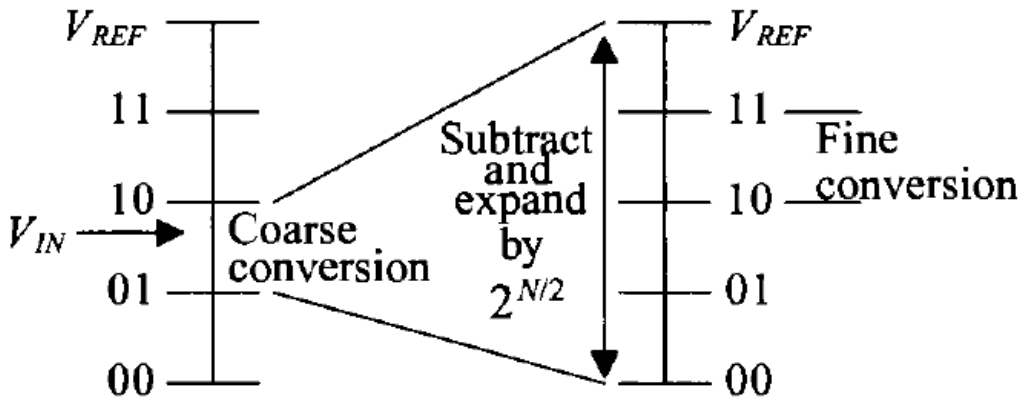
N Bit

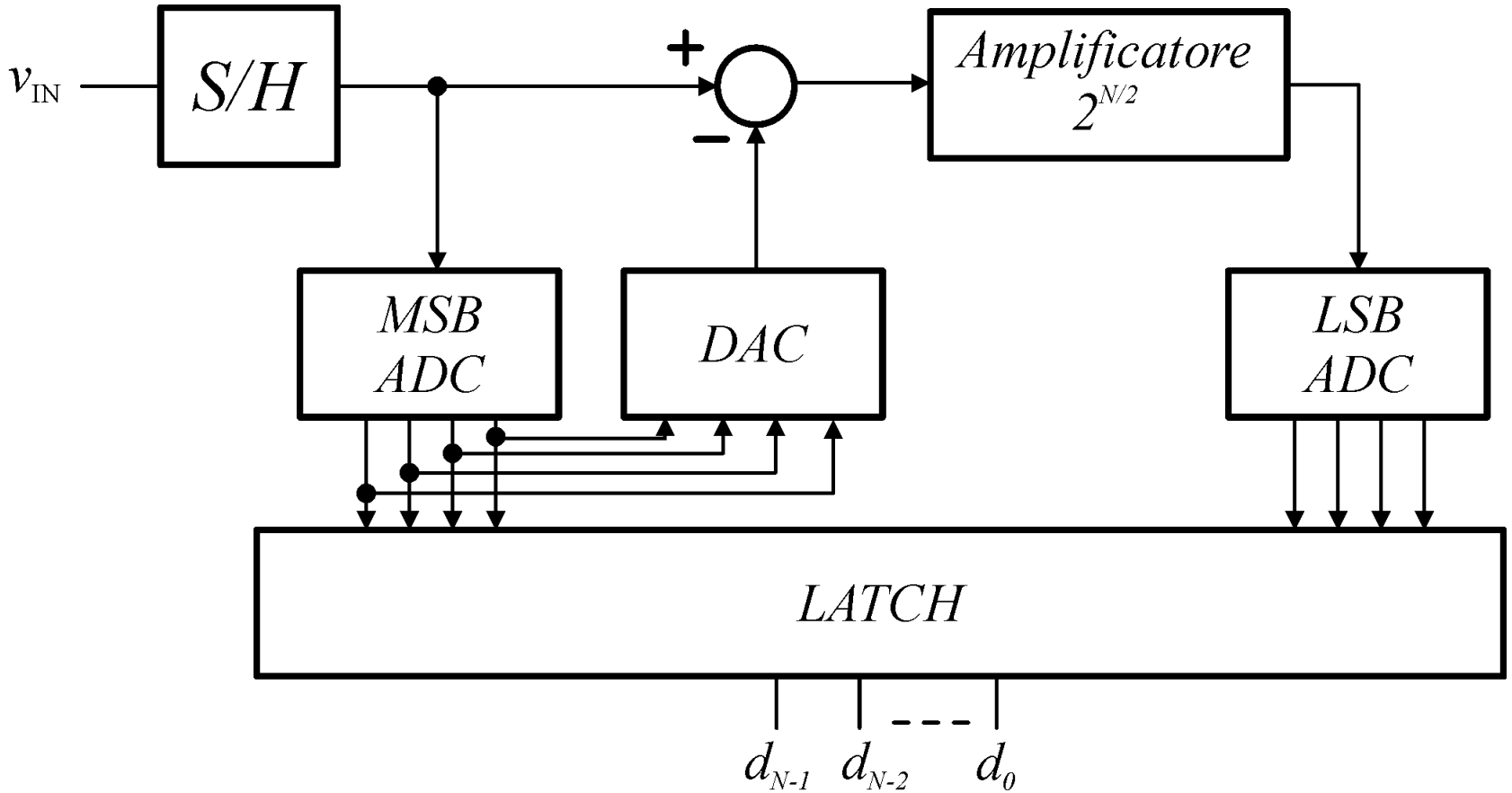
2^N Resistenze

$\left(2^N - 1\right)$ Comparatori

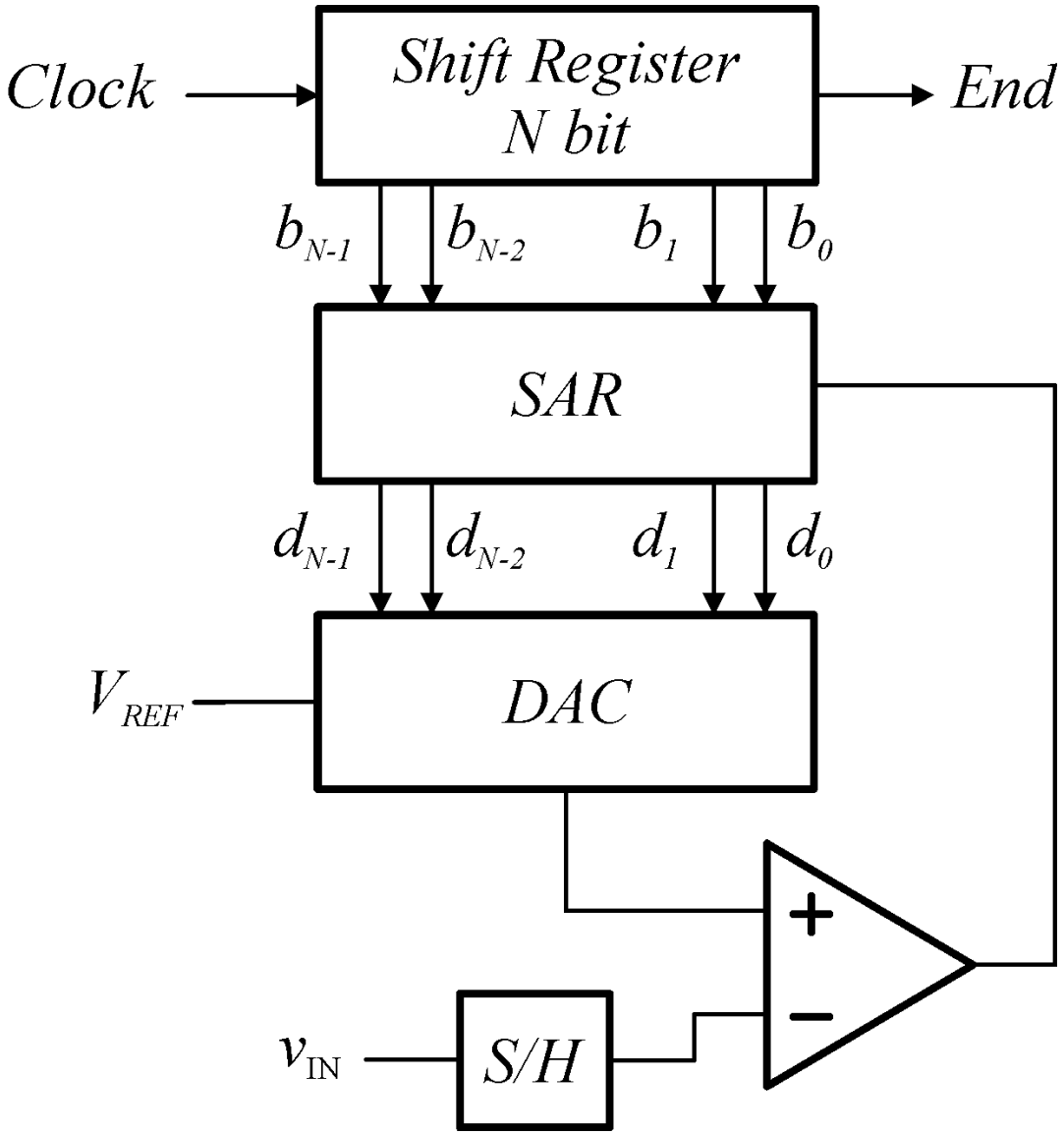


Convertitore A/D flash





Convertitore A/D ad approssimazioni successive (SAR)



Convertitore A/D ad approssimazioni successive (SAR)