Chapter 8

Digital and Analog Interfacing Methods

Lesson 11 Part d

Interface for generating Analog Outputs using Pulse Width Modulation

Pulse width modulation

1. A Pulse width modulated output obtained using a digital number x.
2. A analog output is obtained by integrating the Pulse width modulated pulses.
3. Pulse frequency is proportional to clock input frequency to a n-bit pulse accumulator
4. Pulse-width of modulated pulse is proportional to value $(2^n - x)$ when x is loaded into a modulation register.

Pulse width modulation

5. The analog output is proportional to value x loaded into PWM register.
6. The number x generates output as if it is obtained by a DAC function.
7. Modulation % = Period for pulse width is '1' divided by Total period of pulse at 1 and at 0 multiplied by 100.

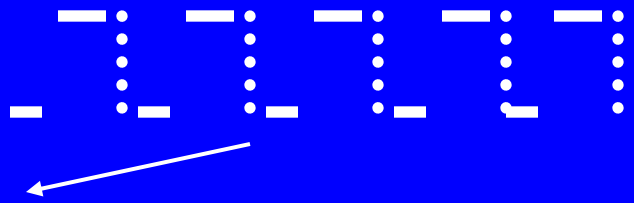
PWM output

- x = digital number in an n-bit PWM register
- PWM output bit = 1 for period T1
- PWM output bit = 0 for period T2
- T1 α $(2^n - x)$;
- T2 α (x);
- $(T1 + T2)$ α (2^n),where
- V Output of integrator α k.(T1)/ (T1+T2)
- k is integration constant

8-bit PWM example

- When x in PWM register = all 0s = 00000000 (=0d). Let pulse-width T1= 0 ms, and T1+T2 = 256 ×5 μs = 1.28 ms
- x= 10000000 (= 128d) generate output width T1 = 0.64 ms, when register count-input pulse periods equal (0.64/128) ms = 5 μs
- x = 11111111 (= 255d) generate width T1 = 1.275 ms.

n-bit PWM example



Count inputs

PWM output

Pulse Accumulator Register

PWM register

Compare

Load Digital Input bits = x

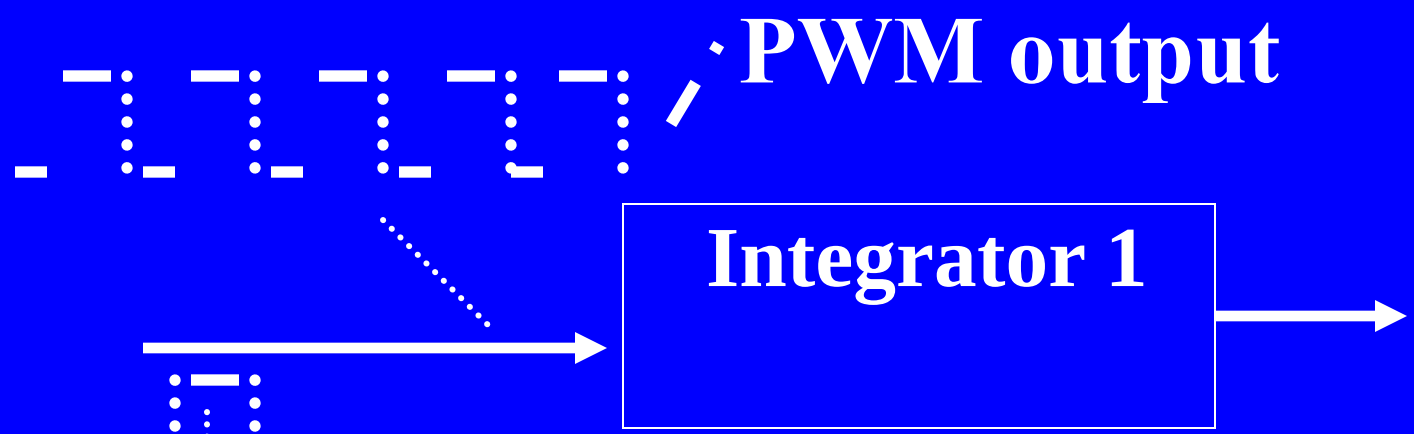
T2

T1

Integrator

Pulse output width T1 α $(2^n - x)$

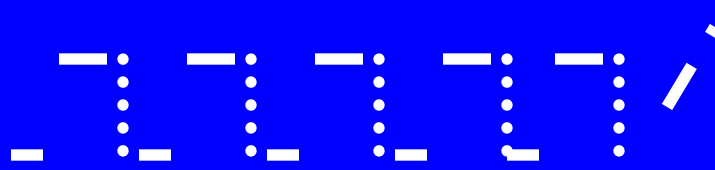
(V output) α $(2^n - x)$



Analog output V $\alpha + (2^n - x)$

Integrator Output

T2 T1



PWM output

Integrator 2

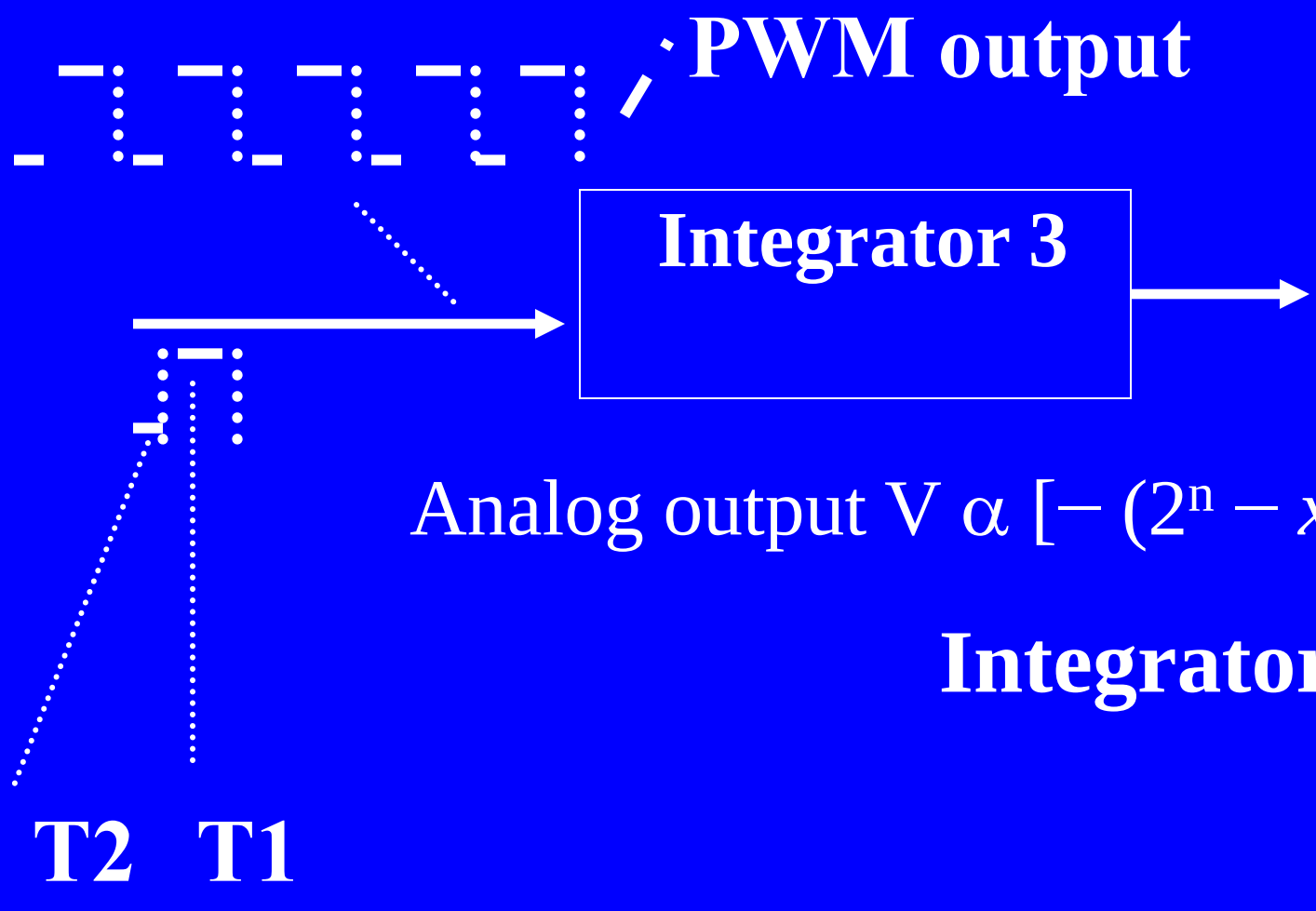
Integrator Output

Analog output V α

$[-(2^n - 1) + (2^n - x)]$

Negative or Positive

T2 T1


PWM output
Integrator 3
Analog output V α [– (2n – x)]
Integrator Output
T2 T1

Summary

We learnt

- Analog Outputs is obtained after integration of pulse width modulated output
- Pulse width of the modulated pulses is proportional to value loaded in pulse width modulation register
- Pulse frequency is proportional to clock input frequency to pulse accumulator
- Integrator can be designed such that + or − or both − and _+ analog outputs obtained as a function of x between 0% and 100%.

End of Lesson 11 Part d

Interface for generating Analog Outputs