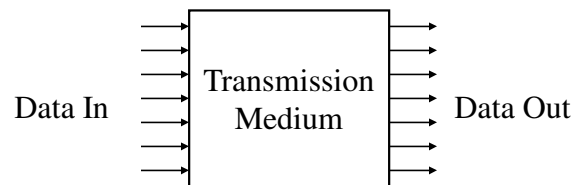
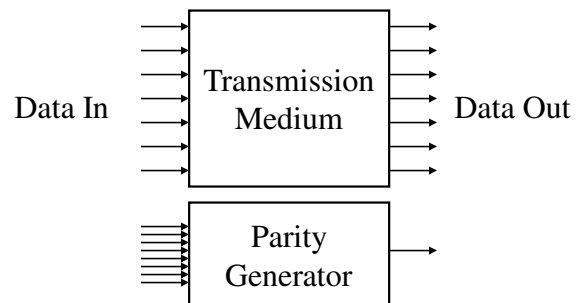


Error Detection with Parity



Error Detection with Parity



Error Correcting Code – by Design

Start with Bit Position = Column Number

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

Error Correcting Code – by Design

Start with Bit Position = Column Number

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1


Error Correcting Code – by Design

Start with Bit Position = Column Number

$D_{10} D_9 D_8 D_7 D_6 D_5 D_4 P_3 D_3 D_2 D_1 P_2 D_0 P_1 P_0$																
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	0
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0

Function → $D_{10} D_9 D_8 D_7 D_6 D_5 D_4 P_3 D_3 D_2 D_1 P_2 D_0 P_1 P_0$

Column Number → 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

Column Number in Binary		1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	
		1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
		1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
		1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Four Bit Column Identifier? Then
build four parity sets

	D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Parity set 0:	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
all columns	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
where LSB of	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
column number	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
is '1'															
	Columns 15, 13, 11, 9, 7, 5, 3, 1														

Four Bit Column Identifier? Then
build four parity sets

	D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Parity set 1:	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
all columns	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
where second	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
bit of	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
column number															
is '1'															
	Columns 15, 14, 11, 10, 7, 6, 3, 2														

Four Bit Column Identifier? Then
build four parity sets

	D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀
Parity set 2:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
all columns	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
where third	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
bit of	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
column number	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
is '1'															

Columns 15, 14, 13, 12, 7, 6, 5, 4

Four Bit Column Identifier? Then
build four parity sets

	D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀
Parity set 3:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
all columns	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
where fourth	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
bit of	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
column number	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
is '1'															

Columns 15, 14, 13, 12, 11, 10, 9, 8

Finally – Add Parity Across Entire Data Set

		D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀
Parity set PT:		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
all columns with data or parity bits	→	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
		1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
		1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
		1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

Columns 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1

SECDED Coding Scheme

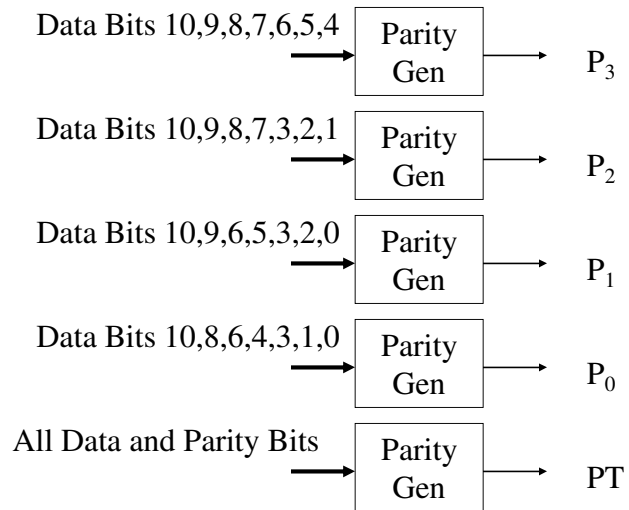
PT – parity across whole word

Pk – parity bits on set basis (any Pk nonzero = error)

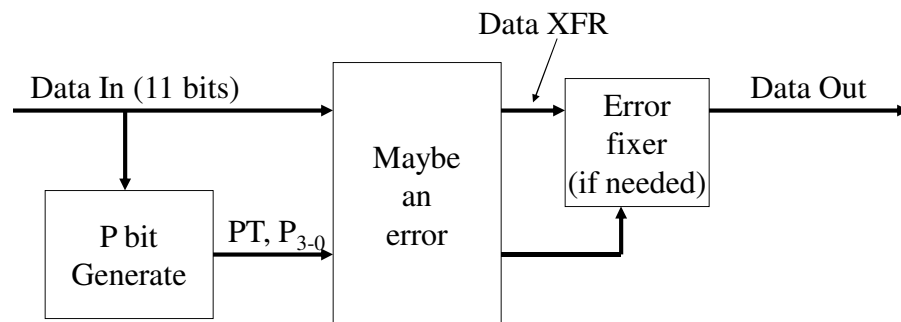
PT	PK	Situation

Good	Good	No error – accept data as passed
Good	Bad	Two bits in error
Bad	Good	PT in error
Bad	Bad	Single bit error – corrected (Error in column P ₃ P ₂ P ₁ P ₀)

To Create Parity Bits for Scheme



Test System



Start point: set up correct
values in parity bits, data bits

0	0	1	0	1	0	1	0	0	1	0	1	1	0	0	1
PT	D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

For demonstration: make one bit wrong

0	0	1	0	1	0	⁰ 1	0	0	1	0	1	1	0	0	1
PT	D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

Check Parity zero for correctness

0	0	1	0	1	0	1 ⁰	0	0	1	0	1	1	0	0	1	
PT	D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀	
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
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Check Parity two for correctness

0	0	1	0	1	0	1 ⁰	0	0	1	0	1	1	0	0	1
PT	D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
P _T	P ₃	P ₂	P ₁	P ₀											
		0	1	0											

Check Parity three for correctness

0	0	1	0	1	0	1 ⁰	0	0	1	0	1	1	0	0	1
PT	D ₁₀	D ₉	D ₈	D ₇	D ₆	D ₅	D ₄	P ₃	D ₃	D ₂	D ₁	P ₂	D ₀	P ₁	P ₀
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
P _T	P ₃	P ₂	P ₁	P ₀											
		1	0	1	0										

Check Parity - Total for correctness

⁰
 PT 0 1 0 1 0 0 0 1 0 1 1 0 0 1
 D₁₀D₉ D₈ D₇ D₆ D₅ D₄ P₃ D₃ D₂ D₁ P₂ D₀ P₁ P₀

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

P_T P₃ P₂ P₁ P₀
 1 1 0 1 0