**Problem**

Design a 3-bit binary up/down counter. The counting mode is determined by an external input x.

If x=0 it counts up else it counts down.

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| |  |  |  |  |  | | --- | --- | --- | --- | --- | | Present | Next | ff’s | | | | x QA QB QC | QA QB QC | DA | DB | DC | | 0 0 0 0 | 0 0 1 | 0 | 0 | 1 | | 1 0 0 0 | 1 1 1 | 1 | 1 | 1 | | 0 0 0 1 | 0 1 0 | 0 | 1 | 0 | | 1 0 0 1 | 0 0 0 | 0 | 0 | 0 | | 0 0 1 0 | 0 1 1 | 1 | 1 | 1 | | 1 0 1 0 | 0 0 1 | 0 | 0 | 1 | | 0 0 1 1 | 1 0 0 | 1 | 0 | 0 | | 1 0 1 1 | 0 1 0 | 1 | 1 | 0 | | 0 1 0 0 | 1 0 1 | 1 | 0 | 1 | | 1 1 0 0 | 0 1 1 | 0 | 1 | 1 | | 0 1 0 1 | 1 1 0 | 1 | 1 | 0 | | 1 1 0 1 | 1 0 0 | 1 | 0 | 0 | | 0 1 1 0 | 1 1 1 | 1 | 1 | 1 | | 1 1 1 0 | 1 0 1 | 1 | 0 | 1 | | 0 1 1 1 | 0 0 0 | 0 | 0 | 0 | | 1 1 1 1 | 1 1 0 | 1 | 1 | 0 | | Use Karnaugh maps to minimize the functions for DA , DB and DC .  The final expressions are:  DA = x Q’A Q’B Q’C + x’ Q’A QB QC + x’ QA Q’B +  x QA QC + QA QB Q’C  DB = xQ’B Q’C + x’ Q’B QC + xQB QC + x’ QB Q’C  DC = Q’B Q’C + QA QB Q’C + Q’A Q’C |