Symbolic Procedure

Using algebraic manipulations obtain a logic diagram consisting of only nand-gates for each of the following Boolean expressions:

1. $f(w,x,y,z) = \overline{y} + w\overline{x} + \overline{w}x\overline{z}$

$$= \overline{\overline{\overline{y} + w\overline{x} + \overline{w}x\overline{z}}}$$
$$= \overline{y \cdot \overline{w\overline{x}} \cdot \overline{\overline{w}x\overline{z}}}$$
$$= NAND\left(y, \overline{w\overline{x}}, \overline{\overline{w}x\overline{z}}\right)$$
$$= NAND(y, NAND(w, \overline{x}), NAND(\overline{w}, x, \overline{z})$$

1. $f(w,x,y,z) = (w+y)(\overline{x}+\overline{z})(\overline{w}+\overline{x}+\overline{y})$

$$= NAND\left(1, \overline{(w+y)(\overline{x}+\overline{z})(\overline{w}+\overline{x}+\overline{y})}\right)$$
$$= NAND\left(1, NAND\big((w+y), (\overline{x}+\overline{z}), (\overline{w}+\overline{x}+\overline{y})\big)\right)$$
$$= NAND\left(1, NAND\left(\overline{\overline{w+y}}, \overline{\overline{\overline{x}+\overline{z}}}, \overline{\overline{\overline{w}+\overline{x}+\overline{y}}}\right)\right)$$
$$= NAND\left(1, NAND\left(\overline{\overline{w}\cdot\overline{y}}, \overline{x\cdot z}, \overline{w\cdot x\cdot y}\right)\right)$$
$$= NAND\left(1, NAND\big(NAND(\overline{w}, \overline{y}), NAND(x,z), NAND(w,x,y)\big)\right)$$

NAND Gate Realizations

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Graphical Procedure

Convert the following Boolean expressions into logic diagrams and using the graphical procedures, convert the logic diagram into a logic diagram consisting of only nand-gates.

1. $f(w,x,y,z) = \overline{w}(x\overline{y} + \overline{x}y) + z(x+y)$

$$= \overline{\overline{\overline{w}(x\overline{y} + \overline{x}y) + z(x+y)}}$$
$$= \overline{\overline{\overline{w}(x\overline{y} + \overline{x}y)} \cdot \overline{z(x+y)}} = NAND(\overline{\overline{w}(x\overline{y} + \overline{x}y)}, \overline{z(x+y)})$$
$$= NAND(NAND(\overline{w}, (x\overline{y} + \overline{x}y)), NAND(z, x+y))$$
$$= NAND(NAND(\overline{w}, \left(\overline{\overline{x\overline{y} + \overline{x}y}}\right)), NAND(z, \overline{\overline{x+y}}))$$
$$= NAND(NAND(\overline{w}, \left(\overline{x\overline{y} \cdot \overline{x}y}\right)), NAND(z, \overline{\overline{x} \cdot \overline{y}}))$$
$$= NAND\left(NAND\left(\overline{w}, NAND\left(\overline{x\overline{y}}, \overline{\overline{x}y}\right)\right), NAND\left(z, NAND(\overline{x}, \overline{y})\right)\right)$$
$$= NAND\left(NAND\left(\overline{w}, NAND(NAND(x, \overline{y}), NAND(\overline{x}, y))\right), NAND\left(z, NAND(\overline{x}, \overline{y})\right)\right)$$

2. $f(w,x,y,z) = (\overline{x} + y\overline{z})[w + (y+z)(\overline{y} + \overline{z})]$

$$= \text{NAND}(1, \overline{(\overline{x} + y\overline{z})[w + (y+z)(\overline{y} + \overline{z})]})$$
$$= NAND\left(1, NAND\left((\overline{x} + y\overline{z}), [w + (y+z)(\overline{y} + \overline{z})]\right)\right)$$
$$= NAND\left(1, NAND\left(\overline{\overline{x} + y\overline{z}}, \overline{[w + (y+z)(\overline{y} + \overline{z})]}\right)\right)$$
$$= NAND\left(1, NAND\left(\overline{x \cdot \overline{y}\,\overline{z}}, \overline{\overline{w} \cdot \overline{y+z} \cdot \overline{\overline{y} + \overline{z}}}\right)\right)$$
$$= NAND\left(1, NAND\left(NAND\left(x, \overline{y\overline{z}}\right), NAND(\overline{w}, \overline{y+z}, \overline{\overline{y} + \overline{z}})\right)\right)$$
$$= NAND\left(1, NAND\left(NAND(x, NAND(y, \overline{z})), NAND\left(\overline{w}, NAND\left(1, \overline{\overline{y+z}}\right), NAND\left(1, \overline{\overline{y} + \overline{z}}\right)\right)\right)\right)$$
$$= NAND\left(1, NAND\left(NAND(x, NAND(y, \overline{z})), NAND(\overline{w}, NAND(1, \overline{\overline{y} \cdot \overline{z}}), NAND(1, \overline{y \cdot z}))\right)\right)$$
$$= NAND\left(1, NAND(NAND(x, NAND(y, \overline{z}), NAND(\overline{w}, NAND(1, NAND(\overline{y}, \overline{z}), NAND(1, NAND(y, z))))\right)\right)$$