ECS 154A Homework 1

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Fall 2013

1. Determine if the following are equivalent or not.

   (a)

   $$WX\overline{Y} + WZ + \overline{W}Y + \overline{WX} = (W + \overline{X} + Y)(\overline{W} + X + Z)(\overline{W} + \overline{Y} + Z)$$

   Equivalent

   (b)

   $$\overline{X} + X\overline{Y}Z = (\overline{X} + Z)(W + \overline{X} + \overline{Y})(\overline{W} + \overline{X} + \overline{Y})$$

   Equivalent

   (c)

   $$\overline{W}XYZ + W\overline{X}YZ + WX\overline{Y}Z + WXY\overline{Z} = (W + Y)(\overline{W} + \overline{Y})(\overline{X} + Z)$$

   Not equivalent. Take the case when $W = 1$ and $X = Y = Z = 0$. The LHS is obviously 0, but the RHS is 1.

   (d)

   $$Z(X + \overline{W}) = Z\overline{W} + XYZ$$

   Not equivalent. Take the case when $Y = 1$ and $W = X = Z = 0$. The LHS is 1, but the RHS is 0.

   (e)

   $$W + \overline{W}Z + Y + \overline{XY} = W + \overline{X} + Y + Z$$

   Equivalent.

2. Use algebraic manipulation to find the minimum sum of products expression.

$$\overline{(\overline{X}+Y)(W+Y+Z+\overline{W})}+\overline{X}Z+(W+\overline{Y}Z)(\overline{Y}Z+\overline{W})$$

$$\overline{(\overline{X}+Y)(W+Y+Z+\overline{W})}+\overline{X}Z+(\overline{Y}Z+W)(\overline{Y}Z+\overline{W}) \qquad \text{(Commutativity)}$$

$$\overline{(\overline{X}+Y)(W+Y+Z+\overline{W})}+\overline{X}Z+\overline{Y}Z \qquad \text{(Combining)}$$

$$\overline{(\overline{X}+Y)}+\overline{(W+Y+Z+\overline{W})}+\overline{X}Z+\overline{Y}Z \qquad \text{(De Morgan's)}$$

$$\overline{\overline{X}}\,\overline{Y}+\overline{(W+Y+Z+\overline{W})}+\overline{X}Z+\overline{Y}Z \qquad \text{(De Morgan's)}$$

$$X\overline{Y}+\overline{(W+Y+Z+\overline{W})}+\overline{X}Z+\overline{Y}Z \qquad \text{(Involution)}$$

$$X\overline{Y}+(\overline{W}\;\overline{Y}\;\overline{Z}\;\overline{\overline{W}})+\overline{X}Z+\overline{Y}Z \qquad \text{(De Morgan's)}$$

$$X\overline{Y}+(\overline{W}\;\overline{Y}\;\overline{Z}\;W)+\overline{X}Z+\overline{Y}Z \qquad \text{(Involution)}$$

$$X\overline{Y}+(\overline{Y}\;\overline{Z}W\overline{W})+\overline{X}Z+\overline{Y}Z \qquad \text{(Commutativity)}$$

$$X\overline{Y}+(\overline{Y}\;\overline{Z}\;0)+\overline{X}Z+\overline{Y}Z \qquad \text{(Complementation)}$$

$$X\overline{Y}+0+\overline{X}Z+\overline{Y}Z \qquad \text{(Nilpotent)}$$

$$X\overline{Y}+\overline{X}Z+\overline{Y}Z \qquad \text{(Identity)}$$

3. Use algebraic manipulation to find the minimum product of sums expression.

$$\overline{(\overline{X}Z+\overline{W})(\overline{X}Z+\overline{Y})+\overline{W}X\overline{Y}}$$

$$\overline{(\overline{X}Z+\overline{W})(\overline{X}Z+\overline{Y})}\;\overline{\overline{W}X\overline{Y}} \qquad \text{(De Morgan's)}$$

$$\overline{(\overline{X}Z+\overline{W})(\overline{X}Z+\overline{Y})}\left(\overline{\overline{W}}+\overline{X}+\overline{\overline{Y}}\right) \qquad \text{(De Morgan's)}$$

$$\overline{(\overline{X}Z+\overline{W})(\overline{X}Z+\overline{Y})}\left(W+\overline{X}+\overline{\overline{Y}}\right) \qquad \text{(Involution)}$$

$$\overline{(\overline{X}Z+\overline{W})(\overline{X}Z+\overline{Y})}(W+\overline{X}+Y) \qquad \text{(Involution)}$$

$$\left(\overline{(\overline{X}Z+\overline{W})}+\overline{(\overline{X}Z+\overline{Y})}\right)(W+\overline{X}+Y) \qquad \text{(De Morgan's)}$$

$$\left(\overline{\overline{X}Z}\;\overline{\overline{W}}+\overline{(\overline{X}Z+\overline{Y})}\right)(W+\overline{X}+Y) \qquad \text{(De Morgan's)}$$

$$\left(\overline{\overline{X}Z}\;W+\overline{(\overline{X}Z+\overline{Y})}\right)(W+\overline{X}+Y) \qquad \text{(Involution)}$$

$$\left(\overline{\overline{X}Z}\;W+\overline{\overline{X}Z}\;\overline{\overline{Y}}\right)(W+\overline{X}+Y) \qquad \text{(De Morgan's)}$$

$$\left(\overline{\overline{X}Z}\;W+\overline{\overline{X}Z}\;Y\right)(W+\overline{X}+Y) \qquad \text{(Involution)}$$

$$\left(\overline{\overline{X}Z}(W+Y)\right)(W+\overline{X}+Y) \qquad \text{(Distributivity)}$$

$$(\overline{\overline{X}}+\overline{Z})(W+Y)(W+\overline{X}+Y) \qquad \text{(De Morgan's)}$$

$$(X+\overline{Z})(W+Y)(W+\overline{X}+Y) \qquad \text{(Involution)}$$

$$(X+\overline{Z})(W+Y)(W+Y+\overline{X}) \qquad \text{(Commutativity)}$$

$$(X+\overline{Z})(W+Y) \qquad \text{(Covering)}$$

4. Minimize the circuit.