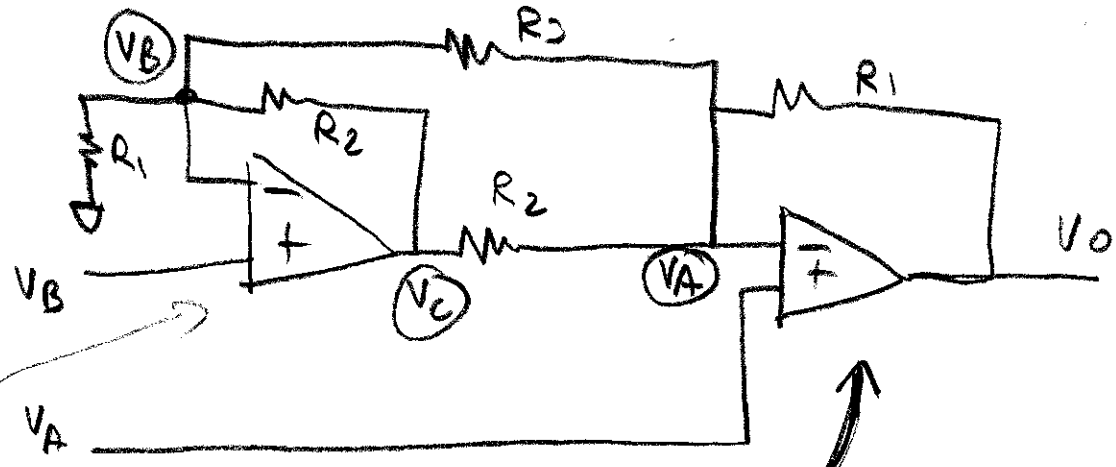
K. KUAN
2-15-93

TWO OP-AMP DIFFERENCE CIRCUIT



$$\frac{V_C - V_A}{R_2} + \frac{V_B - V_A}{R_3} + \frac{V_O - V_A}{R_1} = 0$$

$$\frac{V_A - V_B}{R_3} + \frac{0 - V_B}{R_1} + \frac{V_C - V_B}{R_2} = 0$$

THIS IS THE LONG WAY - BUT IT WORKS

$$R_1R_3V_C - R_1R_3V_A + R_1R_2V_B - R_1R_2V_A + R_2R_3V_O - R_2R_3V_A = 0$$

$$R_1R_2V_A - R_1R_2V_B - R_2R_3V_B + R_1R_3V_C - R_1R_3V_B = 0$$

$$V_O = \left[(R_1R_2 + R_1R_3 + R_2R_3)V_A - R_1R_2V_B - R_1R_3V_C\right]/R_2R_3$$

$$V_C = \left[(R_1R_2 + R_1R_3 + R_2R_3)V_B - R_1R_2V_A\right]/R_1R_3$$

$$V_O = \frac{\left[(R_1R_2 + R_1R_3 + R_2R_3)V_A - R_1R_2V_B - (R_1R_2 + R_1R_3 + R_2R_3)V_B + R_1R_2V_A\right]}{R_2R_3}$$

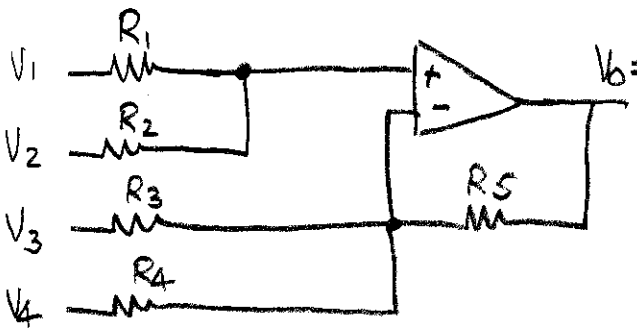
$$V_O = (V_A - V_B)\left[2R_1R_2 + R_1R_3 + R_2R_3\right]/R_2R_3$$

$$\boxed{V_O = (V_A - V_B)\left[1 + \frac{R_1}{R_2} + \frac{2R_1}{R_3}\right]}$$

ANALYSIS/DESIGN PROBLEM

12/31/97
K. KUHN

1. DERIVE THE TRANSFER FUNCTION GIVEN FOR THE FOLLOWING CIRCUIT.



$$V_o = V_1\left(\frac{R_2}{R_1+R_2}\right)\left(1+\frac{R_5}{R_3 \| R_4}\right) + V_2\left(\frac{R_1}{R_1+R_2}\right)\left(1+\frac{R_5}{R_3 \| R_4}\right) - V_3\frac{R_5}{R_3} - V_4\frac{R_5}{R_4}$$

2. DETERMINE A SET OF RESISTORS TO IMPLEMENT THE FOLLOWING TRANSFER FUNCTION:

$$V_o = 2.85V_1 + 2.19V_2 - 2.40V_3 - 1.64V_4$$

DERIVE THE DESIGN EQUATIONS FOR THIS CIRCUIT. USE RATIOS TO ELIMINATE UNNECCESARY VARIABLES. I.E.

CHOOSE R_1, THEN $R_2 = K_1 R_1$
CHOOSE R_3, THEN $R_4 = K_2 R_3$
} WHY DOES THIS PARTICULAR CHOICE SIMPLIFY THINGS?

ALSO, REPRESENT THE TRANSFER FUNCTION AS

$$V_o = G_1V_1 + G_2V_2 - G_3V_3 - G_4V_4$$

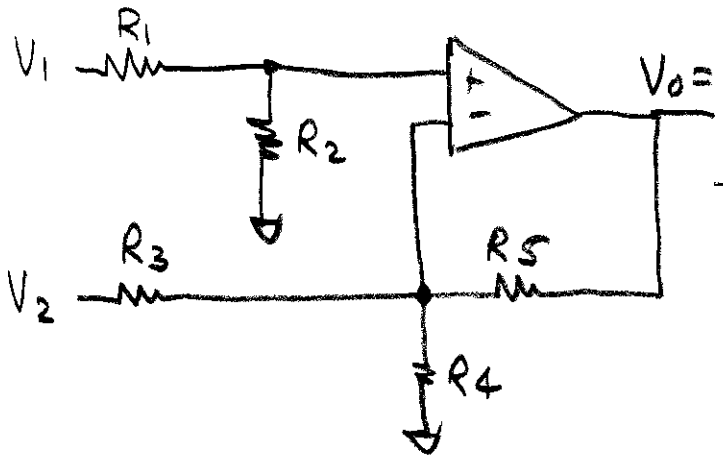
NOW THE TRANSFER EQUATION CAN BE SOLVED FOR K_1, K_2, AND R_5. FROM K_1 AND K_2 WE OBTAIN R_2 AND R_4.

ONE SOLUTION:
$R_1 = 10K$, $R_2 = 13K$ $R_3 = 15K$ $R_4 = 22K$ $R_5 = 36K$

GENERAL DIFFERENCE CIRCUIT

12 3 97
K. KUHN

DERIVE THE TRANSFER FUNCTION GIVEN FOR THE FOLLOWING CIRCUIT.



$$V_o = V_1\left(\frac{R_2}{R_1+R_2}\right)\left(1+\frac{R_5}{R_3 \| R_4}\right) - V_2\frac{R_5}{R_3}$$

DERIVE THE DESIGN EQUATIONS FOR THIS CIRCUIT GIVEN: $V_o = G_1 V_2 - G_2 V_2$, FIND R_1, R_2, R_3, R_4, R_5

NOTE: DEPENDING ON VALUES FOR G_1 & G_2 IT IS POSSIBLE FOR EITHER R_2 OR R_4 TO BE INFINITE (I.E. NOT NEEDED).

USE $R_1 = R_3 = 10K$ AND DETERMINE R_2, R_4, R_5 FOR

$V_o = 10V_1 - V_2$

$V_o = 5V_1 - 2V_2$

$V_o = 3V_1 - 3V_2$

$V_o = 2V_1 - 5V_2$

$V_o = V_1 - 10V_2$

CHECK EACH RESULT BY SUBSTITUTING INTO THE GENERAL TRANSFER FUNCTION ABOVE.