I. NORMAL

B. Output Equations

$$c_4 = 0.5(c_{45} + c_{46})$$
(1)

$$c_5 = 0.5(c_{45} + c_{57})$$
(2)

$$c_6 = 0.5(c_{69} + c_{46})$$
(3)

$$c_7 = 0.5(c_{57} + c_{78})$$
(4)

$$c_8 = 0.5(c_{78} + c_{89})$$
(5)

$$c_9 = 0.5(c_{69} + c_{89})$$
(6)

A. State Equations

$$y_1 = v_4 \qquad (1)$$

$$y_2 = i_{41} \qquad (2)$$

$$y_3 = i_{45} + \frac{c_{45}}{2c_4} \left(-i_{41} - i_{45} - i_{46} \right) \qquad (3)$$

$$y_4 = i_{46} + \frac{c_{46}}{2c_4} \left(-i_{41} - i_{45} - i_{46} \right) \qquad (4)$$

$$c_4 v_4' = -i_{41} - i_{45} - i_{46} \qquad (1)$$

$$c_5 v_5' = -i_{5A} + i_{75} + i_{45} \qquad (2)$$

$$c_6 v_6' = -i_{6B} + i_{96} + i_{46} \qquad (3)$$

$$c_7 v_7' = -i_{72} - i_{78} - i_{75} \qquad (4)$$

$$c_8 v_8' = -i_{8C} + i_{78} + i_{98} \qquad (5)$$

$$c_9 v_9' = -i_{93} - i_{98} - i_{96} \qquad (6)$$

$$D_4 i_{5A}' = v_5 - R_A i_{5A} \qquad (7)$$

$$D_6 i_{6B}' = v_6 - R_B i_{6B} \qquad (8)$$

$$D_1 i_{41}' = v_4 - e_1 \qquad (10)$$

$$D_4 i_{41}' = v_4 - e_1 \qquad (10)$$

$$D_4 i_{41}' = v_4 - e_1 \qquad (10)$$

$$D_4 i_{40}' = v_4 - v_5 - R_4 i_{45} \qquad (11)$$

$$D_4 i_{40}' = v_4 - v_5 - R_5 i_{75} \qquad (14)$$

$$D_5 i_{75}' = v_7 - v_5 - R_5 i_{75} \qquad (14)$$

$$D_7 i_{75}' = v_7 - v_8 - R_7 i_{78} \qquad (15)$$

$$D_8 i_{96}' = v_9 - v_6 - R_8 i_{96} \qquad (17)$$

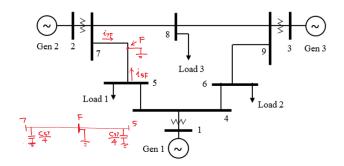
(17)

(18)

 $L_{89}i_{98}' = v_9 - v_8 - R_{89}i_{98}$

II. LINE 5-7 MIDPOINT SHORT TO GROUND

B. Output Equations



$$c_4 = 0.5(c_{45} + c_{46}) (13)$$

$$c_5 = 0.5c_{45} + \frac{0.25c_{57}}{} \tag{14}$$

$$c_6 = 0.5(c_{69} + c_{46}) (15)$$

$$c_7 = 0.25c_{57} + 0.5c_{78} \tag{16}$$

$$c_8 = 0.5(c_{78} + c_{89}) (17)$$

$$c_9 = 0.5(c_{69} + c_{89}) (18)$$

A. State Equations

$$c_4 v_4' = -i_{41} - i_{45} - i_{46} \tag{1}$$

$$c_5 v_5' = -i_{5A} - i_{5F} + i_{45} \tag{2}$$

$$c_6 v_6' = -i_{6B} + i_{96} + i_{46} \tag{3}$$

$$c_6 v_6 = -\iota_{6B} + \iota_{96} + \iota_{46} \tag{5}$$

$$c_7 v_7' = -i_{72} - i_{78} - i_{7F} \tag{4}$$

$$c_8 v_8' = -i_{8C} + i_{78} + i_{98} \tag{5}$$

$$c_9 v_9' = -i_{93} - i_{98} - i_{96} \tag{6}$$

$$L_A i'_{5A} = v_5 - R_A i_{5A} \tag{7}$$

$$L_B i'_{6B} = v_6 - R_B i_{6B} \tag{8}$$

$$L_C i_{8C}' = v_8 - R_C i_{8C} (9)$$

$$L_1 i_{41}' = v_4 - e_1 \tag{10}$$

$$L_{45}i_{45}' = v_4 - v_5 - R_{45}i_{45} \tag{11}$$

$$L_{46}i_{46}' = v_4 - v_6 - R_{46}i_{46} \tag{12}$$

$$L_2 i_{72}' = v_7 - e_2 \tag{13}$$

$$0.5L_{57}i_{7F}' = v_7 - 0.5R_{57}i_{7F} \tag{14}$$

$$L_{78}i_{78}' = v_7 - v_8 - R_{78}i_{78} \tag{15}$$

$$L_{78}i_{78} = v_7 - v_8 - Iv_78i_{78}$$
 (15)
 $L_3i'_{93} = v_9 - e_3$ (16)

(16)

$$L_{69}i'_{69} = v_9 - v_6 - R_{69}i_{69} \tag{17}$$

$$L_{89}i_{98}' = v_9 - v_8 - R_{89}i_{98} \tag{18}$$

$$0.5L_{57}i'_{5F} = v_5 - 0.5R_{57}i_{5F} \tag{19}$$

$$y_1 = v_4 \tag{1}$$

$$y_2 = i_{41}$$
 (2)

$$y_3 = i_{45} + \frac{c_{45}}{2c_4} (-i_{41} - i_{45} - i_{46}) \tag{3}$$

$$y_4 = i_{46} + \frac{c_{46}}{2c_4}(-i_{41} - i_{45} - i_{46}) \tag{4}$$

$$y_5 = v_7 \tag{5}$$

$$y_6 = \frac{i_{7F}}{4c_7} + \frac{c_{57}}{4c_7} (-i_{72} - i_{7F} - i_{78})$$
 (6)

$$y_7 = i_{72}$$
 (7)

$$y_8 = i_{78} + \frac{c_{78}}{2c_7} (-i_{72} - i_{7F} - i_{78})$$
 (8)

$$y_9 = v_9 \tag{9}$$

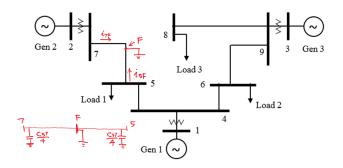
$$y_{10} = i_{96} + \frac{c_{69}}{2c_9} (-i_{93} - i_{96} - i_{98})$$
 (10)

$$y_{11} = i_{98} + \frac{c_{89}}{2c_9} \left(-i_{93} - i_{96} - i_{98} \right) \tag{11}$$

$$y_{12} = i_{93} (12)$$

III. LINE 5-7 MIDPOINT SHORT TO GROUND, Line 7-8 Removed

B. Output Equations



$$c_4 = 0.5(c_{45} + c_{46}) (13)$$

$$c_5 = 0.5c_{45} + \frac{0.25c_{57}}{} \tag{14}$$

$$c_6 = 0.5(c_{69} + c_{46}) \tag{15}$$

$$c_7 = 0.25c_{57} \tag{16}$$

$$c_8 = 0.5c_{89} \tag{17}$$

$$c_9 = 0.5(c_{69} + c_{89}) (18)$$

A. State Equations

$$y_4 = i_{46} + \frac{\epsilon_{40}}{2c_4}(-$$

(5)

$$c_4 v_4' = -i_{41} - i_{45} - i_{46} \tag{1}$$

$$c_5 v_5' = -i_{5A} + i_{5F} + i_{45} \tag{2}$$

$$c_6 v_6' = -i_{6B} + i_{96} + i_{46} \tag{3}$$

$$c_7 v_7' = -i_{72} - i_{7F} \tag{4}$$

$$c_7 c_7 = -\iota_{72} - \iota_{7F} \tag{4}$$

 $c_8 v_8' = -i_{8C} + i_{98}$

$$c_9 v_9' = -i_{93} - i_{98} - i_{96} \tag{6}$$

$$L_A i_{5A}' = v_5 - R_A i_{5A} (7)$$

$$L_B i'_{6B} = v_6 - R_B i_{6B} \tag{8}$$

$$L_C i_{8C}' = v_8 - R_C i_{8C} \tag{9}$$

$$L_1 i_{41}' = v_4 - e_1 \tag{10}$$

$$L_{45}i_{45}' = v_4 - v_5 - R_{45}i_{45} \tag{11}$$

$$L_{46}i_{46}' = v_4 - v_6 - R_{46}i_{46} \tag{12}$$

$$L_2 i_{72}' = v_7 - e_2 \tag{13}$$

$$0.5L_{57}i_{7F}' = v_7 - 0.5R_{57}i_{7F} \tag{14}$$

$$L_{78}t_{78} = v_7 - v_8 + R_{78}i_{78} \tag{15}$$

$$L_3 i_{93}' = v_9 - e_3 \tag{16}$$

$$L_{69}i_{69}' = v_9 - v_6 - R_{69}i_{69} \tag{17}$$

$$L_{89}i_{98}' = v_9 - v_8 - R_{89}i_{98} \tag{18}$$

$$0.5L_{57}i_{5F}' = v_5 - 0.5R_{57}i_{5F} \tag{19}$$

$$y_1 = v_4 \tag{1}$$

$$y_2 = i_{41}$$
 (2)

$$y_3 = i_{45} + \frac{c_{45}}{2c_4} \left(-i_{41} - i_{45} - i_{46} \right) \tag{3}$$

$$y_4 = i_{46} + \frac{c_{46}}{2c_4}(-i_{41} - i_{45} - i_{46}) \tag{4}$$

$$y_5 = v_7 \tag{5}$$

$$y_6 = i_{7F} + \frac{c_{57}}{4c_7}(-i_{72} - i_{7F}) \tag{6}$$

$$y_7 = i_{72}$$
 (7)

$$\mathcal{L} = i_{78} + \frac{c_{78}}{2c_{7}} \left(i_{72} - i_{78} \right) \tag{8}$$

$$y_9 = v_9 \tag{9}$$

$$y_{10} = i_{96} + \frac{c_{69}}{2c_9} (-i_{93} - i_{96} - i_{98})$$
 (10)

$$y_{11} = i_{98} + \frac{c_{89}}{2c_9} \left(-i_{93} - i_{96} - i_{98} \right) \tag{11}$$

$$y_{12} = i_{93} (12)$$

IV. POST-FAULT, LINE 5-7 REMOVED

$$c_4 = 0.5(c_{45} + c_{46}) (13)$$

$$c_5 = 0.5c_{45} \tag{14}$$

$$c_6 = 0.5(c_{69} + c_{46}) (15)$$

$$c_7 = 0.5c_{78} \tag{16}$$

$$c_8 = 0.5(c_{78} + c_{89}) (17)$$

$$c_9 = 0.5(c_{69} + c_{89}) (18)$$

B. Output Equations

$$y_1 = v_4 \tag{1}$$

$$y_2 = i_{41}$$
 (2)

$$y_3 = i_{45} + \frac{c_{45}}{2c_4} (-i_{41} - i_{45} - i_{46}) \tag{3}$$

$$y_4 = i_{46} + \frac{c_{46}}{2c_4} \left(-i_{41} - i_{45} - i_{46} \right) \tag{4}$$

$$y_5 = v_7 \tag{5}$$

$$\mathbf{y} = i_{75} + \frac{c_{57}}{2c_7} \underbrace{i_{72} \quad i_{75} - i_{78}}_{(6)}$$

$$y_7 = i_{72}$$
 (7)

$$y_8 = i_{78} + \frac{c_{78}}{2c_7}(-i_{72} - i_{78}) \tag{8}$$

$$y_9 = v_9 \tag{9}$$

$$y_{10} = i_{96} + \frac{c_{69}}{2c_9} (-i_{93} - i_{96} - i_{98})$$
 (10)

$$y_{11} = i_{98} + \frac{c_{89}}{2c_9} (-i_{93} - i_{96} - i_{98})$$
 (11)

$$y_{12} = i_{93} (12)$$

A. State Equations

$$c_4 v_4' = -i_{41} - i_{45} - i_{46} \tag{1}$$

$$c_5 \frac{v_5'}{} = -i_{5A} + i_{45} \tag{2}$$

$$c_6 v_6' = -i_{6B} + i_{96} + i_{46} \tag{3}$$

$$c_7 v_7' = -i_{72} - i_{78} \tag{4}$$

$$c_8 v_8' = -i_{8C} + i_{78} + i_{98} \tag{5}$$

$$c_9 v_9' = -i_{93} - i_{98} - i_{96} \tag{6}$$

$$L_A i'_{5A} = v_5 - R_A i_{5A} \tag{7}$$

$$L_B i'_{6B} = v_6 - R_B i_{6B} \tag{8}$$

$$L_C i'_{8C} = v_8 - R_C i_{8C} \tag{9}$$

$$L_1 i_{41}' = v_4 - e_1 \tag{10}$$

$$L_{45}i'_{45} = v_4 - v_5 - R_{45}i_{45} \tag{11}$$

$$L_{46}i'_{46} = v_4 - v_6 - R_{46}i_{46} \tag{12}$$

$$L_2 i_{72}' = v_7 - e_2 (13)$$

$$L_{57}i_{75}' = v_7 - v_5 R_{57}i_{75} \tag{14}$$

$$L_{78}i_{78}' = v_7 - v_8 - R_{78}i_{78} \tag{15}$$

$$L_3 i_{93}' = v_9 - e_3 \tag{16}$$

$$L_{69}i_{69}' = v_9 - v_6 - R_{69}i_{69} \tag{17}$$

$$L_{89}i_{98}' = v_9 - v_8 - R_{89}i_{98} \tag{18}$$