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Comparison, Simulation and Analytical Investigation of Voltages, Currents and Powers Waveforms of the at Sixteen Different Combination Step-Down Three Phase Transformer Connections

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Abstract:- This article investigates different currents, voltages, phase differences and powers of sixteen different connections step-down three phase connections transformers fed sinusoidally for analytical and simulation conditions. In this paper, analytical modeling and equations for step-down three phase transformer based on current point signal and voltage polarity are presented. A discussion based on their theoretical use is then presented in the simulation along with calculations regarding their power performances.

Results obtained from simulations and analytical situations of sources, transformer primary, transformer secondaries and loads currents (A), voltages (V), powers (W), between sources and transformer primary, between transformer primary and transformer secondaries and between transformer secondaries and loads phase differences were also obtained.

These models are also validated by simulation results of currents, voltages, phase differences and powers waveforms for each analytical case. PSpice program is used for this simulation.

Keywords:- *Transformer Modeling, Polarity. Transformer Simulation, Step-down Transformer,*

I. I.INTRODUCTION

Sources, primary and secondary windings of the transformer, loads can be connected with any combination of delta and wye. Known and used transformer winding connections are star-star, wye (star)-delta, delta-star, delta-delta. The diagrams of connections, the groups of YY, DD, YD and YD connections and the clock-hour figures of the vectors groups, are taking aspects for the design, manufacture and operation of transformers, especially power transformers.[1, 2}

II. MATHEMATİCAL MODELS AND RESULTS

To insure correct wiring, polarity marks are shown on connection diagrams. The polarity mark is usually shown as a round dot, on or adjacent to terminals. An ideal transformer circuit as a controlled source is shown Figure 1.

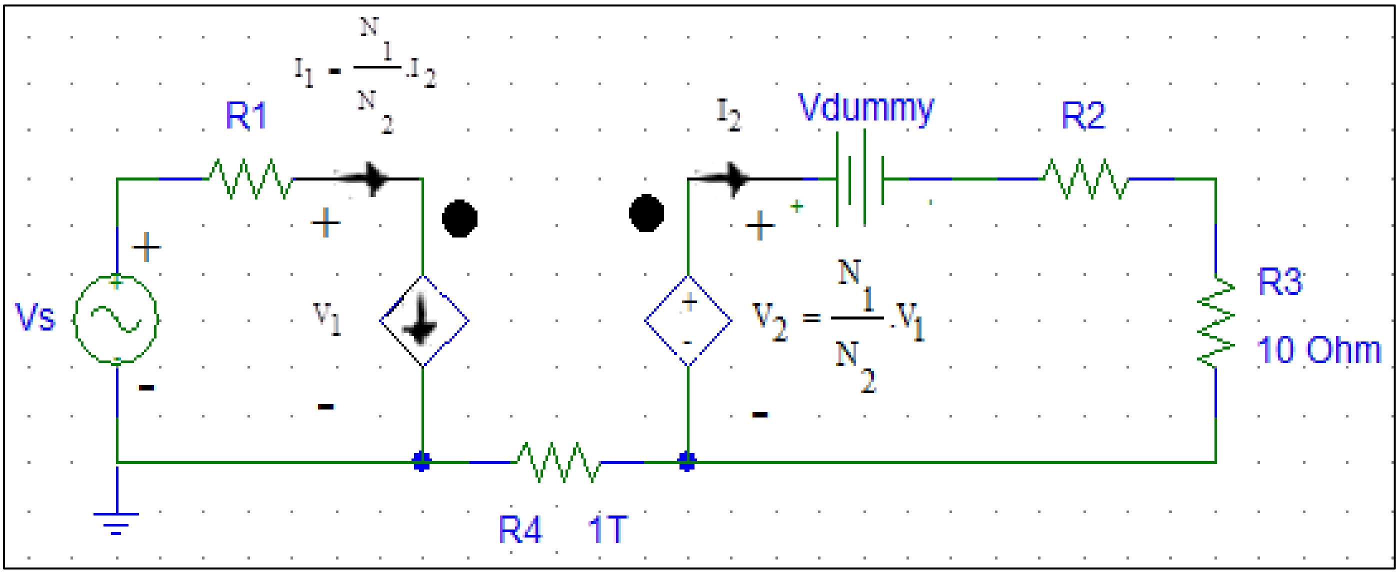

Fig 1 Controlled Sources Single-Phase Step-Down One Phase Transformer Equivalent Circuit

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A step-down transformer is a transformer where the delivered voltage is less than the supplied voltage

$$\frac{V_{(primer)}}{V_{(seconder)}} = \frac{N_1}{N_2} = \frac{2}{1}$$

$$V_{primer} = 2xV_{(seconder)}$$

$$V_{(primer)} = 220V$$

$$V_{(seconder)} = \frac{V_{(primer)}}{2} = 110V$$

$$\frac{I_{(prümer)}}{I_{(seconder)}} = -\left(\frac{-N_2}{+N_1}\right) = -\left(\frac{-1}{+2}\right) = \frac{1}{2}$$

$$I_{(prümer)} = 0{,}5xI_{(seconder)}$$

$$I_{(seconder)} = 2xI_1$$

$$I_{(seconder)} = \frac{V_{(seconder)}}{R_L} = \frac{110}{10} = 11A$$

$$I_{(primer)} = 0{,}5xI_{(seconder)} = 5{,}5A$$

$$P_s = V_s x I_s = 220x5{,}5 = 1210W$$

$$P_{V(primer)} = V_{(primer)}xI_{(prümer)} = 220x5{,}5 = 1210W$$

$$P_{V(seconder)} = V_{(seconder)}xI_{(seconder)} = 110x11 = 1210W$$

$$P_{RL} = R_L x I_{RL}^2 = 10x11^2 = 1210W$$

Examining the losses of sixteen different conditions a 1200 W, 220 / 110 V, 50 Hz three phase transformer equivalent circuit was used. Its operation under 16 different conditions was examined.

The results that were obtained from the simulation three phase transformer connections DDYY, YDYD and DYDY calculated for every cases.

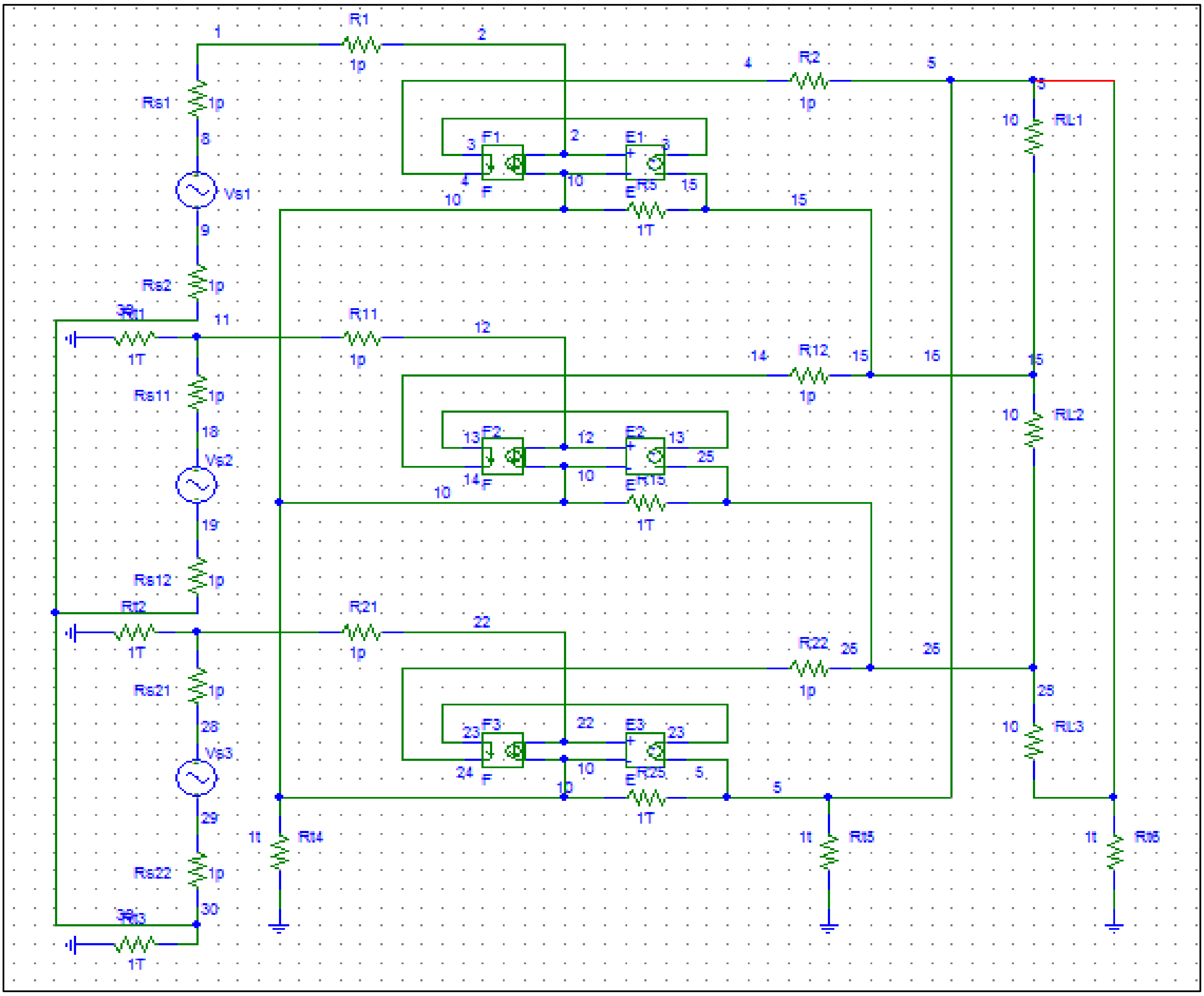

Fig 2a Three phase YYDD Connections for Sources, Transformer Primers, Transformer Seconders and Loads Equivalent Circuits

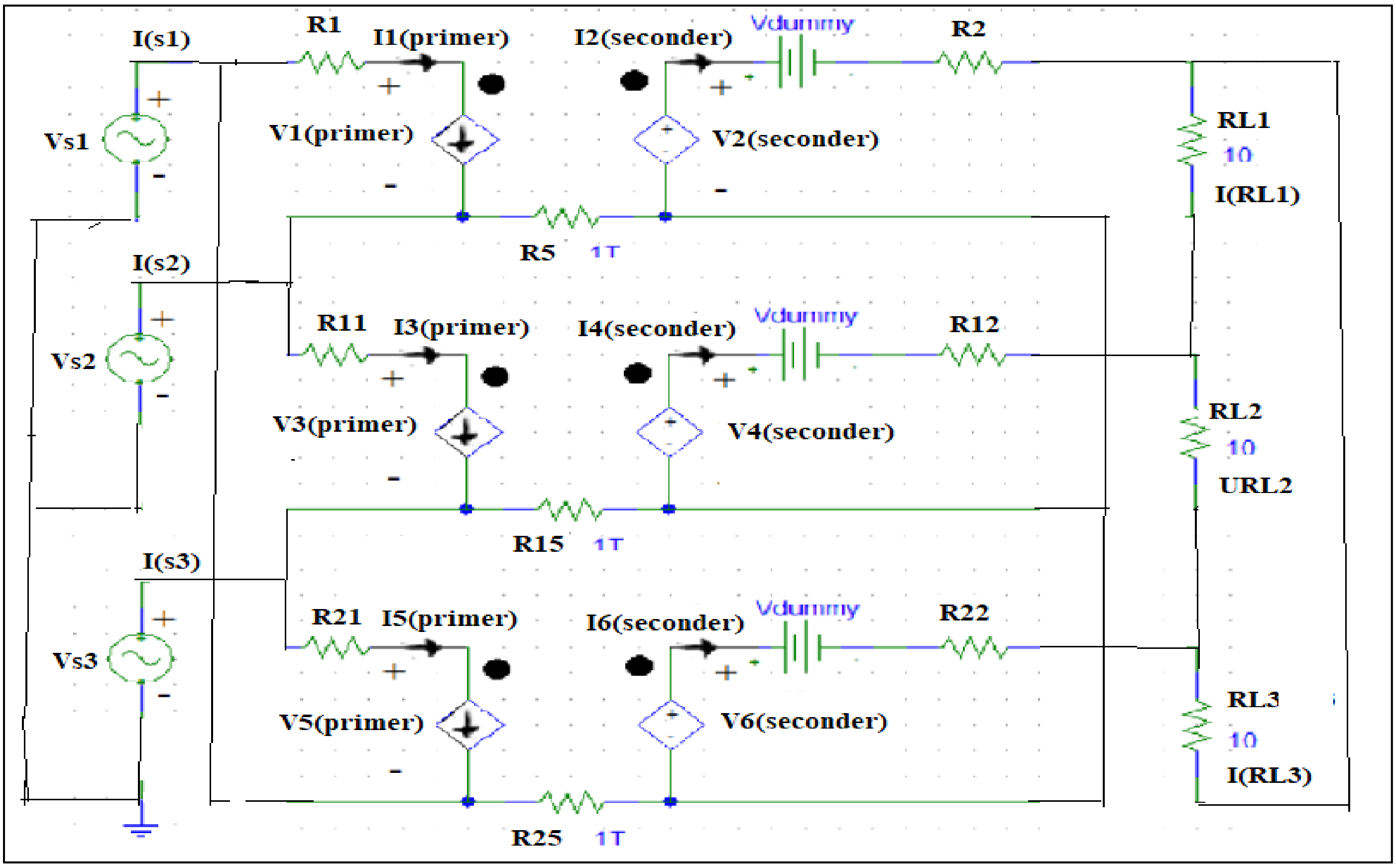

Fig 3a Three phase YDYD Connections for Sources, Transformer Primers, Transformer Seconders and Loads Equivalent Circuits

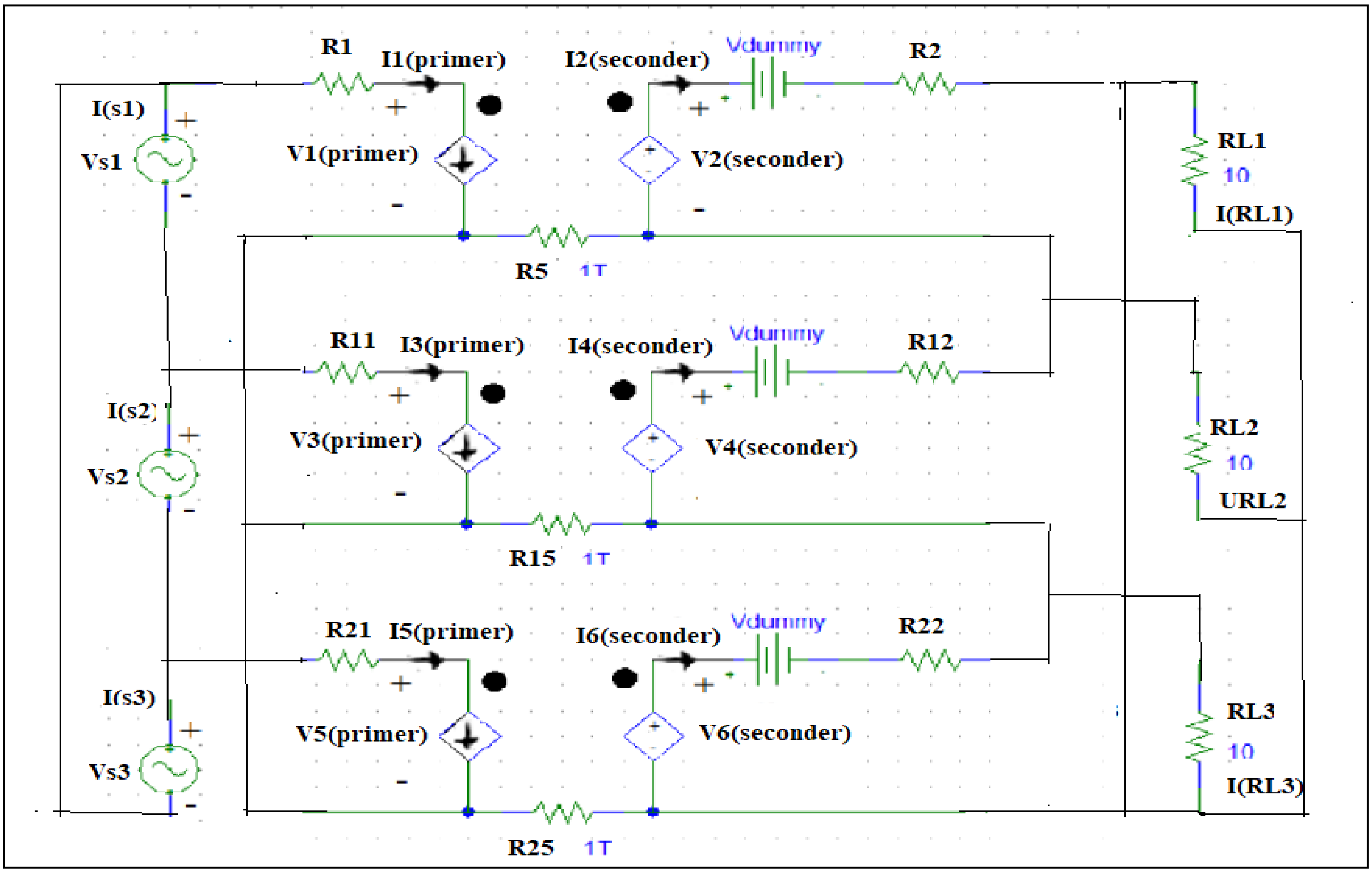

Fig 4a Three phase DYDY Connections for Sources,Transformer Primers, Transformer Seconders and Loads Equivalent CircuitsLoads Equivalent

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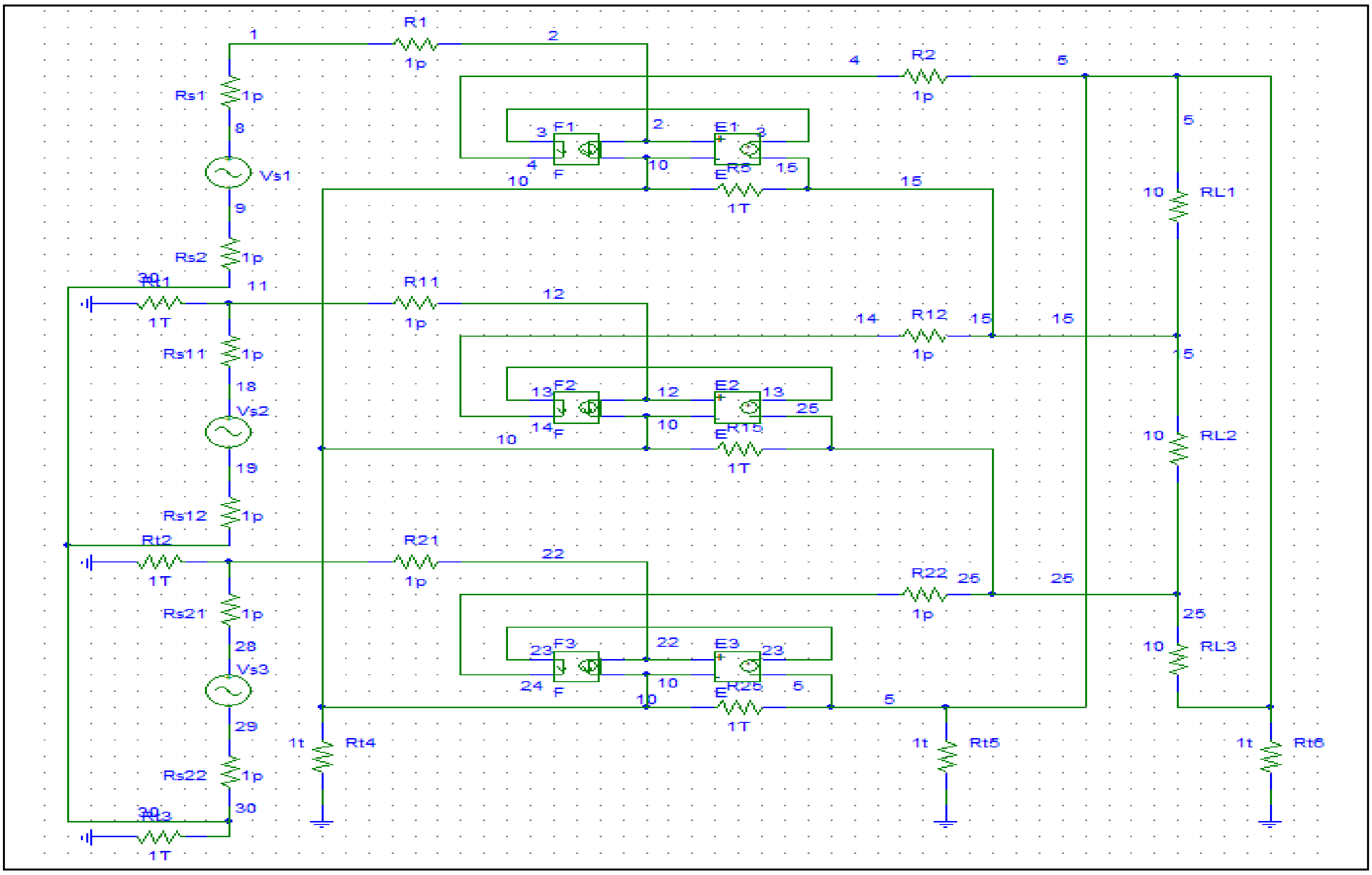

Fig 2b The Circuit Diagram of Figure 2a has been Redrawn for PSpice Schematic Analysis

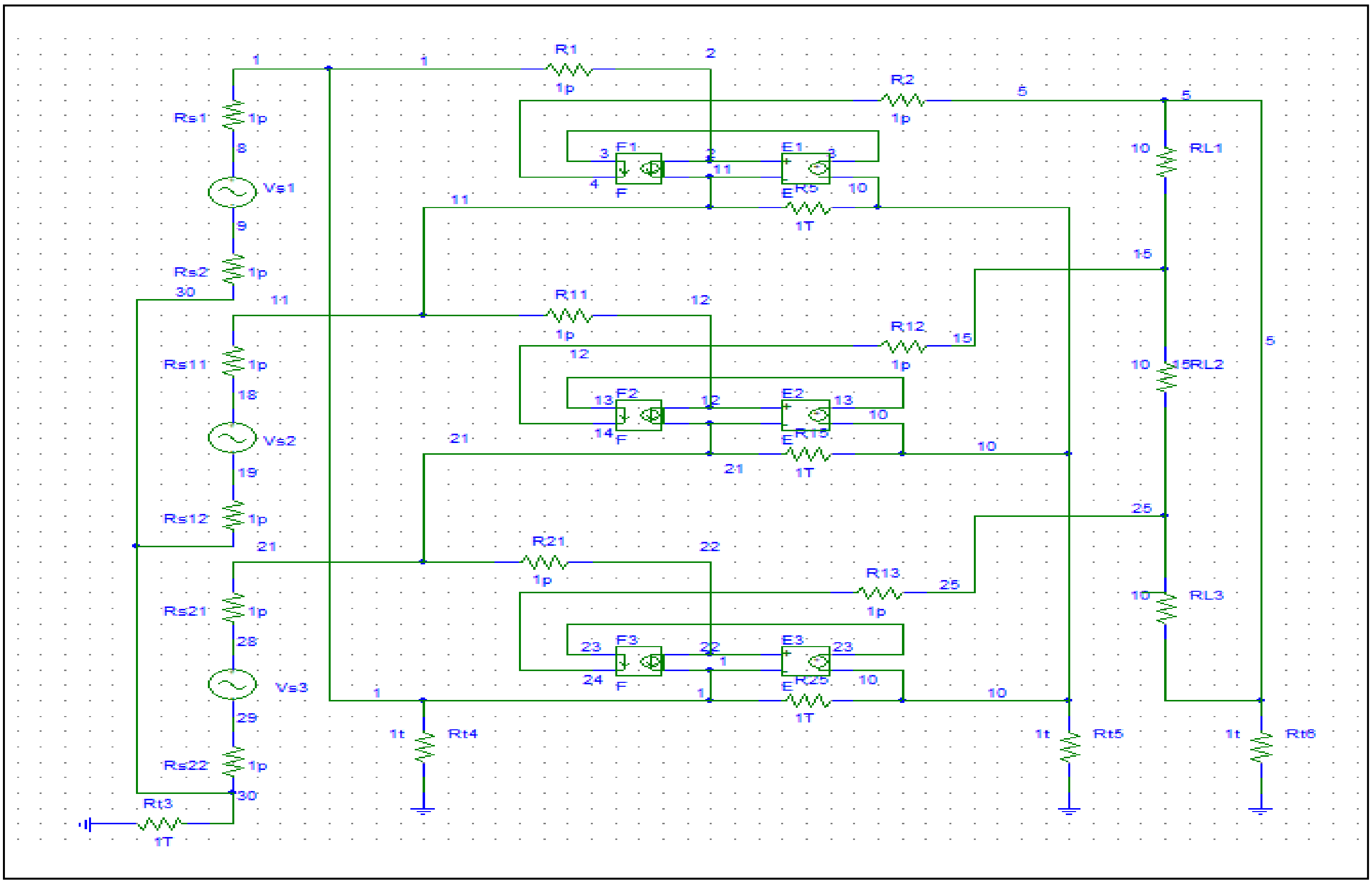

Fig 3b The Circuit Diagram of Figure 3a has been Redrawn for PSpice Schematic Analysis

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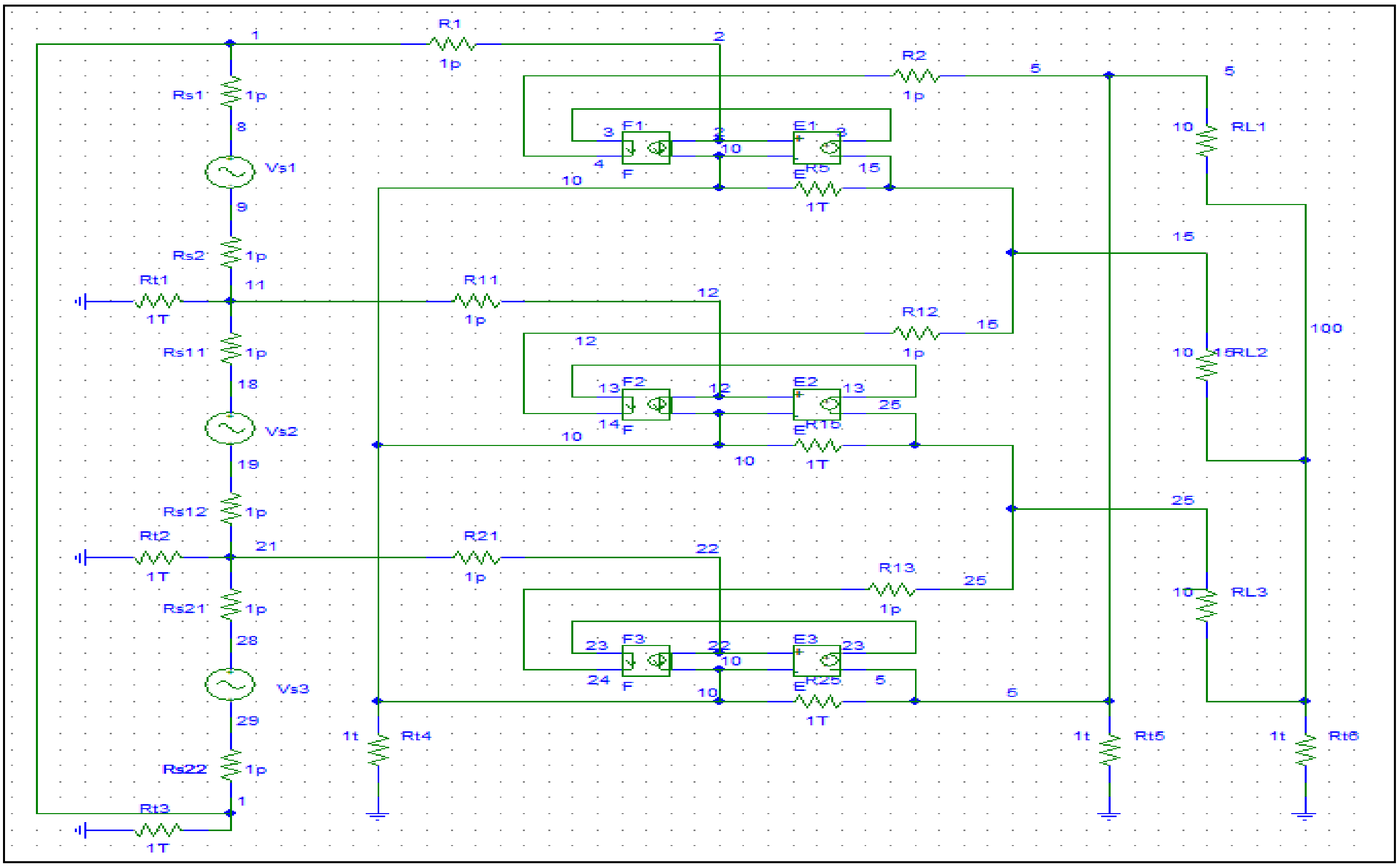

Fig 4b The Circuit Diagram of Figure 4a has been Redrawn for PSpice Schematic Analysis

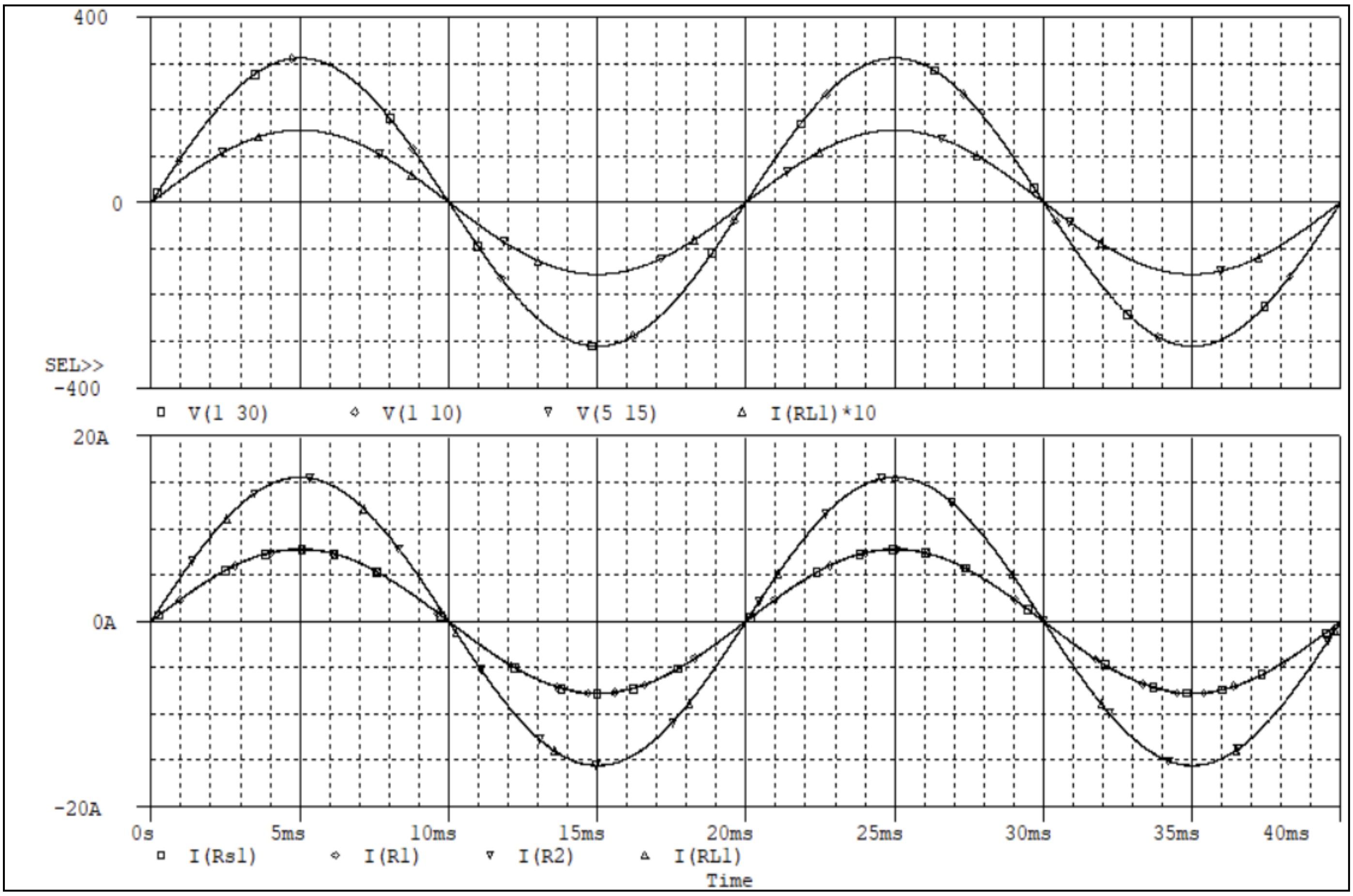

Fig 2c PSpice Plot of Maksimum Values Currents, Voltages of Step-Down YYDD Three Phase Commections Case for Fig. 2-b

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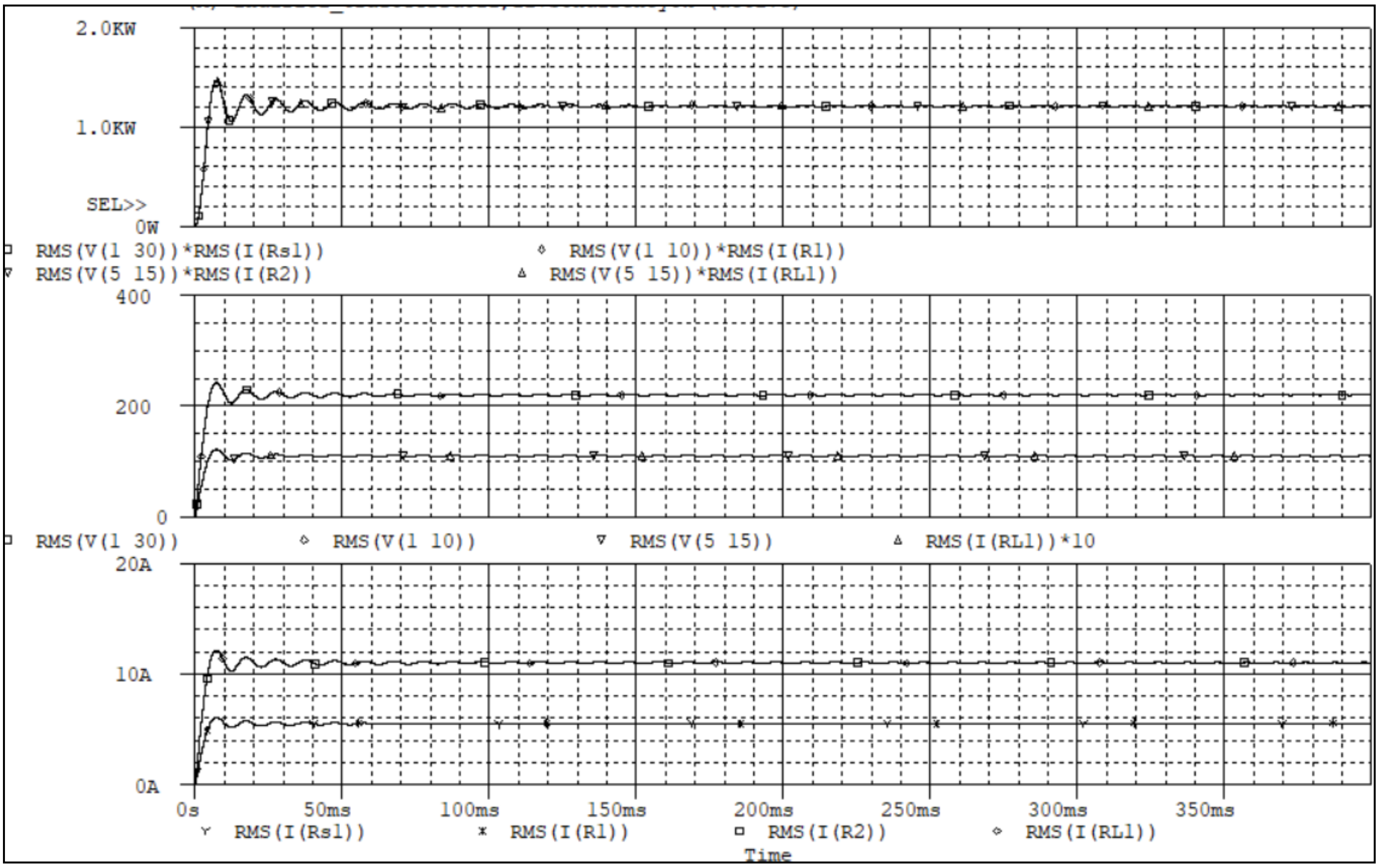

Fig 2d PSpice plot of Effective Values Currents, Voltages, Powers of Step-Down YYDD Three Phase Commections Case for Fig. 2-b

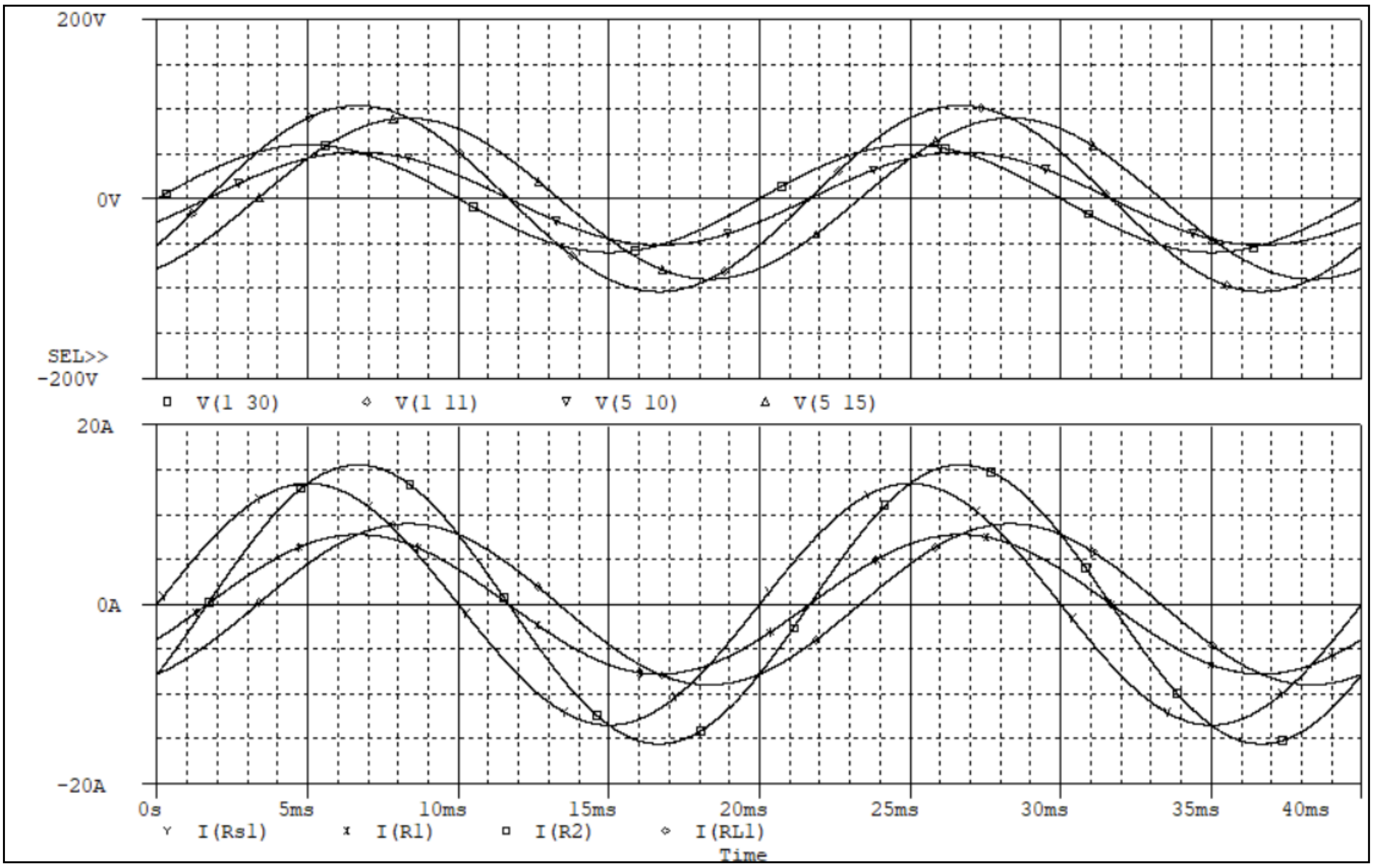

Fig 3c PSpice Plot of Maksimum Values Currents, Voltages of Step-Down YDYD Three Phase Commections Case for Fig. 3-b

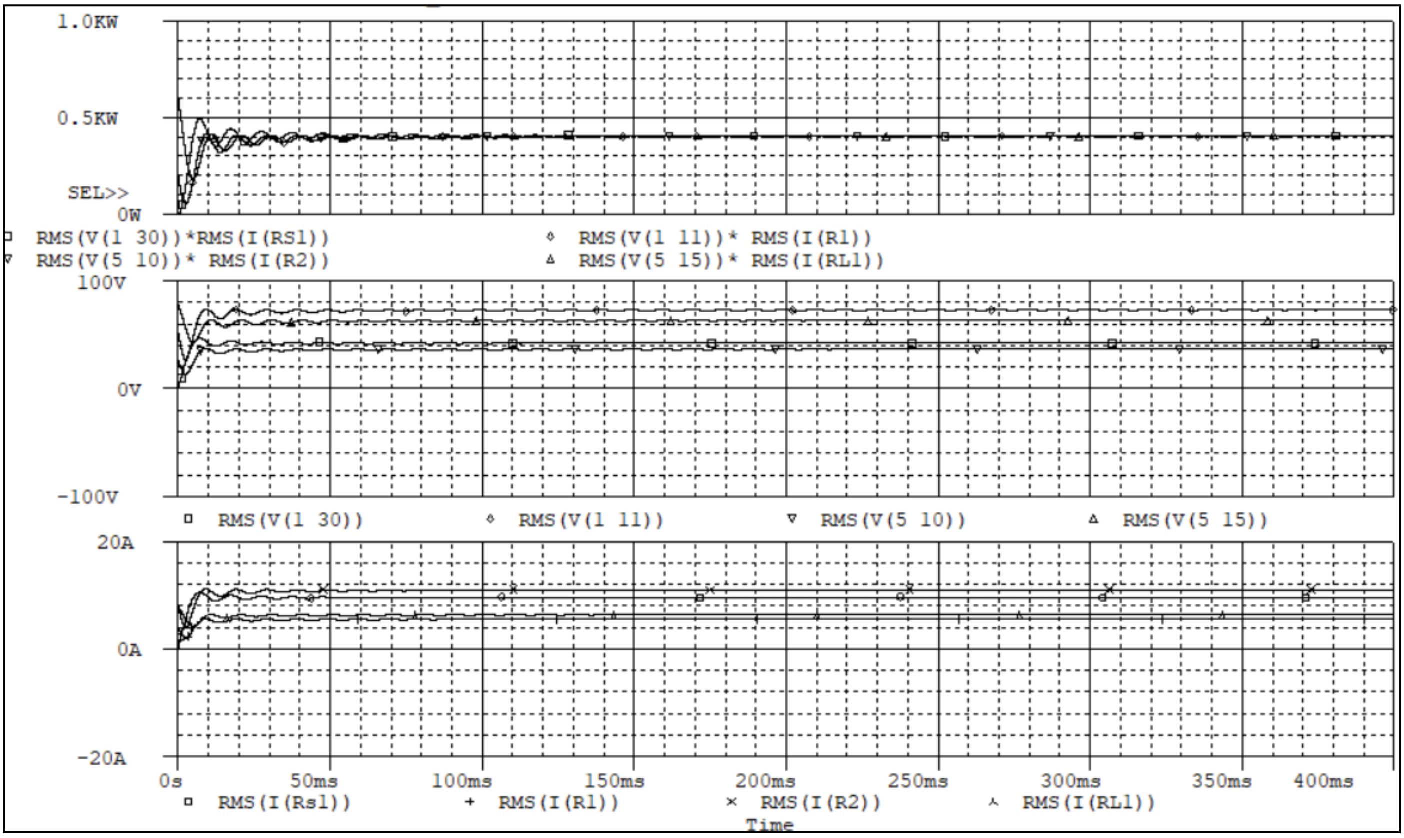

Fig 3d PSpice plot of Effective Values Currents, Voltages, Powers of Step-Down YDYD Three Phase Commections Case for Fig. 3-b

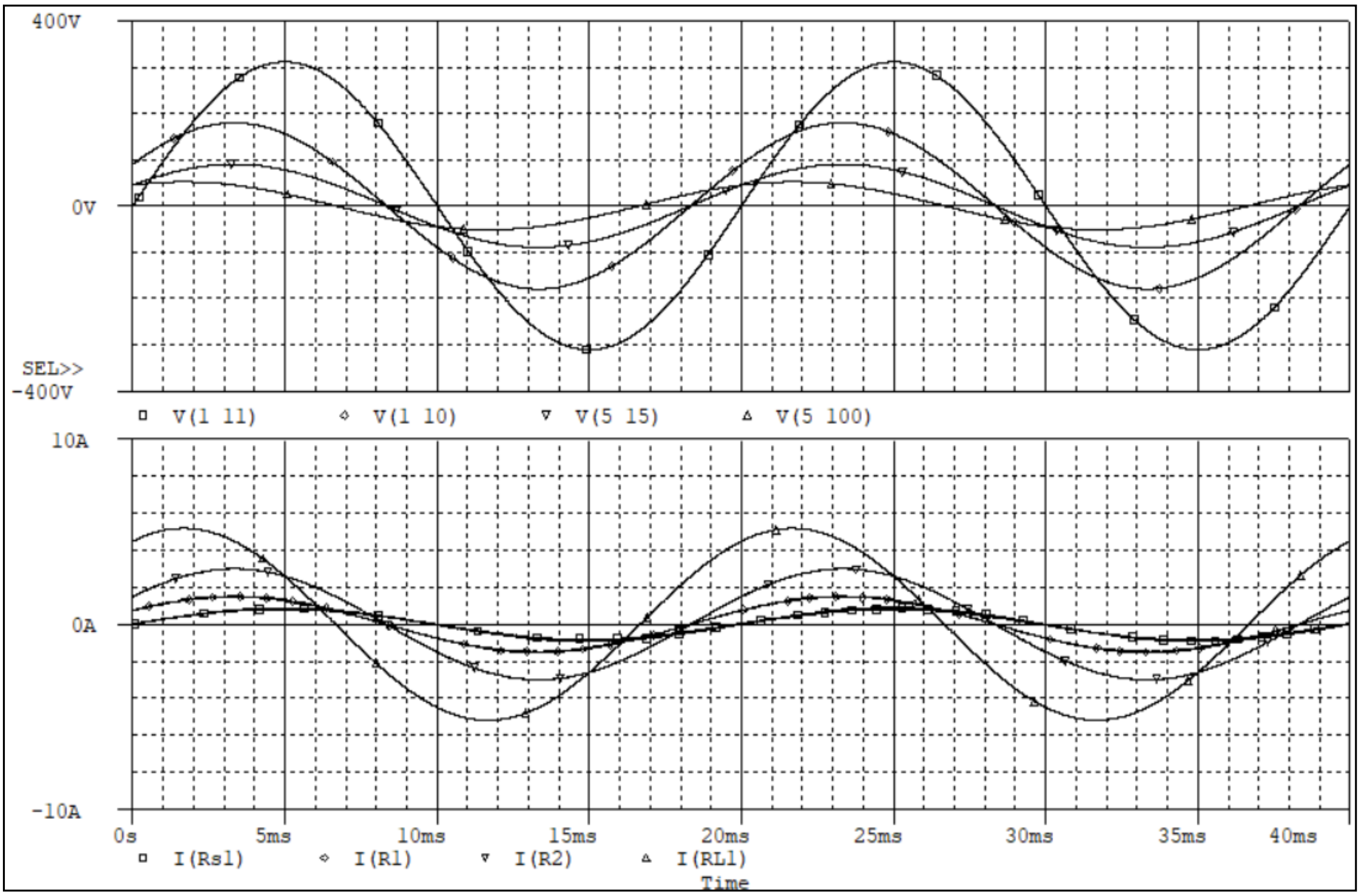

Fig 4c PSpice Plot of Maksimum Values Currents, Voltages of Step-Down DYDY Three Phase Commections Case for Fig. 4-b

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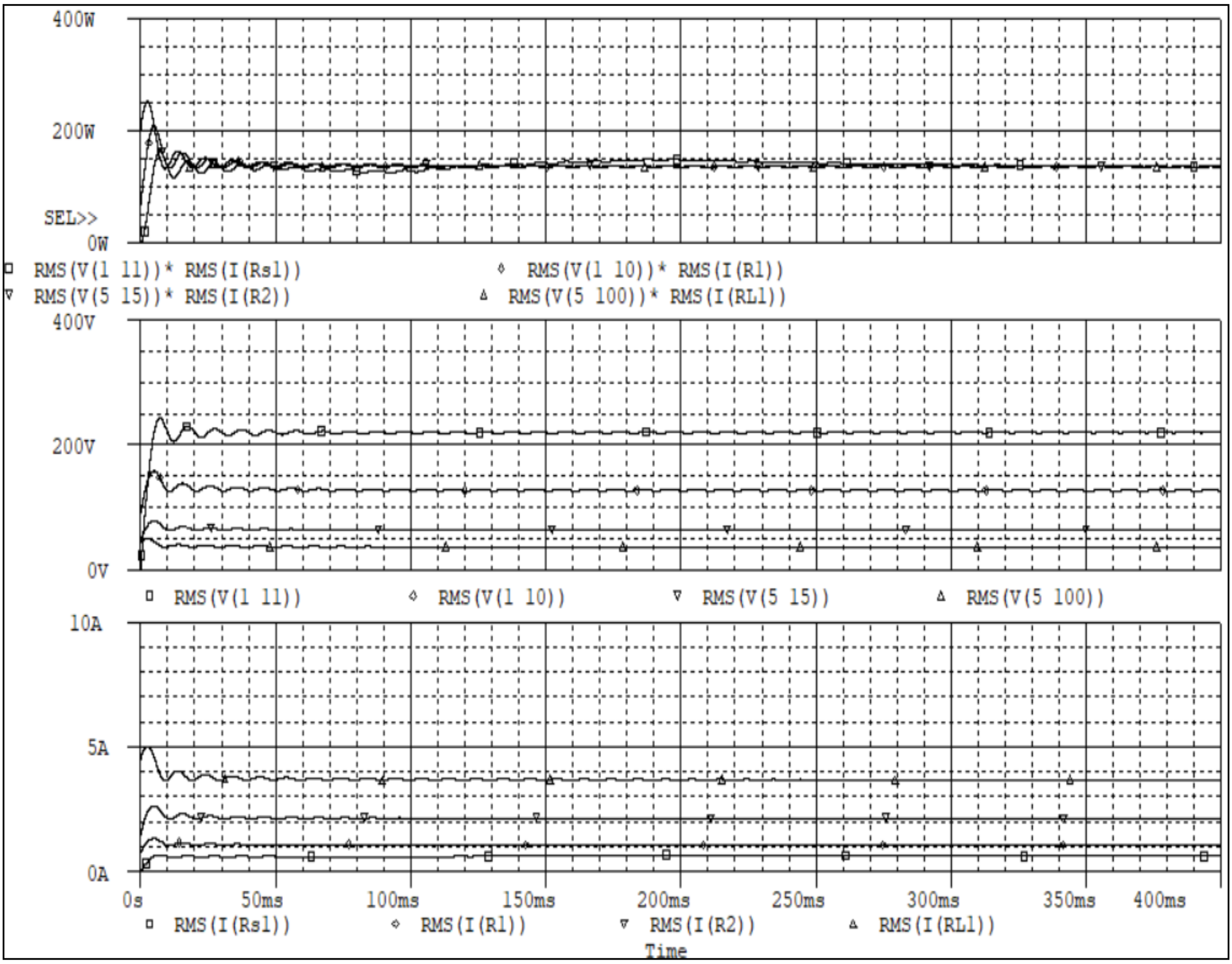

Fig 4d PSpice plot of Effective Values Currents, Voltages, Powers of Step-Down DYDY Three Phase Commections Case for Fig. 4-b

The results that were obtained from the simulation three phase transformer connection sixteen different combinations calculated for every cases.

	Supply	Transformer		Load
		Primer	Seconder	
1	Y	Y	Y	Y
2	Y	Y	D	D
3	D	D	D	D
4	D	D	Y	Y
5	Y	D	D	D
6	Y	D	Y	Y
7	D	Y	D	D
8	D	Y	Y	Y
9	Y	Y	D	Y
10	D	D	D	Y
11	Y	D	D	Y
12	D	Y	D	Y
13	Y	D	Y	D
14	D	Y	Y	D
15	D	D	Y	D
16	Y	Y	Y	D

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III. CONCLUSION

Fig. 2a, Fig. 3a, Fig. 4a Three phase YYDD, YDYD and DYDY connections Sources,Transformer Primers, Transformer Seconders and Loads Equivalent Circuit,

Fig. 2b, Fig. 3b, and 4b The Circuit Diagram of Figure 2a, 3a and 4a has been Redrawn for PSpice Schematic Analysis.

Fig. 2c, Fig. 3c and Fig. 4c PSpice Plot of Maksimum Values Currents, Voltages of YYDD,YDYD and DYDY Case for Fig. 2-b, Fig. 2-b , and Fig. 2-b Three Phase Commections and Fig. 2d, Fig. 3d and Fig. 4d,

PSpice plot of Effective Values Currents, Voltages, Powers of YYDD, YDYD and DYDY Three Phase Commections Case for Fig. 2-b, Fig. 3-b and Fig. 4-b.

Fig. 2a, 3a and 4a three phase connections show PSpice simulation schematics and results of previously mention mathematical models of step-down three phase transformers connections. As it can be seen clearly the mathematical models are validated by simulations.

From the analytical and simulation results, Effective Values Currents (I(s), I(primer), I(seconder) and I(RL)), Effective Values Voltages (Vs, V(primer), V(seconder) and V(RL)), and Powers (Ps, P(primer), P(seconder)and P(RL)) for a three phase connections with sixteen different connections types of circuits, the analytical results of the Currents (I(s), I(primer), I(seconder) and I(RL)), Voltages (Vs, V(primer), V(seconder) and V(RL)), and Powers (Ps, P(primer), P(seconder)and P(RL)) are different, as well as the analytical results of the modeling. The results are verified by the simulation result.

Additionally, an easy-to-install circuits three phase connections are proposed to verify the analytical results. To the practical nominal power of transformer, step-down transformer primary voltage = 220 V, primary current = 5,5 A, transformer secondary voltage = 110 V, secondary current = 11 A.

Fig. 2c, 2d, 3c, 3d 4c and 4d show the simulation results obtained in the analysis of schematic circuits in Pspice. As is clearly seen from the analytical and simulation results, IS, I(primer), I(seconder) and IRL currents and VS , V(primer), V(seconder) and VRL voltages, and PS , P(primer), P(seconder) and PRL Powers, for each circuit for different types of three phase transformer circuit;

It has been confirmed that the analytical calculation values obtained in the analysis of the three phase connection circuit and the simulation plot values obtained in the Pspice analysis are the same.

To obtain these results, three phase circuits for analytical calculations of IS, I(primer), I(seconder) and IRL currents and VS , V(primer), V(seconder) and VRL voltages, and PS P(primer), P(seconder) and PRL Powers are obtained analytical and simulation result different values are obtained.

According to the step-down three phase three phase circuit for analytical calculations and simulation results three sixteen different total power losses value are obtained. The sixteen conditions mentioned total power losses is given below:

YYYY,YYDY,DDDD,DDYY,YDDD,YDYY,

Power value=1210 W

YDYD,YYDY,DDDY,DYDD,DYYY,YDDY,DYYD,DDYD,YYYD,

Power value=403,33 W

DYDY

Power value=134,44 W

Sixteen different combination step-down three phase connections transformer powers are 1210W, 403,33W and 134,44 W. The three different power values result are obtained.

APPENDIX I. Results obtained from simulations and analytical situations of sources, transformer primary, transformer secondaries and loads currents (A), voltages (V), powers (W), between sources and transformer primary, between transformer primary and transformer secondaries and between transformer secondaries and loads phase differences were also obtained.

➢ *Measured Data for any Condition*

Table 1-2-3-4 YYYY,YYDD,DDDD,DDYY,

V(s1)	**V(primer)**	**V(seconder)**	**V(RL1)**
220	220	110	110
I(s1)	I(primer)	I (seconder)	I(RL1)
5,5	5,5	11	11
Phase difference			
0	0	0	0
P(s1)	P(primer)	P(seconder)	P(RL1)
1210	1210	1210	1210

Table 5-6 YDDD,YDYY

V(s1)	**V(primer)**	**V(seconder)**	**V(RL1)**
127,017	220	110	110
I(s1)	I(primer)	I (seconder)	I(RL1)
9,526	5,5	11	11
Phase difference			
0	-30	-30	-30
P(s1)	P(primer)	P(seconder)	P(RL1)
1210	1210	1210	1210

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Table 7 YDYD

V(s1)	V(primer)	V(seconder)	V(RL1)
42,34	73,3333	36,666	63,508
I(s1)	I(primer)	I(seconder)	I(RL1)
9,526	5,5	11	6,3508
Phase difference			
0	-30	-30	-60
P(s1)	P(primer)	P(seconder)	P(RL1)
403,33	403,33	403,33	403,33

Table 8-9 YYDY,DDDY

V(s1)	V(primer)	V(seconder)	V(RL1)
220	220	110	63,508
I(s1)	I(primer)	I(seconder)	I(RL1)
1,833	1,8333	3,666	6,3508
Phase difference			
0	0	0	30
P(s1)	P(primer)	P(seconder)	P(RL1)
403,33	403,33	403,33	403,33

Table 10-11 DYDD,DYYY

V(s1)	V(primer)	V(seconder)	V(RL1)
220	127,017	63,508	63,508
I(s1)	I(primer)	I(seconder)	I(RL1)
1,8333	3,175	6,3508	6,3508
Phase difference			
0	30	30	30
P(s1)	P(primer)	P(seconder)	P(RL1)
403,33	403,33	403,33	403,33

Table 12 YDDY

V(s1)	V(primer)	V(seconder)	V(RL1)
127,017	220	110	63,508
I(s1)	I(primer)	I(seconder)	I(RL1)
3,175	1,8333	3,666	6,3508
Phase difference			
0	-30	-30	0
P(s1)	P(primer)	P(seconder)	P(RL1)
403,333	403,333	403,33	403,333

Table 13 DYYD

V(s1)	V(primer)	V(seconder)	V(RL1)
127,017	73,333	36,666	63,508
I(s1)	I(primer)	I(seconder)	I(RL1)
3,1754	5,5	11	6,3508
Phase difference			
0	30	30	0
P(s1)	P(primer)	P(seconder)	P(RL1)
403,333	403,333	403,333	403,333

Table 14-15 DDYD,YYYD

V(s1)	V(primer)	V(seconder)	V(RL1)
73,3333	73,3333	36,667	63,508
I(s1)	I(primer)	I(seconder)	I(RL1)
5,5	5,5	11	6,3508
Phase difference			
0	0	0	-30
P(s1)	P(primer)	P(seconder)	P(RL1)
403,333	403,333	403,33	403,333

Table 16 DYDY

V(s1)	V(primer)	V(seconder)	V(7 10)
220	127,017	63,509	36,6666
I(s1)	I(primer)	I(seconder)	IRy1
0,61111	1,05848	2,117	3,6666
Phase difference			
0	30	30	60
P(s1)	P(primer)	PR3	PRy1
134,444	134,444	134,44	134,444

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