浙江大学



本科实验报告

姓名: 叶星汝

学院: 电气工程学院

系: 电机工程系

专业: 电气工程及其自动化

学号: 3160103013

指导教师: 王晓菲

2020年1月5日

浙江大学实验报告

课程名称: 微电网构架与控制策略 实验类型: 仿真实验

实验项目名称: 微电网运行与控制系统仿真实验

学生姓名: 叶星汝 专业: 电气工程及其自动化学号: 3160103013

指导老师: 王晓菲

实验地点: 环科楼 305 实验日期: 2020 年 1 月 5 日

一、实验目的和要求(必填)

- 二、实验内容和原理(必填)
- 三、主要仪器设备
- 四、操作方法与实验步骤
- 五、实验数据记录和处理
- 六、实验结果与分析(必填)

七、讨论、心得

注:不同类型的实验课对实验报告可有不同要求,各个学科的实验报告可以根据自己的学科特点做适当的调整,但上述基本内容中的第一、二、三、六条为必须填写的内容。

一、实验目的和要求

- 1. 理解微电网的构成、运行及控制
- 2. 掌握光伏、蓄电池、风能等发电技术
- 3. 设计微网结构并建模

二、实验内容和原理

内容:

1.分布式发电(distributed generation, DG):指利用各种分散存在的能源,包括可再生源(太阳能、生物质能、小型风能、小型水能、波浪能等)和本地可方便获取的化石类燃料(天然气、煤气、柴油等)进行发电供能的技术。

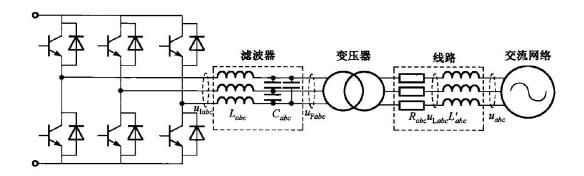
采用分布式发电,有助于充分利用各地丰富的清洁和可再生能源,向用户提供"绿色电力",是实现"节能减排"的重要举措。

2.微电网:分布式能源、能量转换装置、负荷、监控和保护装置等汇集而成的小型发配电系统,是一个能够实现自我控制和管理的自治系统。

微电网的组建建立在分布式电源对系统运行的主动控制上,这种控制能力可以允许配电 网连接到主网,当出现故障或其他外部扰动或自然灾害时,可以独立于主网实现孤岛运行, 从而提高供电质量。

原理: 分模块:

(1) 典型的三相电压型逆变器并网结构



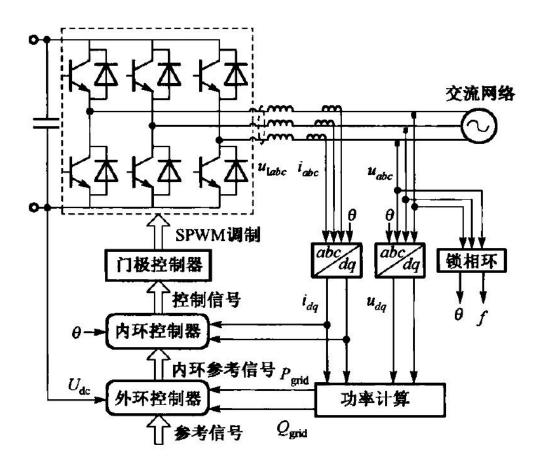
$$\begin{cases} L \frac{di_{Id}}{dt} = u_{Id} - u_{Fd} - \omega Li_{Iq} \\ L \frac{di_{Iq}}{dt} = u_{Iq} - u_{Fq} + \omega Li_{Id} \end{cases} & \begin{cases} L \frac{di_{Ia}}{dt} = u_{Ia} - u_{Fa} \\ L \frac{di_{Ib}}{dt} = u_{Ic} - u_{Fb} \\ L \frac{di_{Ic}}{dt} = u_{Ic} - u_{Fc} \end{cases} \end{cases}$$

$$\begin{cases} C' \frac{du_{Fd}}{dt} = i_{Id} - \frac{u_{Fd} - u_{Ld}}{R} - \omega C'u_{Fq} \\ C' \frac{du_{Fq}}{dt} = i_{Iq} - \frac{u_{Fq} - u_{Lq}}{R} + \omega C'u_{Fd} \end{cases} & \begin{cases} C' \frac{du_{Fa}}{dt} = i_{Ia} - \frac{u_{Fa} - u_{La}}{R} \\ C' \frac{du_{Fb}}{dt} = i_{Ib} - \frac{u_{Fb} - u_{Lb}}{R} \\ C' \frac{du_{Fc}}{dt} = i_{Ic} - \frac{u_{Fc} - u_{Lc}}{R} \end{cases} \end{cases}$$

$$\begin{cases} L' \frac{di_{d}}{dt} = u_{Ld} - u_{d} - \omega L'i_{q} \\ L' \frac{di_{d}}{dt} = u_{Lq} - u_{q} + \omega L'i_{d} \end{cases} & \begin{cases} L' \frac{di_{d}}{dt} = u_{Lb} - u_{b} \\ L' \frac{di_{c}}{dt} = u_{Lc} - u_{c} \end{cases} \end{cases}$$

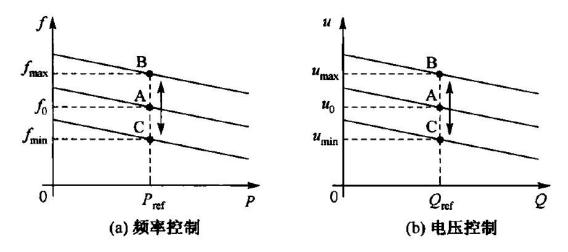
派克变换后==》

(2) 逆变器的控制方法:双环控制 SPWM 调制的三相电压型逆变器控制系统

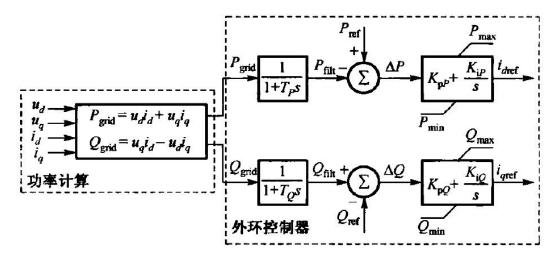


(3) 恒功率控制 (P/Q 控制)

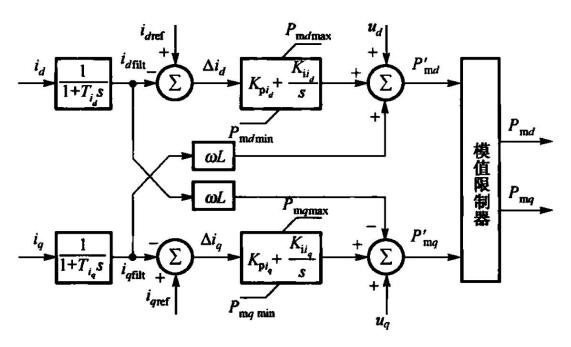
目标: 使输出的有功功率和无功功率等于其参考值



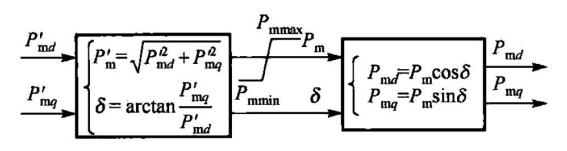
a) 恒功率控制(PQ 控制)外环控制器典型结构



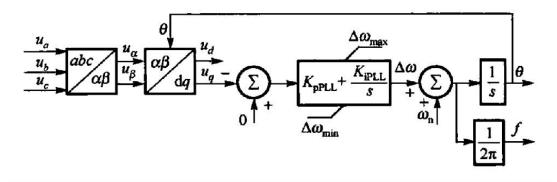
b) 内环控制器 - dq0 旋转坐标系控制



c) 模值限制器



d) 锁相环

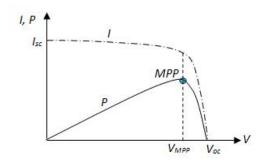


三、主要仪器设备

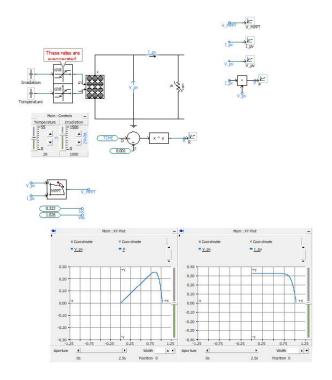
PSCAD 仿真软件

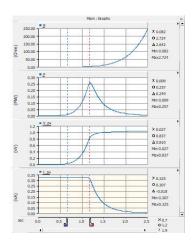
四、操作方法与实验步骤+实验数据记录和处理

(1) 最大功率点追踪控制太阳能控制器

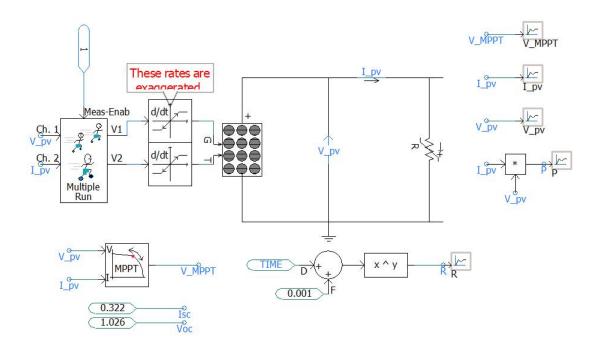


Typical I-V and P-V characteristics of a PV array





 V_{MPP} =0.84kV, P_{M} =0.26MVA == \rangle



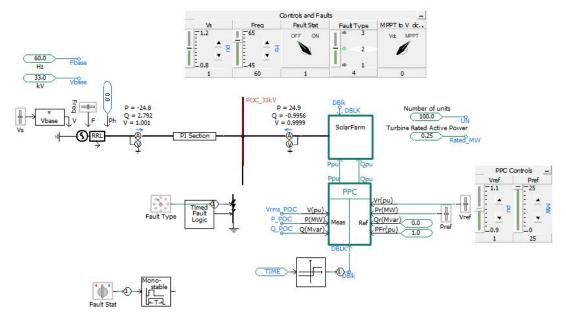
2 3 3 4 4 5 6 6 7 7 8 9 9 10 11 12 13 14 15 16 17 18 19 20 17 18 19 20 18 19 19 19 19 19 19 19 19 19 19 19 19 19	mperature 20 Runs: 	0.905506586 0.211633000 0.539237895 0.171862808 0.664675620 0.29888088 0.151133570 0.838417002 0.501041167 0.318146659 0.212395158 0.147863026 0.106648154 0.792806589 0.60488058 0.472019448 0.375659878 0.472019448 0.3756598783E 0.6900083319 0.7751611295E 0.18659270193056984511 0.4607306770 bbe 1, Out # 1	15
3 4 4 5 6 6 7 7 8 8 9 10 11 12 13 14 15 16 17 18 19 20 17 18 19 20 17 18 19 20 17 18 19 19 19 19 19 19 19 19 19 19 19 19 19	000 000 000 000 000 000 000 000 000 00	0.262830904 0.905506586 0.211633000 0.539237895 0.171862808 0.664675620 0.29888088 0.151133570 0.838417082 0.501041167 0.318146659 0.212395158 0.147863026 0.106648154 0.792806589 0.604880858 0.472019448 0.3756598783E- 0.690008331 Out # 1 0.3756598783E- 0.6900083319 0.7751611295E- 0.18659270193056984511 0.4607306770 bbe 1, Out # 1	15 0.1066498670E-01 17 0.1157496850E-01 17E-01 0.1248495030E-01 17E-01 0.1339493210E-01 18E-02 0.1430491390E-01 18E-03 0.161248750E-01 18E-03 0.1703485930E-01 18E-04 0.1885482290E-01 18E-04 0.2067478650E-01 18E-04 0.2158476830E-01 18E-05 0.2431471371E-01 18E-05 0.2431471371E-01 18E-05 0.2522469551E-01 18E-05 0.252246951E-01 18E-05 0.2613467731E-01 18E-05 0.2704465911E-01 1 0ut # 2 19 0.9755004900E-02 0.2704465911E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
4 5 6 6 7 7 8 9 9 100 111 122 13 144 15 16 17 18 19 20 16 17 18 19 20 17 18 19 19 20 17 19 19 19 19 19 19 19 19 19 19 19 19 19	1 and h mperature 000000 00000000000000000000000000000	0.905506586 0.211633000 0.539237895 0.171862808 0.664675620 0.29888088 0.151133570 0.838417002 0.501041167 0.318146659 0.212395158 0.147863026 0.106648154 0.792806589 0.60488058 0.472019448 0.375659878 0.472019448 0.3756598783E 0.6900083319 0.7751611295E 0.18659270193056984511 0.4607306770 bbe 1, Out # 1	0.1248495030E-01 0.7E-01 0.1248495030E-01 0.7E-01 0.1339493210E-01 0.8E-02 0.1430491300E-01 0.8E-03 0.1612487750E-01 0.8E-03 0.1703485930E-01 0.8E-03 0.1703485930E-01 0.8E-04 0.1895482290E-01 0.8E-04 0.2967478650E-01 0.8E-04 0.2249475010E-01 0.8E-04 0.2249475010E-01 0.8E-05 0.2431471371E-01 0.8E-05 0.2613467731E-01 0.1E-05 0.2613467731E-01 0.1E-05 0.2704465911E-01 0.1 0ut # 2 0.9755004900E-02 0.2704465911E-01 0.10139983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
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12 13 14 15 16 17 18 19 20 d for run # diation te 11 Based on 2 tion tempe 0000 100.0 0000 2000. 0000 1050. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	200 200 200 200 200 200 200 200 200 200	0.501041167 0.318146659 0.212395158 0.147863026 0.106648154 0.792806589 0.604880858 0.472019448 0.375659878 as been repeated 0ut # 1 0.3756598783E- 0.6900083319 0.7751611295E- 0.18659270193056984511 0.4607306770 ble 1, Out # 1	0E-04 0.1976480470E-01 0E-04 0.2067478650E-01 09E-04 0.2158476830E-01 09E-04 0.2249475010E-01 04E-04 0.2340473191E-01 04E-05 0.2431471371E-01 04E-05 0.2522469551E-01 04E-05 0.2704465911E-01 04E-05 0.2704465911E-01 05 0.9755004900E-02 02704465911E-01 01 0.1839983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
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14 15 16 17 18 19 20 d for run # diation te Based on 2 Tion tempe 0000 100.0 0000 2000. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	1 and h emperature 00 20 Runs: 10000000 0000000000000000000000	0.212395158 0.147663026 0.106648154 0.792806589 0.604880858 0.472019448 0.375659878 as been repeated 0ut # 1 0.3756598783E 0.6900083319 0.7751611295E 0.18659270193056984511 0.4607306770 bbe 1, Out # 1	09E-04 0.2158476830E-01 08E-04 0.2249475010E-01 08E-04 0.2349473191E-01 08E-05 0.2431471371E-01 08E-05 0.2522469551E-01 08E-05 0.2522469551E-01 08E-05 0.2613467731E-01 08E-05 0.2704465911E-01 0
15 16 17 18 19 20 d for run # diation te diation tempe 0000 100.0 0000 2000. 0000 1050. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	20 Runs:	0.147863026 0.106648154 0.792806589 0.604880858 0.472019448 0.375659878 as been repeated 0.690008331 Out # 1 0.3756598783E 0.6900083319 0.7751611295E- 0.18659270193056984511 0.4607306770 bbel 1, Out # 1	00t # 2 00 0.9755004900E-02 00t # 2 00 0.9755004900E-02 00t # 2 00 0.9755004900E-02 00t # 2 00 0.9755004900E-02 00t # 2 00t # 3 00t #
16 17 18 19 20 d for run # diation tempe 0000 100.0 0000 2000.0000 591.6 0000 -165.0 0000 2265. Functions (%)	000 000 000 000 000 1 and h emperature 000 00 Runs: erature 000000 000000 000000 000000 0079783 014259 for Varia	0.106648154 0.792806589 0.604880858 0.472019448 0.375659878 as been repeated Out # 1 0.3756598783E- 0.6900083319 0.7751611295E- 0.1865927019 3056984511 0.4607306770 bbe 1, Out # 1	14E-04 0.2340473191E-01 18E-05 0.2431471371E-01 17E-05 0.22522469551E-01 181E-05 0.2613467731E-01 181E-05 0.2704465911E-01 181 for the last run beld 1
17 18 19 20 d for run # diation te diation tempe 0000 100.0 0000 2000. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	1 and h mperature 00 00 00 00 1 and h mperature 00 00 00 00 00 00 00 00 00 00 00 00 00	0.792806589 0.604880858 0.472019448 0.375659878 as been repeated Out # 0.690008331 Out # 1 0.3756598783E- 0.6900083319 0.7751611295E- 0.18659270193056984511 0.4607306770 bbe 1, Out # 1	08E-05 0.2431471371E-01 07E-05 0.2522469551E-01 08E-05 0.2613467731E-01 03E-05 0.2704465911E-01 01
18 19 20 d for run # diation te 1 Based on 2 tion tempe 0000 100.0 0000 2000. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	1 and h emperature 00 20 Runs: crature 0000000 000000 000000 0079783 0142590 0014259 for Varia 80	0.604880858 0.472019448 0.375659878 as been repeated Out # 0.690008331 Out # 1 0.3756598783E- 0.6900083319 0.7751611295E- 0.1865927019 3056984511 0.4607306770 bble 1, Out # 1	07E-05 0.2522469551E-01 08E-05 0.2613467731E-01 08E-05 0.2704465911E-01 08 for the last run belot 0
19 20 d for run # diation te diation tempe 0000 100.0 0000 2000. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	1 and hemperature 100 20 Runs:	0.472019448 0.375659878 as been repeated 0.690008331 0.690008331 0.7751611295E- 0.1865927019 3056984511 0.4607306770 bble 1, Out # 1	01E-05 0.2613467731E-01 03E-05 0.2704465911E-01 01 for the last run belot 0 out # 2 0 0.9755004900E-02 0.2704465911E-01 0.1839983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
d for run # diation te 1 Based on 2 tion tempe 0000 100.0 0000 2000. 0000 1050. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	1 and h emperature 000 20 Runs: 21 Erature 000000 000000 000000 000000 0014259 for Varia Cumula	O.375659878 as been repeated Out # 1 0.3756598783E- 0.6900083319 0.7751611295E- 0.18659270193056984511 0.4607306770 ble 1, Out # 1	Out # 2 Out # 3 Out # 3 Out # 4 Out #
d for run # diation te Based on 2 tion tempe 0000 100.0 0000 2000. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	1 and h imperature 100 20 Runs:	Out # 1 0.690008331 Out # 1 0.3756598783E- 0.6900083319 0.7751611295E- 0.18659270193056984511 0.4607306770 ble 1, Out # 1	Out # 2 Out # 3 Out # 3 Out # 4 Out # 3 Out # 4 Out #
diation te 1 Based on 2	mperature 20 Runs: 	Out # 1 0.690008331 Out # 1 0.3756598783E-0.6900083319 0.7751611295E-0.18659270193056984511 0.4607306770 Out # 1	1 Out # 2 .9 0.9755004900E-02 Out # 2 .05 0.9755004900E-02 0.2704465911E-01 .01 0.183993200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
1 Based on 2 tion tempe 0000 100.0 0000 2000. 0000 1550. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	20 Runs: Prature 2000000 2000000 2000000 2000000 2000000	Out # 1 0.3756598783E- 0.6900083319 0.7751611295E- 0.1885927019 3056984511 0.4607306770	Out # 2 -05 0.9755004900E-02 0.2704465911E-01 -01 0.1839983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
Based on 2 tion tempe 0000 100.0 0000 2000. 0000 1550. 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	20 Runs:	Out # 1 0.3756598783E- 0.6900083319 0.7751611295E- 0.1865927019 3056984511 0.4607306770 bble 1, Out # 1	Out # 2 -05 0.9755004900E-02 0.2704465911E-01 -01 0.1839983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
tion tempe 0000 100.0 0000 2000. 0000 1050. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	erature 1000000 1000000 1000000 1000000 10000 1000	0.3756598783E- 0.6900083319 0.7751611295E- 0.1865927019 3056984511 0.4607306770 ble 1, Out # 1	-05 0.9755004900E-02 0.2704465911E-01 -01 0.1839983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
tion tempe 0000 100.0 0000 2000. 0000 1550. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	erature 0000000 .000000 .000000 .000000 .0079783 0142590 .014259 for Varial	0.3756598783E- 0.6900083319 0.7751611295E- 0.1865927019 3056984511 0.4607306770 ble 1, Out # 1	-05 0.9755004900E-02 0.2704465911E-01 -01 0.1839983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
0000 100.0 0000 2000. 0000 1050. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	0000000 000000 000000 0079783 0142590 014259 for Varial	0.3756598783E- 0.6900083319 0.7751611295E- 0.1865927019 3056984511 0.4607306770 ble 1, Out # 1	-05 0.9755004900E-02 0.2704465911E-01 -01 0.1839983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
0000 2000. 0000 1050. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	.000000 .000000 .0079783 .0142590 .014259 for Varial	0.6900083319 0.7751611295E- 0.1865927019 3056984511 0.4607306770 ble 1, Out # 1	0.2704465911E-01 0.1839983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01 100-Cumulative Prob.
0000 1050. 0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	000000 5079783 0142590 014259 for Varia Cumula 80	0.7751611295E- 0.1865927019 3056984511 0.4607306770 ble 1, Out # 1	-01 0.1839983200E-01 0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
0000 591.6 0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	5079783 0142590 .014259 for Varia Cumula 80	0.1865927019 3056984511 0.4607306770 ble 1, Out # 1	0.5383524933E-02 0.7343423371E-02 0.2945624063E-01
0000 -165.0 0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	0142590 0014259 for Varia Cumula 80	3056984511 0.4607306770 ble 1, Out # 1	0.7343423371E-02 0.2945624063E-01
0000 2265. Functions (%) Probability(%) 80.00000000 5.000000000	for Varia Cumula	0.4607306770 ble 1, Out # 1	0.2945624063E-01
Functions (%) Probability(%) 80.00000000 5.000000000	for Varia Cumula	ble 1, Out # 1	100-Cumulative Prob.
Probability(%) 80.00000000 5.000000000	Cumula 80		100-Cumulative Prob.
Probability(%) 80.00000000 5.000000000	Cumula 80		100-Cumulative Prob.
80.00000000 5.000000000	80		
5.000000000		.00000000	20.00000000
		.000000000	15.00000000
0.000000000		.00000000	15.00000000
5.000000000		.000000000	10.00000000
0.000000000		.00000000	10.00000000
0.000000000		.00000000	10.00000000
5.000000000		.00000000	5.000000000
0.000000000	95	.00000000	5.000000000
0.000000000	95	.00000000	5.000000000
5.000000000	10	0.0000000	0.000000000
			90.00000000
			80.00000000
			70.00000000
			60.00000000
			50.00000000
			40.00000000
			30.00000000
			20.00000000
10.00000000			10.00000000
10.00000000	10	0.0000000	0.000000000
n Random Number	Generati	on	
	Probability(%) 10.00000000 10.00000000 10.00000000 10.00000000	Probability(\$) Cumula 10.00000000 10 10.00000000 20 10.00000000 30 10.00000000 40 10.00000000 50 10.00000000 60 10.00000000 80 10.00000000 90 10.00000000 10	10.00000000 20.00000000 10.00000000 30.00000000 10.00000000 40.0000000 10.00000000 50.00000000 10.00000000 70.00000000 10.00000000 80.00000000 10.00000000 90.00000000

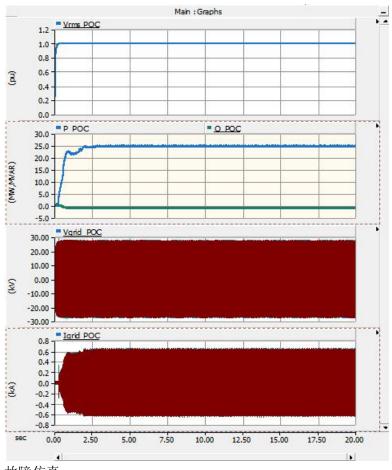
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3	2	1000	0.10799012	78E-04 0.128177436	5E-02
4	3	1000	0.16198302	28E-04 0.192266154	7E-02
5	4	1000	0.21597447	20E-04 0.256254872	9E-02
6	5	1000	0 26996447	54E-04 0.320443591	1F-02
7	6	1000			
				32E-04 0.384532309	
8	7	1000		54E-04 0.448621027	
9	В	1000	0.43192581	21E-04 0.512709745	8E-02
10	9	1000	0.48591003	33E-04 0.576798464	0E-02
11	10	1000	0.53989380	92E-04 0.640887182	2E-02
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38 S 3 S 3 S 3 S 3 S 3 S 3 S 3 S 3 S 3 S					
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17	16	1000		64E-04 0.102541949	
	2.77				
18	17	1000		70E-04 0.108950821	
19	18	1000	0.97170299	28E-04 0.115359692	8E-01
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22	21	1000		73E-03 0.134586308	
23	22	1000	0.11875734	10E-03 0.140995180	1E-01
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26	25	1000		57E-03 0.160221795	
7.7					
27	26	1000		18E-03 0.166630667	
28	27	1000	0.14573789	35E-03 0.173039539	2E-01
29	28	1000	0.15113357	07E-03 0.179448411	0E-01
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35	34	1000	0.18350460	25E-03 0.217901642	0E-01
36	35	1000		92E-03 0.224310513	
10 mm	10000				
27	36	1000		16E-03 0.230719385	
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46	45	1000		92E-03 0.288399232	
47	46	1000			8E-01
			0.24823107	86E-03 0.294808103	
48	100				7E-01
48	47	1000	0.25362401	38E-03 0.301216975	
48 49	47 48	1000 1000	0.25362401 0.25901680	38E-03 0.301216975 48E-03 0.307625847	5E-01
48 49 50	47 48 49	1000 1000 1000	0.25362401 0.25901680 0.26440945	38E-03 0.301216975 48E-03 0.307625847 15E-03 0.314034719	5E-01 3E-01
48 49	47 48	1000 1000	0.25362401 0.25901680 0.26440945	38E-03 0.301216975 48E-03 0.307625847	5E-01 3E-01
48 49 50	47 48 49	1000 1000 1000	0.25362401 0.25901680 0.26440945	38E-03 0.301216975 48E-03 0.307625847 15E-03 0.314034719	5E-01 3E-01
48 49 50 51	47 48 49 50	1000 1000 1000 1000	0.25362401 0.25901680 0.26440945	38E-03 0.301216975 48E-03 0.307625847 15E-03 0.314034719 40E-03 0.320443591	5E-01 3E-01 1E-01
48 49 50 51	47 48 49 50 m occurred f	1000 1000 1000 1000 1000	0.25362401 0.25901680 0.26440945 0.26980195 and has been repeate	38E-03 0.301216975 48E-03 0.307625847 15E-03 0.314034719 40E-03 0.320443591	5E-01 3E-01 1E-01 belor
48 49 50 51	47 48 49 50 m occurred f	1000 1000 1000 1000	0.25362401 0.25901680 0.26440945 0.26980195 and has been repeate	38E-03 0.301216975 48E-03 0.307625847 15E-03 0.314034719 40E-03 0.320443591 d for the last run	5E-01 3E-01 1E-01 belon
48 49 50 51 The optimus Run #	47 48 49 50 m occurred f inradia	1000 1000 1000 1000 1000 for run # 51 ttion temper	0.25362401 0.25901680 0.26440945 0.26980195 and has been repeate	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.314034719 40E-03 0.320443591 d for the last run 1 Out #	5E-01 3E-01 1E-01 belon
48 49 50 51 The optimus Run #	47 48 49 50 m occurred f inradia	1000 1000 1000 1000 for run \$ 51 temper 1000	0.25362401 0.25901680 0.26440945 0.26980195 and has been repeate ature Out \$ 0.26980195	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.314034719 40E-03 0.320443591 d for the last run 1 Out #	5E-01 3E-01 1E-01 belon
48 49 50 51 The optimus Run # 52 Statistica:	47 48 49 50 m occurred f inradia 50	1000 1000 1000 1000 50r run # 51 tition temper 1000	0.25362401 0.2590160 0.26940940 0.26980195 and has been repeate ature Out \$ 0.26980195	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.314034719 40E-03 0.320443591 d for the last run 1 Out #	5E-01 3E-01 1E-01 belon
48 49 50 51 The optimus Run # 52 Statistica:	47 48 49 50 m occurred f inradia 50	1000 1000 1000 1000 1000 for run \$ 51 tition temper 1000 sed on 51 Ru	0.25362401 0.25901680 0.26440945 0.26980195 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195	38E-03 0.301216975 48E-03 0.307625847 15E-03 0.314034719 40E-03 0.320443591 d for the last run 1 Out # 40E-03 0.320443591	5E-01 3E-01 1E-01 belon
48 49 50 51 The optimum Run # 52	47 48 49 50 m occurred f inradia 50 l Summary Ba	1000 1000 1000 1000 1000 for run \$ 51 temper 1000	0.25362401 0.25901600 0.2694090 0.26980195 and has been repeate ature Out \$ 0.26980195	38E-03 0.301216975 48E-03 0.307625847 15E-03 0.314034719 40E-03 0.320443591 d for the last run 1 Out # 40E-03 0.320443591	5E-01 3E-01 1E-01 belon
48 49 50 51 The optimum Run # 52 Statistical	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.00000000	1000 1000 	0.25362401 0.25901680 0.26940945 0.26980195 and has been repeate ature Out \$ 0.26980195 uns: tre Out \$ 1 00 0.00000000000000000000000000000000	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 0 to the last run 1	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52	47 48 49 50 m occurred f inradia 50 l Summary Ba	1000 1000 	0.25362401 0.25901680 0.26940945 0.26980195 and has been repeate ature Out \$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 15E-03 0.310423591 40E-03 0.320443591 Out # 2 0.000000000 -03 0.320443591E-	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.00000000	1000 1000 	0.25362401 0.25901680 0.26940945 0.26980195 and has been repeate ature Out \$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 0 to the last run 1	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean:	47 48 49 50 m occurred f inradia 50 1 Summary Ba inradiatio 0.0000000 50.0000000 25.0000000	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$ 0.26980195 uns: ure Out \$ 1 00 0.00000000 00 0.2698019540E 00 0.1349304611E	38E-03 0.301216975 48E-03 0.307625847 15E-03 0.314024719 40E-03 0.320443591 d for the last run 1 Out \$ 40E-03 0.320443591 Out \$ 2 0.000000000 -03 0.320443591E-03 0.1603217956E-	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev:	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687	1000 1000 	0.25362401 0.25901680 0.26940945 0.26980195 and has been repeate ature Out \$ 0.26980195 us: Out \$ 1 00 0.00000000 00 0.2698019540E 00 0.134980461EE 00 0.8021788467E	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out # 40E-03 0.320443591 Out # 2 0.000000000 -03 0.3204435911E-03 0.1603217556E- 04 0.9527473910E-	5E-01 3E-01 1E-01 below 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev:	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687	1000 1000 	0.25362401 0.25901680 0.26940945 0.26980195 and has been repeate ature Out \$ 0.26980195 us: Out \$ 1 00 0.00000000 00 0.2698019540E 00 0.134980461EE 00 0.8021788467E	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out # 40E-03 0.320443591 Out # 2 0.000000000 -03 0.3204435911E-03 0.1603217556E- 04 0.9527473910E-	5E-01 3E-01 1E-01 below 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev:	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687	1000 1000 	0.25362401 0.25901680 0.26940945 0.26980195 and has been repeate ature Out \$ 0.26980195 us: Out \$ 1 00 0.00000000 00 0.2698019540E 00 0.134980461EE 00 0.8021788467E	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out # 40E-03 0.320443591 Out # 2 0.000000000 -03 0.3204435911E-03 0.1603217556E- 04 0.9527473910E-	5E-01 3E-01 1E-01 below 2 1E-01
48 49 50 51 The optimum Run # 52 Statistica Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level:	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 14.866067 -5.53117294 55.53117294	1000 1000	0.25362401 0.25901680 0.26940195 0.26980195 and has been repeate 0ut \$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.214034719 40E-03 0.320443591 d for the last run 1	5E-01 3E-01 1E-01 below 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level:	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.000000 25.0000000 48.660687 -5.53117294 55.5311729	1000 1000	0.25362401 0.25901680 0.26940945 0.26980195 and has been repeate ature Out \$ 1 0.26980195 uns: ure Out \$ 1 00 0.00000000 00.2698019540E 00 0.2698019540E 00 0.2698019540E 00 0.29981693459E 00 0.2996778568E Variable 1, Out \$ 1	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out # 40E-03 0.320443591 Out # 2 0.000000000 -03 0.3204435911E-03 0.1602217956E04 0.9527472510E04 0.9527472510E04 0.3558921696E-	5E-01 3E-01 1E-01 below 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Mean: Std Dev: 20 Level: 900 Level: Probability	47 48 49 50 m occurred f inradia 50 1 Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687 -5.5311729 55.5311729 y Density Fu	1000 1000	0.25362401 0.25901680 0.26940195 0.26980195 and has been repeate ature Out \$ 0.26980195 us: cre Out \$1 000 0.00000000 000 0.26980195400 00 0.1949204611E 000 0.8021788467E 000 0.2996778568E Variable 1, Out \$1	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out \$ 40E-03 0.320443591 Out \$2 0.000000000 -03 0.200443591E04 0.9527472910E043544857845E03 0.2558921696E-	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Mean: Std Dev: 20 Level: 900 Level: Probability	47 48 49 50 m occurred f inradia 50 1 Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687 -5.5311729 55.5311729 y Density Fu	1000 1000	0.25362401 0.25901680 0.26940195 0.26980195 and has been repeate ature Out \$ 0.26980195 us: cre Out \$1 000 0.00000000 000 0.26980195400 00 0.1949204611E 000 0.8021788467E 000 0.2996778568E Variable 1, Out \$1	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out \$ 40E-03 0.320443591 Out \$2 0.000000000 -03 0.200443591E04 0.9527472910E043544857845E03 0.2558921696E-	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Mean: Std Dev: 20 Level: 900 Level: Probability	47 48 49 50 m occurred f inradia 50 1 Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687 -5.5311729 55.5311729 y Density Fu	1000 1000	0.25362401 0.25901680 0.26940195 0.26980195 and has been repeate ature Out \$ 0.26980195 us: cre Out \$1 000 0.00000000 000 0.26980195400 00 0.1949204611E 000 0.8021788467E 000 0.2996778568E Variable 1, Out \$1	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out \$ 40E-03 0.320443591 Out \$2 0.000000000 -03 0.200443591E04 0.9527472910E043544857845E03 0.2558921696E-	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Mean: Std Dev: 20 Level: 900 Level: Probability	47 48 49 50 m occurred f inradia 50 1 Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687 -5.5311729 55.5311729 y Density Fu	1000 1000	0.25362401 0.25901680 0.26940195 0.26980195 and has been repeate ature Out \$ 0.26980195 us: cre Out \$1 000 0.00000000 000 0.26980195400 00 0.1949204611E 000 0.8021788467E 000 0.2996778568E Variable 1, Out \$1	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out \$ 40E-03 0.320443591 Out \$2 0.000000000 -03 0.200443591E04 0.9527472910E043544857845E03 0.2558921696E-	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Mean: Std Dev: 20 Level: 900 Level: Probability	47 48 49 50 m occurred f inradia 50 1 Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687 -5.5311729 55.5311729 y Density Fu	1000 1000	0.25362401 0.25901680 0.26940195 0.26980195 and has been repeate ature Out \$ 0.26980195 us: cre Out \$1 000 0.00000000 000 0.26980195400 00 0.1949204611E 000 0.8021788467E 000 0.2996778568E Variable 1, Out \$1	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out \$ 40E-03 0.320443591 Out \$2 0.000000000 -03 0.200443591E04 0.9527472910E043544857845E03 0.2558921696E-	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Mean: Std Dev: 20 Level: 900 Level: Probability	47 48 49 50 m occurred f inradia 50 1 Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687 -5.5311729 55.5311729 y Density Fu	1000 1000	0.25362401 0.25901680 0.26940195 0.26980195 and has been repeate ature Out \$ 0.26980195 us: cre Out \$1 000 0.00000000 000 0.26980195400 00 0.1949204611E 000 0.8021788467E 000 0.2996778568E Variable 1, Out \$1	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.214034719 40E-03 0.320443591 d for the last run 1 Out \$ 40E-03 0.320443591 Out \$2 0.000000000 -03 0.200443591E04 0.9527472910E043544857845E03 0.2558921696E-	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Mean: Std Dev: 20 Level: 900 Level: Probability	47 48 49 50 m occurred f inradia 50 1 Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660687 -5.5311729 55.5311729 y Density Fu	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.00000000 -03 0.320443591E-03 0.1602217956E-04 0.9527472910E-04 0.9527472910E-04 0.3544857845E-03 0.3558921696E- 100-Cumulative Pr 90.158023529 50.78623529	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 90.12490097 0.67450488 0.94430683 0.94430683 0.92410687	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660657 -5.53117294 55.53117294 y Density Fu Range Pr 70E-04 9 50E-04 9	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.00000000 -03 0.320443591E-03 0.1602217956E-04 0.9527472910E-04 0.9527472910E-04 0.3544857845E-03 0.3558921696E- 100-Cumulative Pr 90.158023529 50.78623529	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 90.12490097 0.67450488 0.94430683 0.94430683 0.92410687	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660657 -5.53117294 55.53117294 y Density Fu Range Pr 70E-04 9 50E-04 9	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.00000000 -03 0.320443591E-03 0.1602217956E-04 0.9527472910E-04 0.9527472910E-04 0.3544857845E-03 0.3558921696E- 100-Cumulative Pr 90.158023529 50.78623529	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 90.12490097 0.67450488 0.94430683 0.94430683 0.92410687	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660657 -5.53117294 55.53117294 y Density Fu Range Pr 70E-04 9 50E-04 9	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.00000000 -03 0.320443591E-03 0.1602217956E-04 0.9527472910E-04 0.9527472910E-04 0.3544857845E-03 0.3558921696E- 100-Cumulative Pr 90.158023529 50.78623529	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 90.12490097 0.67450488 0.94430683 0.94430683 0.92410687	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660657 -5.53117294 55.53117294 y Density Fu Range Pr 70E-04 9 50E-04 9	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.00000000 -03 0.320443591E-03 0.1602217956E-04 0.9527472910E-04 0.9527472910E-04 0.3544857845E-03 0.3558921696E- 100-Cumulative Pr 90.158023529 50.78623529	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 90.12490097 0.67450488 0.94430683 0.94430683 0.92410687	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660657 -5.53117294 55.53117294 y Density Fu Range Pr 70E-04 9 50E-04 9	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.00000000 -03 0.320443591E-03 0.1602217956E-04 0.9527472910E-04 0.9527472910E-04 0.3544857845E-03 0.3558921696E- 100-Cumulative Pr 90.158023529 50.78623529	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 90.12490097 0.67450488 0.94430683 0.94430683 0.92410687	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660657 -5.53117294 55.53117294 y Density Fu Range Pr 70E-04 9 50E-04 9	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.00000000 -03 0.320443591E-03 0.1602217956E-04 0.9527472910E-04 0.9527472910E-04 0.3544857845E-03 0.3558921696E- 100-Cumulative Pr 90.158023529 50.78623529	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 90.12490097 0.67450488 0.94430683 0.94430683 0.92410687	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660657 -5.53117294 55.53117294 y Density Fu Range Pr 70E-04 9 50E-04 9	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.00000000 -03 0.320443591E-03 0.1602217956E-04 0.9527472910E-04 0.9527472910E-04 0.3544857845E-03 0.3558921696E- 100-Cumulative Pr 90.158023529 50.78623529	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 90.12490097 0.67450488 0.94430683 0.94430683 0.92410687	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.8660657 -5.53117294 55.53117294 y Density Fu Range Pr 70E-04 9 50E-04 9	1000 1000	0.25362401 0.25901680 0.26940195 0.26980195 and has been repeate ature Out \$ 0.26980195 us: cre Out \$1 000 0.00000000 000 0.26980195400 00 0.1949204611E 000 0.8021788467E 000 0.2996778568E Variable 1, Out \$1	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.00000000 -03 0.320443591E-03 0.1602217956E-04 0.9527472910E-04 0.9527472910E-04 0.3544857845E-03 0.3558921696E- 100-Cumulative Pr 90.158023529 50.78623529	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Maximum: Mean: 38td Dev: 28 Level: 90% Level: Probability Centre of I 0.12490097' 0.40470293: 0.674504883 0.12141087: 0.17837127(0.202351460 0.235331660	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 25.0000000 25.0000000 48.8660687 -5.53117294 55.5311729 y Density Fu Parage Pr 70E-04 9 10E-04	1000 1000	0.25362401 0.25901680 0.26940945 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 us:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 48E-03 0.214034719 40E-03 0.320443591 Out # 2 0.000000000 -03 0.3204435911E- 03 0.1602217956E- 04 0.3527472510E- 04 0.3527472510E- 04 0.3527472510E- 04 0.35215686 70.58822539 60.78431373 50.98039216 41.17647059 21.37254902 21.56862745 11.76470588 0.0000000000	5E-01 3E-01 1E-01 belon 2 1E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Maximum: Mean: 20 Level: 900 Level:	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 25.0000000 25.0000000 4.8660687 -5.53117294 55.53117294 9000000 9000000 90000000000000000000	1000 1000	0.25362401 0.25901680 0.26940195 and has been repeate ature Out \$ 0.26980195 us: 0.26980195 us: 0.26980195 us: 0.26980195 us: 0.26980195 us: 0.26980195 us: 0.2698019540E 0.2698019540E 0.2698019540E 0.2698019540E 0.2698019540E 0.2698019540E 0.2698019540E 0.2698019540E 0.2981693459E 0.299677856E Variable 1, Out \$ 1 'ummulative Prob.(*) 9.803921569 19.60784214 29.41176471 39.21568627 49.01960784 58.82352941 68.62745098 78.43137255 68.23529412 100.0000000 Variable 2, Out \$ 2	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.3107625847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.000000000 Out # 2 0.0000000000 Out # 2 0.00000000000 Out # 2 0.00000000000000000000000000000000000	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level: Probability Centre of I 0.12490097' 0.40470293' 0.674504868' 0.12141087' 0.14639107' 0.20235146' 0.22593166' 0.25631185' Probability Centre of I	47 48 49 50 m occurred f inradiation 50 1 Summary Ba inradiation 0.0000000 25.0000000 14.8660687 -5.53117294 55.5311729 y Density Fu Range Pr 70E-04 9 50E-04 9 93E-03 9 47E-03 9 93E-03 9 47E-03 9 93E-03 9 63E-03 1 y Density Fu	1000 1000	0.25362401 0.25901600 0.26940195 and has been repeate ature Out \$ 1 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.310434719 40E-03 0.320443591 Out # 2 0.00000000 O3 0.320443591 O4 0.320443591 O4 0.320443591 O5 0.32043591 O5 0.32043591 O5 0.32043591 O5 0.32043 O5 0.3204	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level: Probability Centre of I 0.12490097' 0.40470293' 0.674504868' 0.12141087' 0.14639107' 0.20235146' 0.22593166' 0.25631185' Probability Centre of I	47 48 49 50 m occurred f inradiation 50 1 Summary Ba inradiation 0.0000000 25.0000000 14.8660687 -5.53117294 55.5311729 y Density Fu Range Pr 70E-04 9 50E-04 9 93E-03 9 47E-03 9 93E-03 9 47E-03 9 93E-03 9 63E-03 1 y Density Fu	1000 1000	0.25362401 0.25901600 0.26940195 and has been repeate ature Out \$ 1 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 18E-03 0.310425847 18E-03 0.310434719 40E-03 0.320443591 Out # 2 0.00000000 O3 0.320443591 O4 0.320443591 O4 0.320443591 O5 0.32043591 O5 0.32043591 O5 0.32043591 O5 0.32043 O5 0.3204	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level: Probability Centre of I 0.12490097' 0.40470293' 0.674504868' 0.12141087' 0.14639107' 0.20235146' 0.22593166' 0.25631185' Probability Centre of I	47 48 49 50 m occurred f inradiation 50 1 Summary Ba inradiation 0.0000000 25.0000000 14.8660687 -5.53117294 55.5311729 y Density Fu Range Pr 70E-04 9 50E-04 9 93E-03 9 47E-03 9 93E-03 9 47E-03 9 93E-03 9 63E-03 1 y Density Fu	1000 1000	0.25362401 0.25901600 0.26940195 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.000000000 Out # 2 0.00000000000 Out # 2 0.00000000000000000000000000000000000	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 20 Level: 900 Level: 900 Level: 0.13490097 0.40470293: 0.94430683 0.94430683 0.12141087 0.17537127 0.20235146 0.2253146 0.2553185 Probabilit: Centre of I 0.160221796 0.48066538 0.48066538	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.00000000 50.0000000 25.0000000 14.866067 -5.53117294 55.53117294 95.53117294 901000000 901000000000000000000000000	1000 1000	0.25362401 0.25901600 0.26940195 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.000000000 Out # 2 0.00000000000 Out # 2 0.00000000000000000000000000000000000	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistica: Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level: Probabilit; Centre of I 0.12490097' 0.40470293: 0.1241087' 0.17537127' 0.20235146' 0.22932166' 0.25631185' Probabilit; Centre of I 0.16022179' 0.48066538, 0.80110897' 0.48066538, 0.80110897'	47 48 49 50 m occurred f inradiation 50 1 Summary Ba inradiation 0.0000000 25.0000000 48.8660687 -5.53117294 55.5311729 y Density Fu Range Pr 70E-04 99 50E-04 99 50E-	1000 1000	0.25362401 0.25901600 0.26940195 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.000000000 Out # 2 0.00000000000 Out # 2 0.00000000000000000000000000000000000	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistica: Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level: Probabilit; Centre of I 0.12490097' 0.40470293: 0.1241087' 0.17537127' 0.20235146' 0.22932166' 0.25631185' Probabilit; Centre of I 0.16022179' 0.48066538, 0.80110897' 0.48066538, 0.80110897'	47 48 49 50 m occurred f inradiation 50 1 Summary Ba inradiation 0.0000000 25.0000000 48.8660687 -5.53117294 55.5311729 y Density Fu Range Pr 70E-04 99 50E-04 99 50E-	1000 1000	0.25362401 0.25901600 0.26940195 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.000000000 Out # 2 0.00000000000 Out # 2 0.00000000000000000000000000000000000	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistica: Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level: Probabilit; Centre of I 0.12490097' 0.40470293: 0.1241087' 0.17537127' 0.20235146' 0.22932166' 0.25631185' Probabilit; Centre of I 0.16022179' 0.48066538, 0.80110897' 0.48066538, 0.80110897'	47 48 49 50 m occurred f inradiation 50 1 Summary Ba inradiation 0.0000000 25.0000000 48.8660687 -5.53117294 55.5311729 y Density Fu Range Pr 70E-04 99 50E-04 99 50E-	1000 1000	0.25362401 0.25901600 0.26940195 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.000000000 Out # 2 0.00000000000 Out # 2 0.00000000000000000000000000000000000	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistica: Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level: Probabilit; Centre of I 0.12490097' 0.40470293: 0.1241087' 0.17537127' 0.20235146' 0.22932166' 0.25631185' Probabilit; Centre of I 0.16022179' 0.48066538, 0.80110897' 0.48066538, 0.80110897'	47 48 49 50 m occurred f inradiation 50 1 Summary Ba inradiation 0.0000000 25.0000000 48.8660687 -5.53117294 55.5311729 y Density Fu Range Pr 70E-04 99 50E-04 99 50E-	1000 1000	0.25362401 0.25901600 0.26940195 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 18E-03 0.214034719 40E-03 0.320443591 Out # 2 0.000000000 Out # 2 0.00000000000 Out # 2 0.00000000000000000000000000000000000	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistica: Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level: Probabilit; Centre of I 0.12490097' 0.40470293: 0.1241087' 0.17537127' 0.20235146' 0.22932166' 0.25631185' Probabilit; Centre of I 0.16022179' 0.48066538, 0.80110897' 0.48066538, 0.80110897'	47 48 49 50 m occurred f inradiation 0.0000000 50.0000000 25.0000000 14.8660687 -5.53117294 55.5311729 y Density Fu Range Pr 70E-04 9 50E-04 9 50E-04 9 50E-04 9 50E-03 9 61E-03 9 71E-03 9	1000 1000	0.25362401 0.25901600 0.26940195 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 48E-03 0.314034719 40E-03 0.320443591 Out \$ 2 0.000000000 Out \$ 2 0.0000000000 Out \$ 2 0.00000000000 Out \$ 2 0.00000000000000000000000000000000000	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 90% Level: 90% Level: 90% Level: 0.12490097' 0.40470293: 0.67450488! 0.12141087: 0.17537127' 0.160221796 0.20235146! 0.25631185: Probability Centre of I 0.160221796 0.404066538, 0.80110997' 0.11215525: 0.144199661. 0.176242979' 0.20288833	47 48 49 50 m occurred f inradiation 0.00000000 50.0000000 25.0000000 14.8660687 -5.53117294 55.53117294 55.53117294 90E-04 99 90E-04 99 90E-04 99 90E-03 99 47E-03 99	1000 1000	0.25362401 0.25901680 0.26940193 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 48E-03 0.314034719 40E-03 0.320443591 Out \$ 2 0.000000000 Out \$ 2 0.0000000000 Out \$ 2 0.00000000000 Out \$ 2 0.00000000000000000000000000000000000	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: Probabilit; Centre of I 0.13490097; 0.40470293; 0.12141087; 0.2953146; 0.2563185; Probabilit; Centre of I 0.16022179; 0.16022179; 0.16022179; 0.11215525; 0.14419961; 0.17624297; 0.2028883; 0.2028883; 0.2028883; 0.24032269; 0.2028883;	47 48 49 50 m occurred f inradia 50 l Summary Ba 0.0000000 50.0000000 25.0000000 14.866067 -5.53117294 55.53117294 75.53117294 901000000 901000000000000000000000000	1000 1000	0.25362401 0.25901680 0.26940195 and has been repeate ature Out \$ 0.26980195 us: 100 0.000000000 000 0.2698019540E 000 0.349304611E 000 0.8021788467E 0002981693455E 000 0.2996778568E Variable 1, Out \$ 1 Cumulative Prob. (\$) 9.803921569 19.60784214 29.41176471 39.21568627 49.01960784 58.82352941 68.62745098 78.43137255 88.2352941 29.41176471 39.21568627 49.01960784 58.82352941 68.62745098 78.43176471 39.21568627 49.01960784 58.82352941 68.62745098 78.4317255	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 48E-03 0.314034719 40E-03 0.320443591 d for the last run 1	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 98% Level: 0.12490097: 0.40470293: 0.42430683: 0.12141087: 0.22932166: 0.2563185: Probabilit; Centre of I 0.160221798: 0.4806538: 0.80110897: 0.17624297! 0.17624297! 0.20288833:	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.866067 -5.53117294 55.53117294 75.53117294 9012-04 9902-04 9922-03 9422-03 9422-01 952662 9772-02 9662-02 9772-02 9662-01 9662-01 97812-01 9812-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01	1000 1000	0.25362401 0.25901680 0.26940195 and has been repeate ature Out \$ 0.26980195 us: 100 0.000000000 000 0.2698019540E 000 0.349304611E 000 0.8021788467E 0002981693455E 000 0.2996778568E Variable 1, Out \$ 1 Cumulative Prob. (\$) 9.803921569 19.60784214 29.41176471 39.21568627 49.01960784 58.82352941 68.62745098 78.43137255 88.2352941 29.41176471 39.21568627 49.01960784 58.82352941 68.62745098 78.43176471 39.21568627 49.01960784 58.82352941 68.62745098 78.4317255	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 48E-03 0.314034719 40E-03 0.320443591 d for the last run 1	5E-01 3E-01 1E-01 belon 21E-01
48 49 50 51 The optimum Run # 52 Statistical Minimum: Maximum: Mean: Std Dev: 2% Level: 98% Level: 98% Level: 0.12490097: 0.40470293: 0.42430683: 0.12141087: 0.22932166: 0.2563185: Probabilit; Centre of I 0.160221798: 0.4806538: 0.80110897: 0.17624297! 0.17624297! 0.20288833:	47 48 49 50 m occurred f inradia 50 l Summary Ba inradiatio 0.0000000 50.0000000 25.0000000 14.866067 -5.53117294 55.53117294 75.53117294 9012-04 9902-04 9922-03 9422-03 9422-01 952662 9772-02 9662-02 9772-02 9662-01 9662-01 97812-01 9812-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01 9912-01	1000 1000	0.25362401 0.25901680 0.26940193 and has been repeate ature Out \$\frac{1}{2}\$ 0.26980195 uns:	38E-03 0.301216975 48E-03 0.307625847 48E-03 0.307625847 48E-03 0.314034719 40E-03 0.320443591 d for the last run 1	5E-01 3E-01 1E-01 belon 21E-01

Initial Seed Used in Random Number Generation

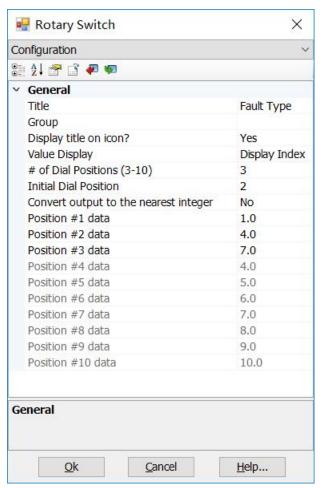
Initial Seed 2072173541

(2) 示例故障仿真 无故障仿真:

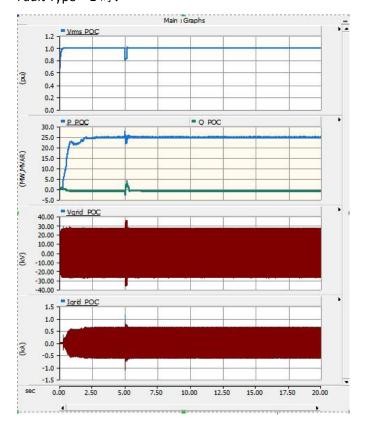




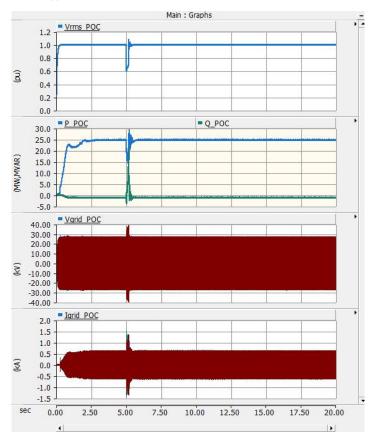
故障仿真:



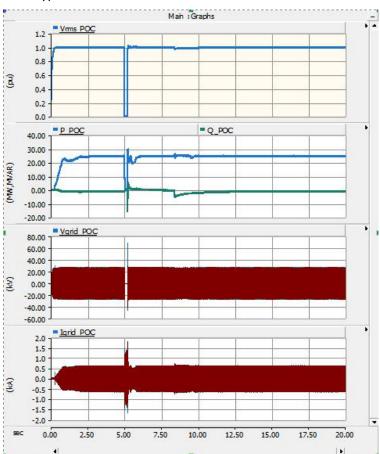
Fault Type = 1 时:



Fault Type = 2 时:



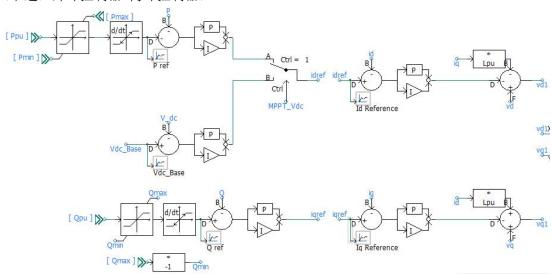
Fault Type = 3 时:

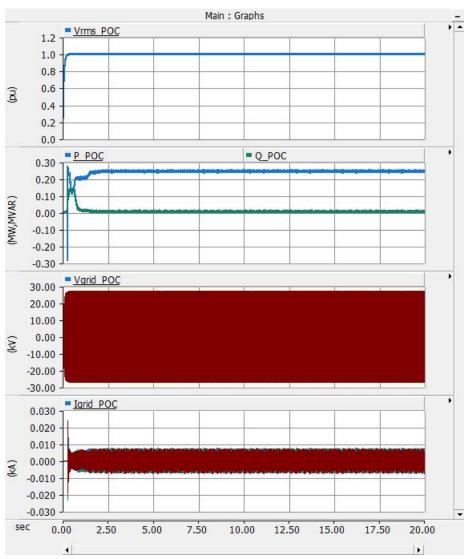


(3) 自搭系统仿真

先搭恒功率系统。

(节选)外环控制器+内环控制器:



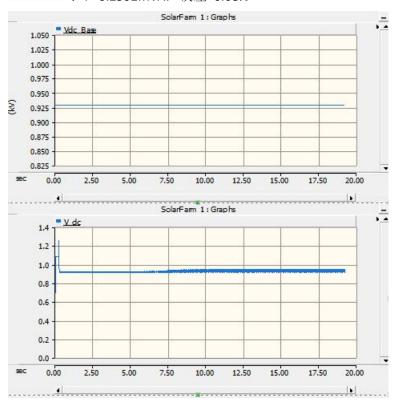


P=0.2515MVA,误差=0.6%

从恒 PQ 控制改成恒 Udc 恒 Q 控制——把恒 P 换成恒 Udc:



: P=0.2502MVA,误差=0.08%



五、实验结果与分析

仿真实验中恒 Udc 恒 Q 控制比恒 PQ 控制得到的输出功率更稳定,误差更小,效果更好。

六、讨论、心得

系统真的很复杂,都是王老师一点一点、一个模块一个模块地讲清楚的。这门课程让我更加了解了微电网,更加理解微电网的构成、运行及控制,初步掌握光伏、蓄电池、风能等发电技术,能简易设计微网结构并建模。