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Overview:

1P1Q screening estimates the complex voltage V vector following a disturbance. This project considers either an outage if generator 2 or generator 3 , but not both, affecting the voltage. The program flow and algorithm is as follows:

Run pre-contingency fast-decoupled XB version power flow analysis
Obtain base case complex voltage vector V
Ask the user to select a valid generator (either 2 or 3) to be out
Delete the user selected generator from the gen data structure
Edit the radial branch reactance and resistance of the generator out to be near infinity*
Determine Bp,Bpp,Sbus,Ybus,Yf,Yt
Determine bus types (pv, pq values)
Perform 1P half=iteration
- Compute real power mismatch and delP
- Determine swing bus
- Remove swing bus from Bp matrix
- Creates temporary Vm voltage magnitudes and removes the swing bus
- Computes delTheta
- Augments delTheta for the swing bus
- Updates the complex voltage

Perform 1Q half-iteration
- Determines the swing bus
- Removes swing and pv buse(s) from Bpp and Vm matrices
- Computes Reactive Power Mismatch
- Computes delVmag
- Augment the delVmag for the swing and pv bus(s)
- Update the complex voltage

Compute Branch flows
- Reads data and converts to internal bus numbering
- Calculates complex power at from branch
- Calculates complex power at the to branch

Display Branch flows
- Prints the post-contingency branch flows at from and to ends in MATLAB

* The author found out that to approximate the 1P1Q bus flows to that of the AC solution, that the outage generator branch had to be modeled as “almost-off” so that power would not want to flow there. The pre-contingency solution considered it in service, however, when the generator is out, there is no load and incentive for the power to flow down the node to the bus. The AC solution correctly assigned a 0 flow to the post-contingency solution, but in the 1P1Q process, without the branch impedances taken to infinity, there would be >0 (big number) of branch flow on that branch, which does not make sense. By changing the branch impedance to near infinity, it corrects the current calculations and hence the power flows.

Output showing the updated "nbus" voltage angle values in radians after the 1P half-iteration of Fast Decoupled for each generator unit outage. Be sure to include the swing angle in your output.

Generator 2 Out

	Vm	Vang
1	1.04	0
2	1.025	-2.2411
3	1.025	-0.16055
4	1.0258	-0.13022
5	0.99563	-0.24741
6	1.0127	-0.20871
7	1.0258	-0.27626
8	1.0159	-0.28715
9	1.0324	-0.20764

Generator 3 Out

	Vm	Vang
1	1.04	0
2	1.025	0.036593
3	1.025	-0.11991
4	1.0258	-0.086116
5	0.99563	-0.14398
6	1.0127	-0.15838
7	1.0258	-0.060453
8	1.0159	-0.13549
9	1.0324	-0.1458

Output showing the updated "nbus" voltage magnitude values after the 1Q half-iteration of Fast Decoupled for each generator unit outage. Be sure to include the generator voltage magnitudes in your output.

Generator 2 Out

	Vm	Vang
1	1.04	0
2	1.3548	0.90046
3	1.025	-0.16055
4	1.0239	-0.13022
5	0.99281	-0.24741
6	1.0109	-0.20871
7	1.012	-0.27626
8	1.005	-0.28715
9	1.0269	-0.20764

Generator 3 Out

	Vm	Vang
1	1.04	0
2	1.025	0.036593
3	1.0646	-0.11991
4	1.0303	-0.086116
5	1.0018	-0.14398
6	1.0192	-0.15838
7	1.0276	-0.060453
8	1.0186	-0.13549
9	1.0382	-0.1458

Output showing the estimated "nbranch" post-contingency MW, MVAR branch flows after the 1P1Q calculation for each generator unit outage. Be sure to show all the branch MW, MVAR flows.

For both generator 2 and 3 below, Matlab does output the branch flows, but since the MATLAB output resulting tables are too long for ms word, please accept screen shots of the output

<u>Generator 2 Out</u>

Fast-Decoupled 1P1Q Estimated Branch flows

From Bus	To Bus	From Bus Real Power (MW)	From Bus Reactive Power (MVAR)	To Bus Real Power (MW)	To Bus Reactive Power (MVAR)
1	4	240.066124	44.661591	-240.066124	-12.907886
2	7	0.000000	0.000000	-0.000000	0.000000
3	9	84.547346	-1.254200	-84.547346	5.242110
4	5	143.229419	19.613758	-141.193402	-20.207870
4	6	88.520069	-6.661154	-87.249101	-2.816381
5	7	15.108073	-29.651268	-14.965049	-0.379258
6	9	-2.689975	-27.166811	2.722795	-9.856532
7	8	16.316996	0.387304	-16.289564	-15.309090
8	9	-82.355862	-19.408496	83.164237	4.682779

<u>Generator 3 Out</u>

Fast-Decoupled 1P1Q Estimated Branch flows

From Bus	To Bus	From Bus Real Power (MW)	From Bus Reactive Power (MVAR)	To Bus Real Power (MW)	To Bus Reactive Power (MVAR)
1	4	160.001524	24.393760	-160.001524	-10.443470
2	7	163.291525	3.659101	-163.291525	12.210923
3	9	0.000000	-0.000000	-0.000000	0.000000
4	5	73.507427	18.574749	-72.925000	-31.797658
4	6	82.440529	-8.245765	-81.352105	-2.456973
5	7	-53.959366	-18.446525	54.890748	-8.379504
6	9	-9.906744	-27.650994	9.974374	-9.943916
7	8	109.457050	-3.904606	-108.491392	-3.513001
8	9	8.373392	-31.558952	-8.316136	9.936753

Table of MW flows using AC model versus 1P1Q model. Include absolute errors and explanation of results.
Table of MVA flows using AC model versus 1P1Q model. Include absolute errors and explanation of results.

Generator 2 Outaged										
FROM	**TO**	**1P1Q FROM MW**	**AC FROM MW**	**Errors**	**1P1Q FROM MVAR**	**AC FROM MVAR**	**1P1Q FROM MVA**	**ACFROM MVA**	**Errors**
1	4	240.07	234.43	5.63	44.66	43.85	244.19	238.50	5.69
2	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	9	84.55	85.00	0.45	-1.25	-0.39	84.56	85.00	0.44
4	5	143.23	144.26	1.03	19.61	20.11	144.57	145.66	1.09
4	6	88.52	90.17	1.65	-6.66	-6.56	88.77	90.41	1.64
5	7	15.11	17.20	2.09	-29.65	-29.56	33.28	34.20	0.92
6	9	-2.69	-1.15	1.54	-27.17	-27.34	27.30	27.37	0.07
7	8	16.32	17.03	0.72	0.39	0.32	16.32	17.04	0.71
8	9	-82.36	-83.00	0.64	-19.41	-19.81	84.61	85.33	0.72
FROM	**TO**	**1P1Q TO MW**	**AC TO MW**	**Errors**	**1P1Q TO MVAR**	**AC TO MVAR**	**1P1Q TO MVA**	**ACTO MVA**	**Errors**
1	4	-240.07	-234.43	5.63	-12.91	-13.55	240.41	234.83	5.59
2	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	9	-84.55	-85.00	0.45	5.24	4.42	84.71	85.11	0.40
4	5	-141.19	-142.20	1.00	-20.21	-20.44	142.63	143.66	1.03
4	6	-87.25	-88.85	1.60	-2.82	-2.66	87.29	88.89	1.60
5	7	-14.97	-17.03	2.07	-0.38	-0.32	14.97	17.04	2.07
6	9	2.72	1.18	1.54	-9.86	-9.66	10.23	9.73	0.49
7	8	-16.29	-17.00	0.71	-15.31	-15.19	22.35	22.80	0.45
8	9	83.16	83.82	0.66	4.68	5.24	83.30	83.98	0.69

Generator 3 Outaged									
FROM	**TO**	**1P1Q FROM MW**	**AC FROM MW**	**Errors**	**1P1Q FROM MVAR**	**AC FROM MVAR**	**1P1Q FROM MVA**	**ACFROM MVA**	**Errors**
1	4	160.00	155.63	4.37	24.39	22.93	161.85	157.31	4.54
2	7	163.29	163.00	0.29	3.66	3.19	163.33	163.03	0.30
3	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	5	73.51	73.07	0.44	18.57	18.20	75.82	75.30	0.52
4	6	82.44	82.56	0.12	-8.25	-8.45	82.85	82.99	0.14
5	7	-53.96	-52.51	1.45	-18.45	-18.48	57.03	55.66	1.36
6	9	-9.91	-8.53	1.38	-27.65	-27.73	29.37	29.01	0.36
7	8	109.46	109.61	0.16	-3.90	-3.98	109.53	109.68	0.16
8	9	8.37	8.64	0.27	-31.56	-31.57	32.65	32.73	0.08
FROM	**TO**	**1P1Q TO MW**	**AC TO MW**	**Errors**	**1P1Q TO MVAR**	**AC TO MVAR**	**1P1Q TO MVA**	**ACTO MVA**	**Errors**
1	4	-160.00	-155.63	4.37	-10.44	-9.75	160.34	155.93	4.41
2	7	-163.29	-163.00	0.29	12.21	12.62	163.75	163.49	0.26
3	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	5	-72.93	-72.49	0.43	-31.80	-31.52	79.56	79.05	0.51
4	6	-81.35	-81.47	0.12	-2.46	-2.27	81.39	81.50	0.11
5	7	54.89	53.39	1.50	-8.38	-8.64	55.53	54.08	1.44
6	9	9.97	8.59	1.39	-9.94	-9.94	14.08	13.14	0.95
7	8	-108.49	-108.64	0.15	-3.51	-3.43	108.55	108.70	0.15
8	9	-8.32	-8.59	0.27	9.94	9.94	12.96	13.14	0.18

Explanation of Results: Overall the 1P1Q seems to be a good approximation for the generator outage. The highest error approximations are seen at the swing bus, since the swing bus accounts for bringing the system back into swing after the outage. The branches 1-4 and 5-7 are to most error prone, also because they are main avenues for power to flow from generation to load. When generator 2 was outages, the radial branch 2-7 was treated as infinite branch with no power going into it. Since there is no load or incentive for the power to flow there, the MW, MVAR, and MVA values are at zero. The same can be said for generator 3 outage and branch 3-9.

Source code for computing the 1P half-iteration.

This is attached in the WinZip file called "Pit.m".

Source code for computing the 1Q half-iteration.

This is attached in the WinZip file called "Qit.m".

Source code for computing the branch MVA flows given the complex V estimate.

This is attached in the WinZip file called "computebranchflows.m".

Script file for generating all results.

The results were mostly exported into excel for analysis. The"Project3.xls"file is attached in the same WinZip file

Brief conclusions for project.

The 1P1Q method produced a good estimation for the generator outage compared to the AC solution. The most error in approximation came on the radial branch leading to the swing bus and the branch leading to the load. The method estimated both the MW and MVAR in good approximation. The results of the bus, Vmagnitude, and Vangles (in radians) were outputted in MATLAB after each 1P and 1Q half-iteration for a generator outage. The updated estimated complex V was then used to calculate the complex power branch flows. The post-contingency branch flows for the 1P1Q method is outputted at the end of the 1P1Q program. A separate program called "program3ac.m" runs the AC portion of the power flow analysis. It is important that before you run the AC solution, that the generator to be out, is commented out of the gen[] data structure in the wscc9bus.m file and saved. The AC solution looks only at the structure of the bus. The results of the AC power flow program will display the same complex branch power flows which are in good approximation to the 1P1Q method flows. The comparison of the flow values between 1P1Q and AC was done in excel. The excel file is attached for your reference.