

REACTIVE ENERGY MANAGEMENT IN GENERATOR



PRINCIPLE OF REACTIVE ENERGY MANAGEMENT

All electrical loads which operate by means of magnetic fields/electromagnetic field effects, such as motors, transformers, fluorescent lighting etc., basically consume two types of power, namely, active power and reactive power

ACTIVE POWER

It is the power used by the loads to meet the functional output requirement.

REACTIVE POWER

It is the power used by the load to meet its magnetic field equipments and the requirements of magnetic losses.

The reactive power is always 90 degree out of phase with respect to the active power.

The unit normally used to express the reactive power is VAR
(in practical usage kvar)

The apparent power kVA is the vector sum of active and reactive power.



EFFECTS OF REACTIVE ENERGY:

It is now obvious that both active and reactive energy are necessary inputs in all electrical systems. However the flow of reactive power has certain negative aspects which result in increased cost of electrical systems and also drop in the efficiency of system operations. The increased flow of reactive power results in the following adverse conditions.

- ★ Overloading of Generator.
- ★ Increased I²R losses leading to additional heating and loss of energy.
- ★ Higher KVA Demand on the system.

POWER FACTOR CORRECTION:

Capacitors are most cost effective and reliable static devices which can generate and supply reactive power (energy). Capacitors consume virtually negligible active power and able to produce reactive power locally, thus enabling Power Factor Correction for inductive loads.

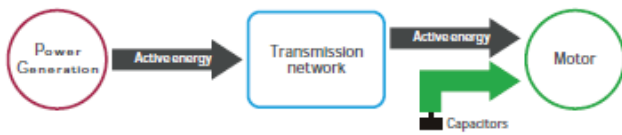


Fig.1

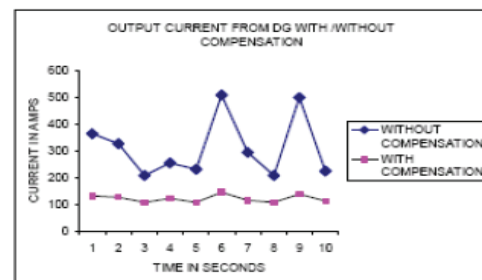


Fig.2

BENEFITS OF IMPROVING REACTIVE ENERGY MANAGEMENT :

By providing proper reactive energy management the adverse effect of flow of reactive energy can be minimized

Fig.3 provides some of the benefits of Reactive power management

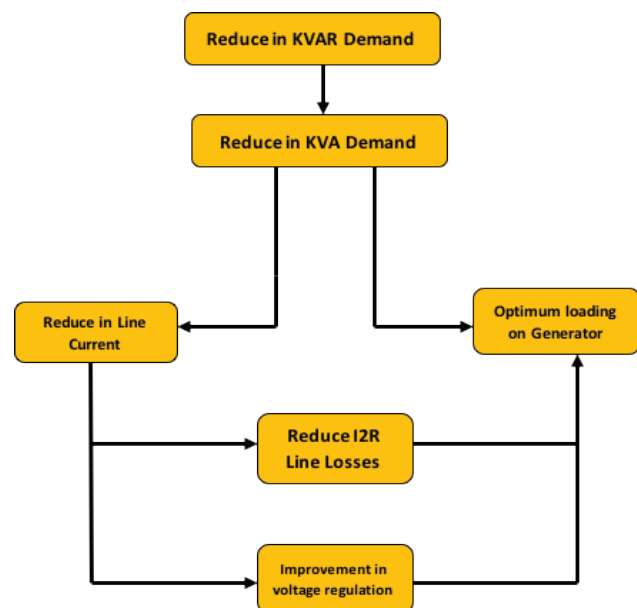


Fig.3



1. INCREASE IN AVAILABLE POWER

A higher power factor optimizes an electrical installation. Fitting APFC system on generator side increases available power at load side.

The table shows the increased available power at the generator output by improving power factor from 0.7 to 0.95 Pf

EXAMPLE 1

Calculation for additional load in kW that can be connected to the generator by improving power factor

Generator Capacity = 250 KVA
 Loading Capacity = 200 KVA (80% Loading)
 Initial Pf 1 = 0.70 pf
 Target Pf 2 = 0.95 pf
 PF = $\text{kW1} / \text{kVA}$
 kW 1 = $\text{kVA} \times \text{Pf1}$
 = 140 kW
 kW2 = $\text{kVA} \times \text{Pf2}$
 = 190 kW

P.F	Additional available power (kW)
0.7	0%
0.8	14.2%
0.9	28.5%
0.95	35%

Additional kW that can be connected = $190 - 140$
 = 50 kW
 % of Additional load = $50 / 140 \times 100$
 = 35 %

EXAMPLE 2

Calculation for additional load in kW that can be connected to the generator by improving power factor from 0.7 to 0.95

Generator Capacity = 500 kVA
 Loading Capacity = 400 kVA (80 % Loading)
 Initial Pf1 = 0.70 Pf
 Target Pf2 = 0.95Pf
 kW1 = $\text{kVA} \times \text{Pf1}$
 = 280 kW
 kW2 = $\text{kVA} \times \text{Pf2}$
 = 380 kW

P.F	Additional available power (kW)
0.7	0%
0.8	14.2%
0.9	28.5%
0.95	35%

Additional kW that can be connected = $380 - 280$
 = 100 kW
 % of Additional load = $100 / 280 \times 100$
 = 35 %



2. REDUCTION IN LINE CURRENT

Installing APFC Equipment results in

- ★ Reduce line current from source
- ★ Reduction in conductor cross section and reduced losses

The table shows that reduction of line current from the generator by improving power factor from 0.7 to 0.95 Pf

EXAMPLE 1

Generator Capacity = 250 kVA
 Loading Capacity = 200 kVA
 kVA1 = kW1 / Pf1
 = 140 / 0.7
 = 200 kVA
 I1 = kVA x 1000 / 1.732 x V
 = 200 x 1000 / 1.732 x 440
 = 262.4 A (Before Pf Compensation)
 kVA2 = kW / Pf2
 = 140 / 0.95
 = 147.36
 I2 = kVA x 1000 / 1.732 x V
 = 147.36 x 1000 / 1.732 x 440
 = 193.36 A (After Pf Compensation)
 Reduction of line current = 262.4 - 193.36
 = 69.04 A
 % of Reduction of line current = 69.04 / 262.4 x 100
 = 26.3%

P.F	Reduction of Line Current
0.7	0%
0.8	12.5%
0.9	22.6%
0.95	26.3%

EXAMPLE 2

Generator Capacity = 500kVA
 Loading Capacity = 400 kVA (80 % Loading)
 kVA1 = kW1 / Pf1
 = 280 / 0.7
 = 400 kVA
 I1 = kVA x 1000 / 1.732 x V
 = 400 x 1000 / 1.732 x 440
 = 524A (Before Pf Compensation)
 kVA2 = kW / Pf2
 = 280 / 0.95
 = 294 kVA
 I2 = kVA x 1000 / 1.732 x V
 = 294 x 1000 / 1.732 x 440
 = 385 A (After Pf Compensation)
 Reduction of line current = 524 - 385
 = 139 A
 % of Reduction of line current = 139 / 524 x 100
 = 26.5%

P.F	Reduction of Line Current
0.7	0%
0.8	12.35%
0.9	22.6%
0.95	26.3%



3. MAXIMUM CURRENT AT VARIOUS POWER FACTORS FOR 415V ALTERNATOR

kVA	Phase	Duty	KW	Current @ 0.8 PF		Current @ 0.85 PF		Current @ 0.9 PF		Current @ 0.95 PF		Current @ 1.0 PF	
				100% Load	80% Load	100% Load	80% Load	100% Load	80% Load	100% Load	80% Load	100% Load	80% Load
7.5	3	Prime	6	10	8	10	8	9	7	9	7	8	7
7.5	1	Prime	6	33	26	31	25	29	23	27	22	26	21
10	3	Prime	8	14	11	13	10	12	10	12	9	11	9
10	1	Prime	8	43	35	41	33	39	31	37	29	35	28
15	3	Prime	12	21	17	20	16	19	15	18	14	17	13
15	1	Prime	12	65	52	61	49	58	46	55	44	52	42
20	3	Prime	16	28	22	26	21	25	20	23	19	22	18
20	1	Prime	16	87	70	82	65	77	62	73	59	70	56
25	3	Prime	20	35	28	33	26	31	25	29	23	28	22
25	1	Prime	20	109	87	102	82	97	77	92	73	87	70
30	3	Prime	24	42	33	39	31	37	30	35	28	33	27
30	1	Prime	24	130	104	123	98	116	93	110	88	104	83
35	3	Prime	28	49	39	46	37	43	35	41	33	39	31
35	1	Prime	28	152	122	143	115	135	108	128	103	122	97
40	3	Prime	32	56	45	52	42	49	40	47	37	45	36
40	1	Prime	32	174	139	164	131	155	124	146	117	139	111
50	3	Prime	40	70	56	65	52	62	49	59	47	56	45
50	1	Prime	40	217	174	205	164	193	155	183	146	174	139
62.5	3	Prime	50	87	70	82	65	77	62	73	59	70	56
62.5	1	Prime	50	272	217	256	205	242	193	229	183	217	174
70	3	Prime	56	97	78	92	73	87	69	82	66	78	62
82.5	3	Prime	66	115	92	108	86	102	82	97	77	92	73
100	3	Prime	80	139	111	131	105	124	99	117	94	111	89
125	3	Prime	100	174	139	164	131	155	124	146	117	139	111
140	3	Prime	112	195	156	183	147	173	139	164	131	156	125
160	3	Prime	128	223	178	209	168	198	158	187	150	178	142
180	3	Prime	144	250	200	236	189	223	178	211	169	200	160
200	3	Prime	160	278	223	262	209	247	198	234	187	223	178
225	3	Prime	180	313	250	295	236	278	223	264	211	250	200
250	3	Prime	200	348	278	327	262	309	247	293	234	278	223
275	3	Prime	220	383	306	360	288	340	272	322	258	306	245
300	3	Prime	240	417	334	393	314	371	297	351	281	334	267
320	3	Prime	256	445	356	419	335	396	317	375	300	356	285
330	3	Standby	264	459	367	432	346	408	326	387	309	367	294
365	3	Prime	292	508	406	478	382	451	361	428	342	406	325
380	3	Prime	304	529	423	498	398	470	376	445	356	423	338
400	3	Prime	320	556	445	524	419	495	396	469	375	445	356
440	3	Standby	352	612	490	576	461	544	435	515	412	490	392
500	3	Prime	400	696	556	655	524	618	495	586	469	556	445
520	3	Standby	416	723	579	681	545	643	514	609	487	579	463
600	3	Prime	480	835	668	786	628	742	594	703	562	668	534
625	3	Prime	500	870	696	818	655	773	618	732	586	696	556
650	3	Prime	520	904	723	851	681	804	643	762	609	723	579
660	3	Standby	528	918	735	864	691	816	653	773	619	735	588
640	3	Prime	512	890	712	838	670	791	633	750	600	712	570
700	3	Standby	560	974	779	917	733	866	693	820	656	779	623
750	3	Prime	600	1043	835	982	786	927	742	879	703	835	668
830	3	Standby	664	1155	924	1087	869	1026	821	972	778	924	739
810	3	Prime	648	1127	902	1061	848	1002	801	949	759	902	721
900	3	Standby	720	1252	1002	1178	943	1113	890	1054	844	1002	801
1010	3	Prime	808	1405	1124	1323	1058	1249	999	1183	947	1124	899
1250	3	Prime	1000	1739	1391	1637	1309	1546	1237	1464	1172	1391	1113
1400	3	Standby	1120	1948	1558	1833	1467	1731	1385	1640	1312	1558	1247
1500	3	Prime	1200	2087	1669	1964	1571	1855	1484	1757	1406	1669	1336
1750	3	Prime	1400	2435	1948	2291	1833	2164	1731	2050	1640	1948	1558
1900	3	Standby	1520	2643	2115	2488	1990	2350	1880	2226	1781	2115	1692
1800	3	Prime	1440	2504	2003	2357	1886	2226	1781	2109	1687	2003	1603
1975	3	Standby	1580	2748	2198	2586	2069	2442	1954	2314	1851	2198	1759
1875	3	Prime	1500	2609	2087	2455	1964	2319	1855	2197	1757	2087	1669
2063	3	Standby	1650.4	2870	2296	2701	2161	2551	2041	2417	1934	2296	1837
2000	3	Prime	1600	2782	2226	2619	2095	2473	1979	2343	1875	2226	1781
2250	3	Standby	1800	3130	2504	2946	2357	2782	2226	2636	2109	2504	2003
2250	3	Prime	1800	3130	2504	2946	2357	2782	2226	2636	2109	2504	2003
2500	3	Standby	2000	3478	2782	3274	2619	3092	2473	2929	2343	2782	2226
2750	3	Prime	2200	3826	3061	3601	2881	3401	2721	3222	2577	3061	2449
3000	3	Standby	2400	4174	3339	3928	3143	3710	2968	3515	2812	3339	2671
3350	3	Prime	2680	4661	3729	4387	3509	4143	3314	3925	3140	3729	2983
3750	3	Standby	3000	5217	4174	4910	3928	4637	3710	4393	3515	4174	3339

Note:

1. For H.T. Alternators, please refer manufactures specifications.
2. Resistive and water loads have unity power factor.