Assignment-2 Active Rectifiers

Name - Aditya Kumar,

Roll no – 24M1355

Q.1) Power flow between AC and DC voltage sources :–

For 1st quadrant (P = 5000 W, Q = 3000 VAR)

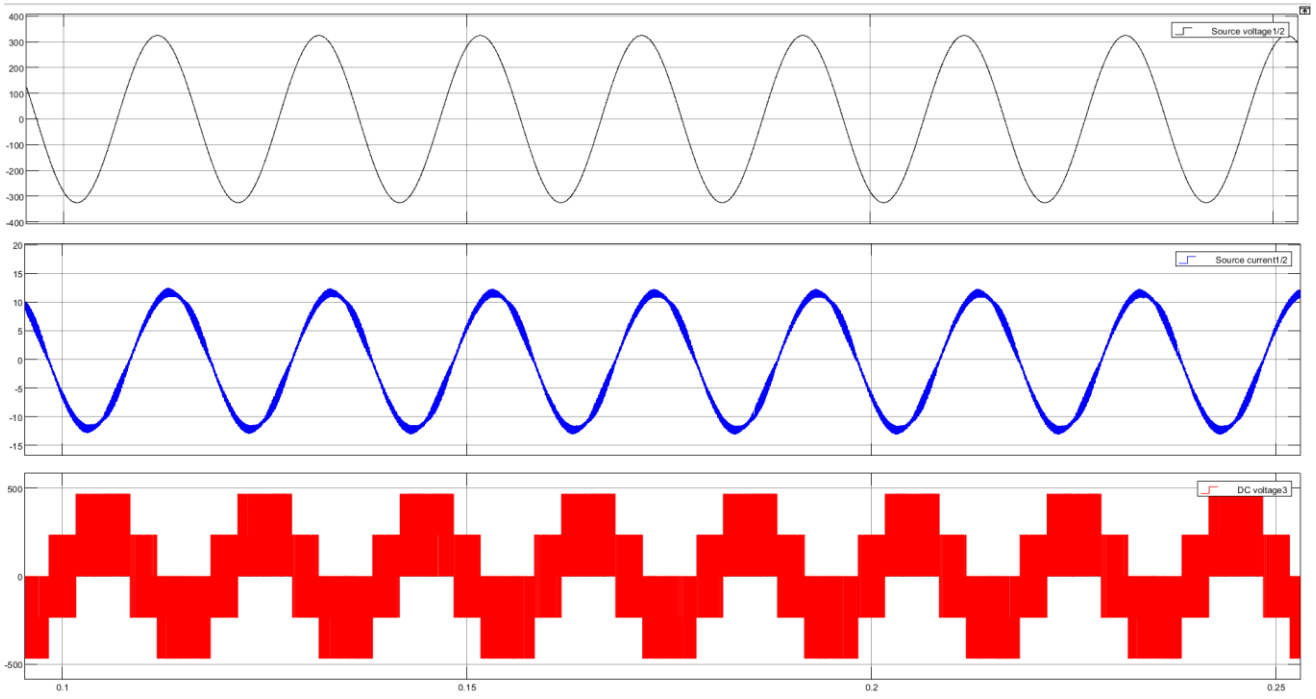

Figure 1 Per-phase AC-side voltage and current, Pole voltage

Phase difference between AC voltage and current: ΔT = 1.868 msec, ϕ = 33.624°

P.F. = 0.832

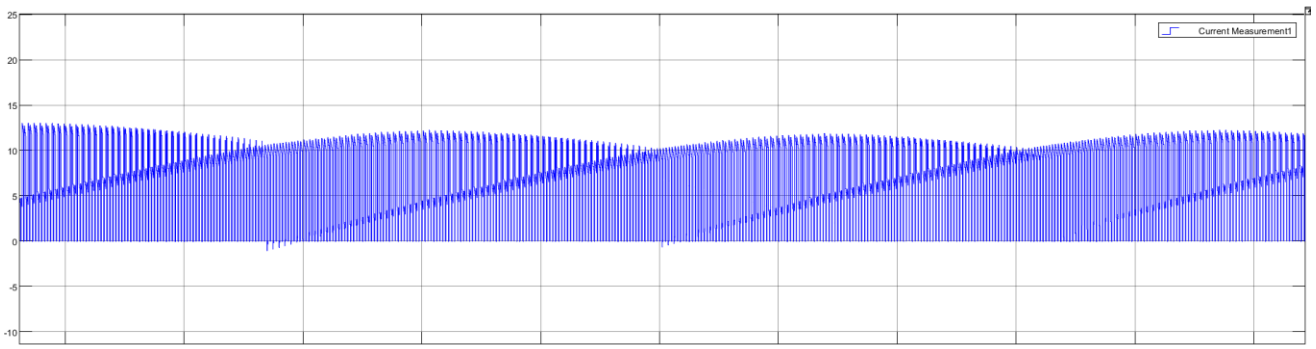

Figure 2 DC-side current

For 2nd quadrant (P = -5000 W, Q = 3000 VAR)

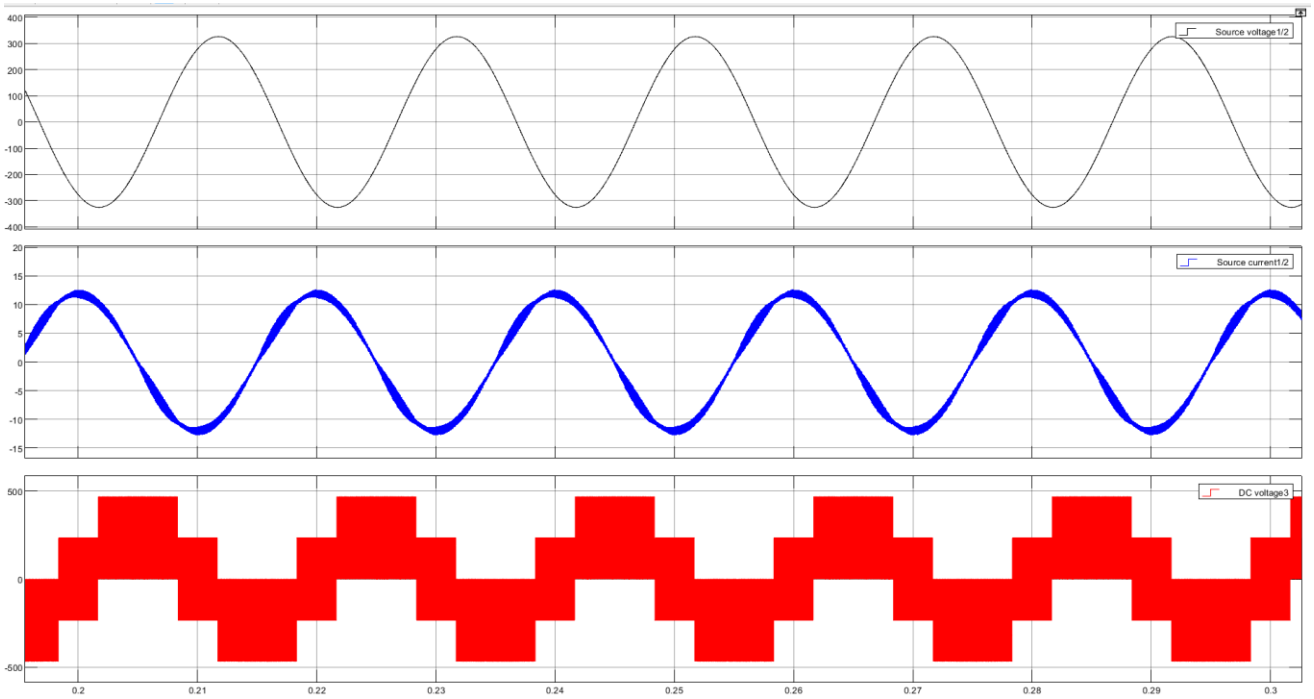

Figure 3 Per-phase AC-side voltage and current, Pole voltage

Phase difference between AC voltage and current: $\Delta T = 1.781$ msec, $\phi = 32.059°$

P.F. = 0.8475

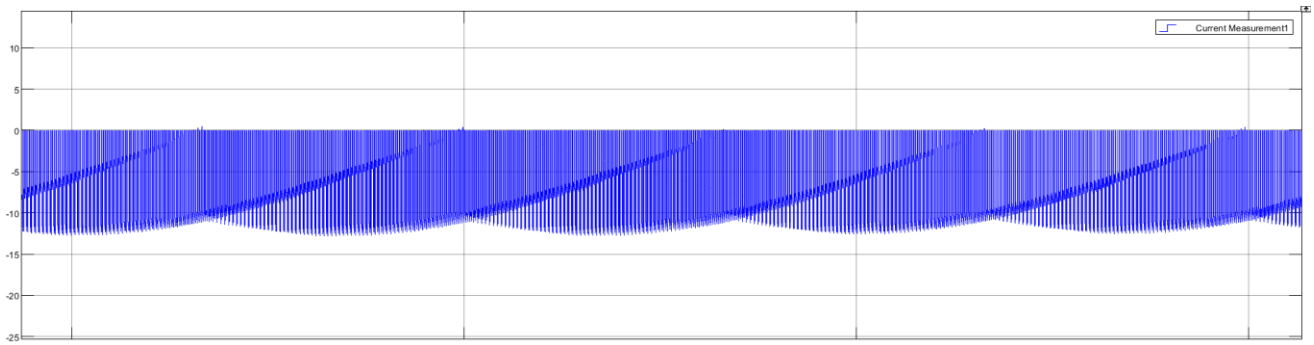

Figure 4 DC-side current

For 3rd quadrant (P = -5000 W, Q = -3000 VAR)

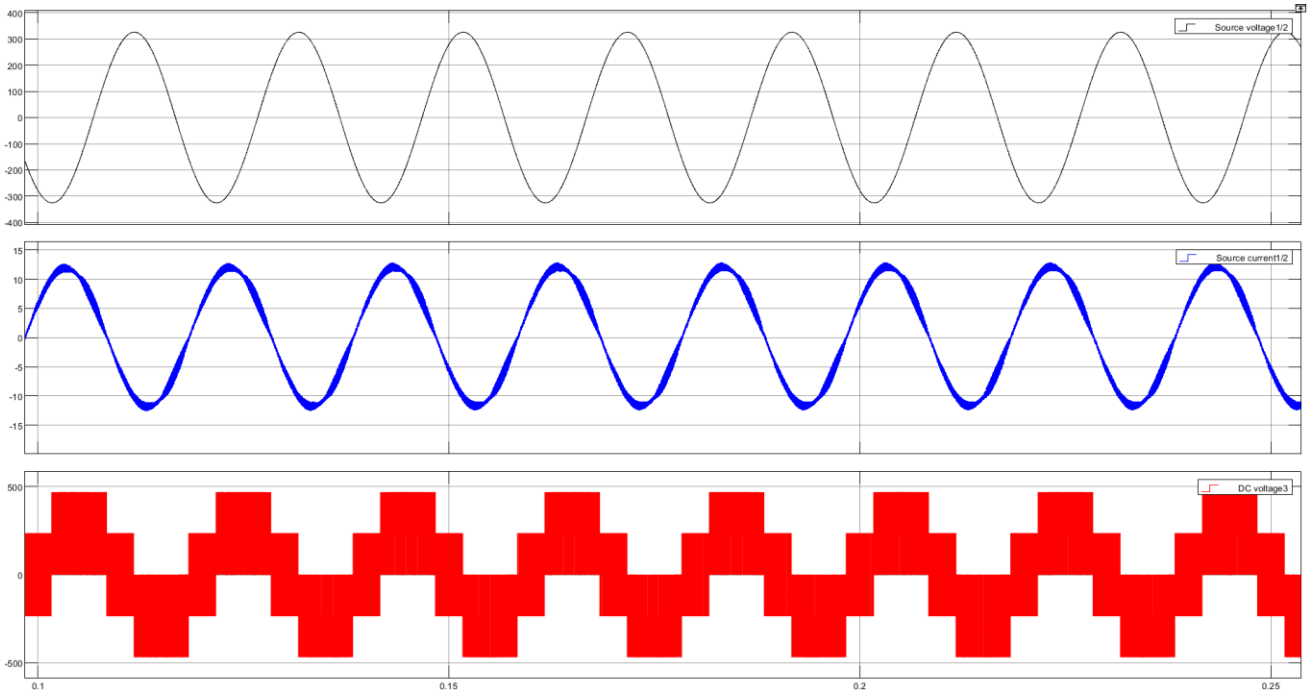

Figure 5 Per-phase AC-side voltage and current, Pole voltage

Phase difference between AC voltage and current: $\Delta T = 1.769$ msec, $\phi = 31.842°$

P.F. = 0.8495

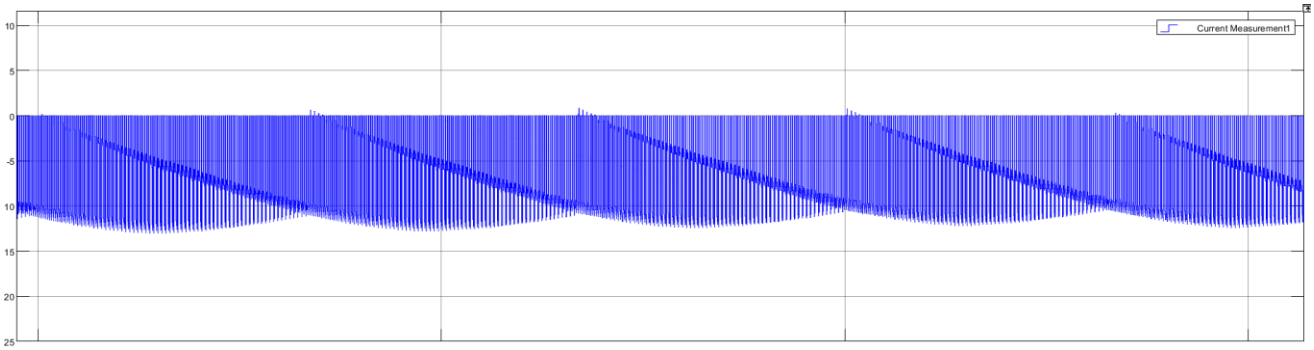

Figure 6 DC-side current

For 4th quadrant (P = 5000 W, Q = -3000 VAR)

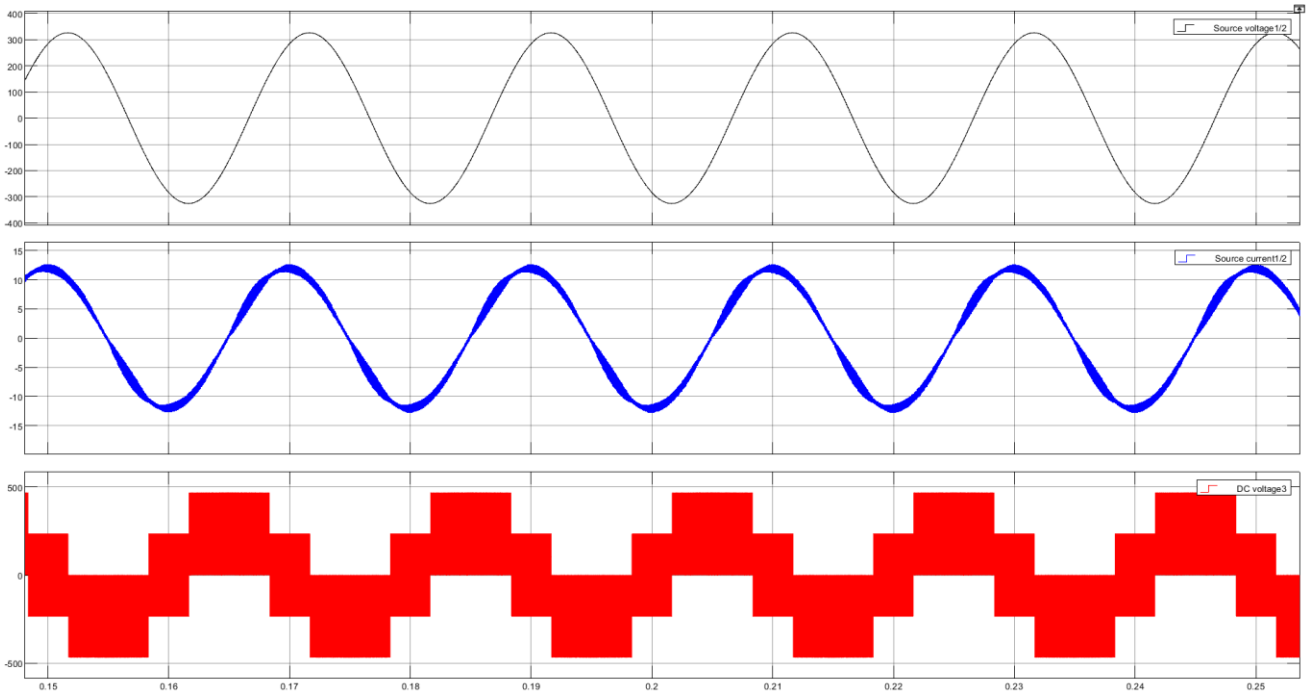

Figure 7 Per-phase AC-side voltage and current, Pole voltage

Phase difference between AC voltage and current: ΔT = 1.704 msec, ϕ = 30.67°

P.F. = 0.8601

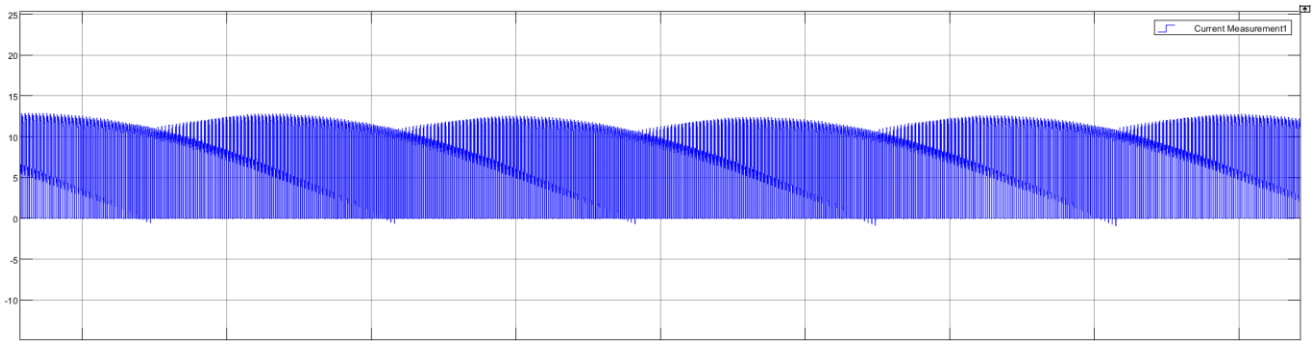

Figure 8 DC-side current

Quad	P	Q	Vn (ph, rms)	delta(degree)	Min Vdc	MI	I (l-l, rms)	Idc (avg)	power factor
1	5000	3000	227.2691	0.9348	556.6933293	0.9183	8.4507	7.118	0.832
2	-5000	3000	228.0661	-1.0505	558.6455726	0.9215	8.4507	-7.151	0.8475
3	-5000	-3000	232.7907	-0.9126	570.2184319	0.9406	8.4507	-7.164	0.8495
4	5000	-3000	232.0099	1.0326	568.3058703	0.9375	8.4507	7.103	0.8601

Min Vdc for any P and Q = 556.6933 V

I_D (avg) for P_{max} and Q_{max} = 7.118 A

Q.2) Power flow between AC voltage and DC current sources:-

	angle	Ir	Iy	Ib		T1 microsec.	T2 microsec.	T0 microsec.	Ic=Ir-Idc (in time T1) (A)	C*deltaV	C microfarad
1	90	10.1595	-5.07961	-5.08043	-0.000543463	35.2594	0	14.74064495	3.011499989	106.1835473	21.23670947
2	90.9	10.1583	-4.94079	-5.21799	-0.000528611	34.9353	0.63209	14.43266124	3.010254103	108.4622105	21.6924421
3	91.8	10.1545	-4.80075	-5.35427	-0.000513628	34.6025	1.26402	14.13345323	3.006501968	110.8004618	22.16009236
4	92.7	10.1482	-4.65952	-5.48922	-0.000498518	34.2613	1.89564	13.84309476	3.000244509	113.197754	22.63955079
5	93.6	10.1395	-4.51715	-5.62282	-0.000483285	33.9116	2.52679	13.56165746	2.991483271	115.6535266	23.13070531
6	94.5	10.1282	-4.37366	-5.75503	-0.000467933	33.5535	3.15732	13.28921077	2.980220414	118.1672063	23.63344126
7	95.4	10.1145	-4.22909	-5.88582	-0.000452466	33.1871	3.78707	13.02582191	2.966458717	120.7382068	24.14764137
8	96.3	10.0982	-4.08347	-6.01516	-0.000436887	32.8126	4.41588	12.77155588	2.950201577	123.3659292	24.67318585
9	97.2	10.0795	-3.93685	-6.14302	-0.0004212	32.4299	5.04361	12.52647541	2.931453003	126.0497618	25.20995236
10	98.1	10.0582	-3.78926	-6.26936	-0.00040541	32.0393	5.67009	12.29064097	2.910217622	128.7890803	25.75781605
11	99	10.0345	-3.64074	-6.39415	-0.000389519	31.6407	6.29517	12.06411074	2.886500673	131.583248	26.31664961
12	99.9	10.0083	-3.49131	-6.51737	-0.000373532	31.2344	6.9187	11.84694062	2.860308007	134.4316162	26.88632323
13	100.8	9.97965	-3.34103	-6.63898	-0.000357453	30.8203	7.54052	11.6391842	2.831646086	137.3335235	27.4667047
14	101.7	9.94852	-3.18992	-6.75895	-0.000341286	30.3986	8.16048	11.44089274	2.800521982	140.2882968	28.05765936
15	102.6	9.91494	-3.03802	-6.87725	-0.000325035	29.9695	8.77843	11.25211515	2.766943374	143.295251	28.6590502
16	103.5	9.87892	-2.88537	-6.99386	-0.000308703	29.5329	9.39421	11.07289802	2.730918546	146.3536891	29.27073782
17	104.4	9.84046	-2.73201	-7.10874	-0.000292295	29.089	10.0077	10.90328557	2.692456387	149.4629025	29.8925805
18	105.3	9.79957	-2.57798	-7.22186	-0.000275816	28.638	10.6187	10.74331964	2.651566385	152.6221709	30.52443419
19	106.2	9.75626	-2.42331	-7.33321	-0.000259268	28.1799	11.227	10.59303971	2.60825863	155.8307628	31.16615256
20	107.1	9.71054	-2.26804	-7.44274	-0.000242656	27.7149	11.8327	10.45248286	2.562543806	159.0879352	31.81758704
21	108	9.66243	-2.11222	-7.55044	-0.000225984	27.243	12.4353	10.32168376	2.514433192	162.392934	32.4785868
22	108.9	9.61194	-1.95587	-7.65628	-0.000209257	26.7644	13.035	10.20067469	2.463938657	165.7449942	33.14899883
23	109.8	9.55907	-1.79904	-7.76023	-0.000192478	26.2792	13.6314	10.0894855	2.411072661	169.1433397	33.82866793
24	110.7	9.50385	-1.64177	-7.86226	-0.000175651	25.7875	14.2244	9.988143632	2.355848245	172.5871838	34.51743676
25	111.6	9.44628	-1.48409	-7.96235	-0.000158781	25.2894	14.8139	9.896674089	2.298279036	176.0757293	35.21514585

For 1st quadrant (P = 5000 W, Q = 3000 VAR)

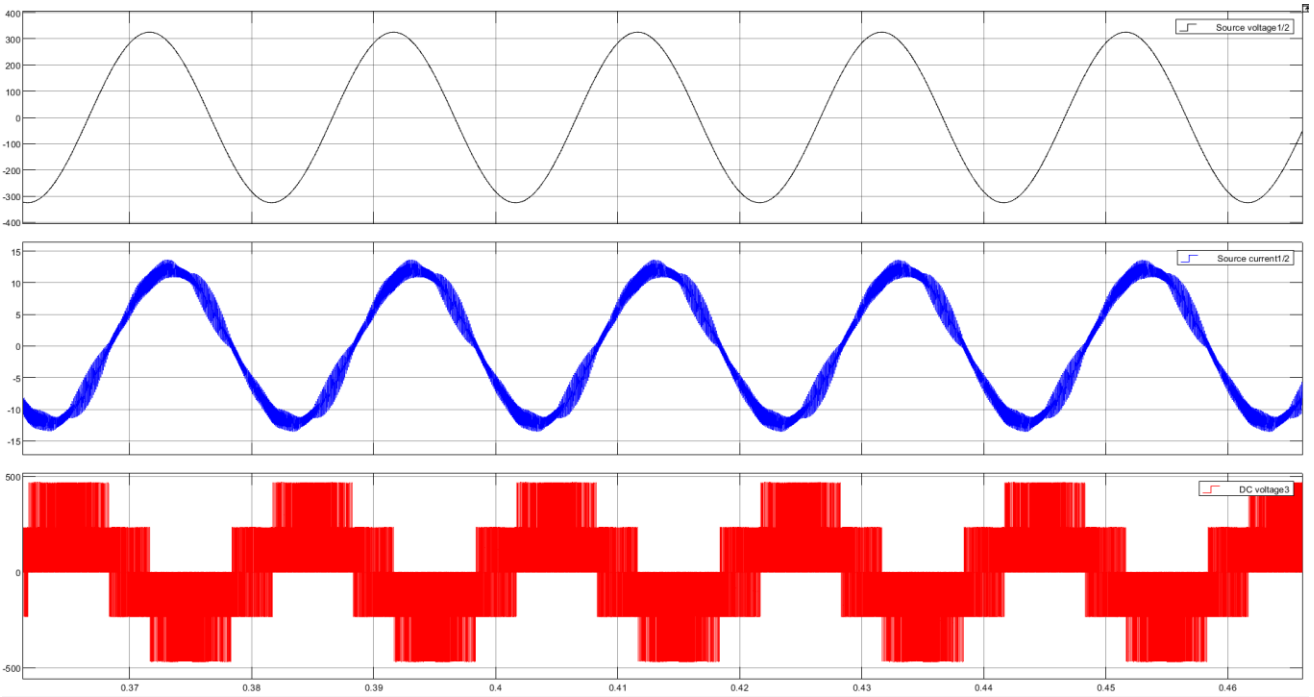

Figure 9 AC side voltage and current, Pole voltage

Phase difference between AC voltage and current: $\Delta T = 2.093$ msec, $\phi = 20.609°$

P.F. = 0.936

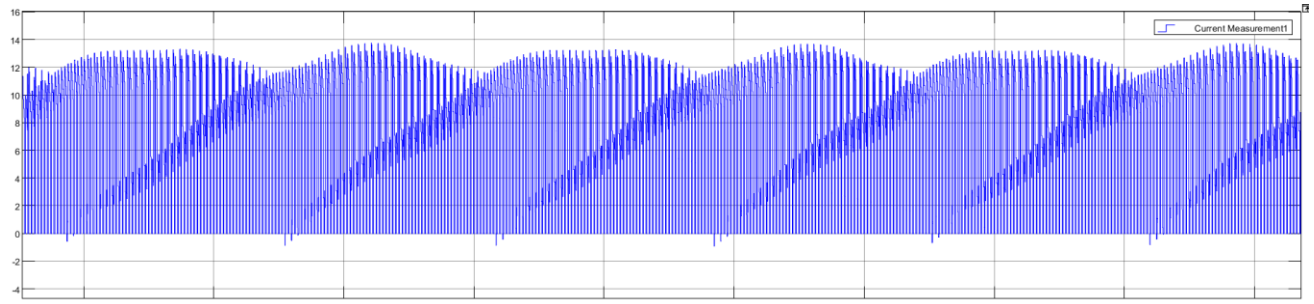

Figure 10 DC side current iD

For 2nd quadrant (P = -5000 W, Q = 3000 VAR)

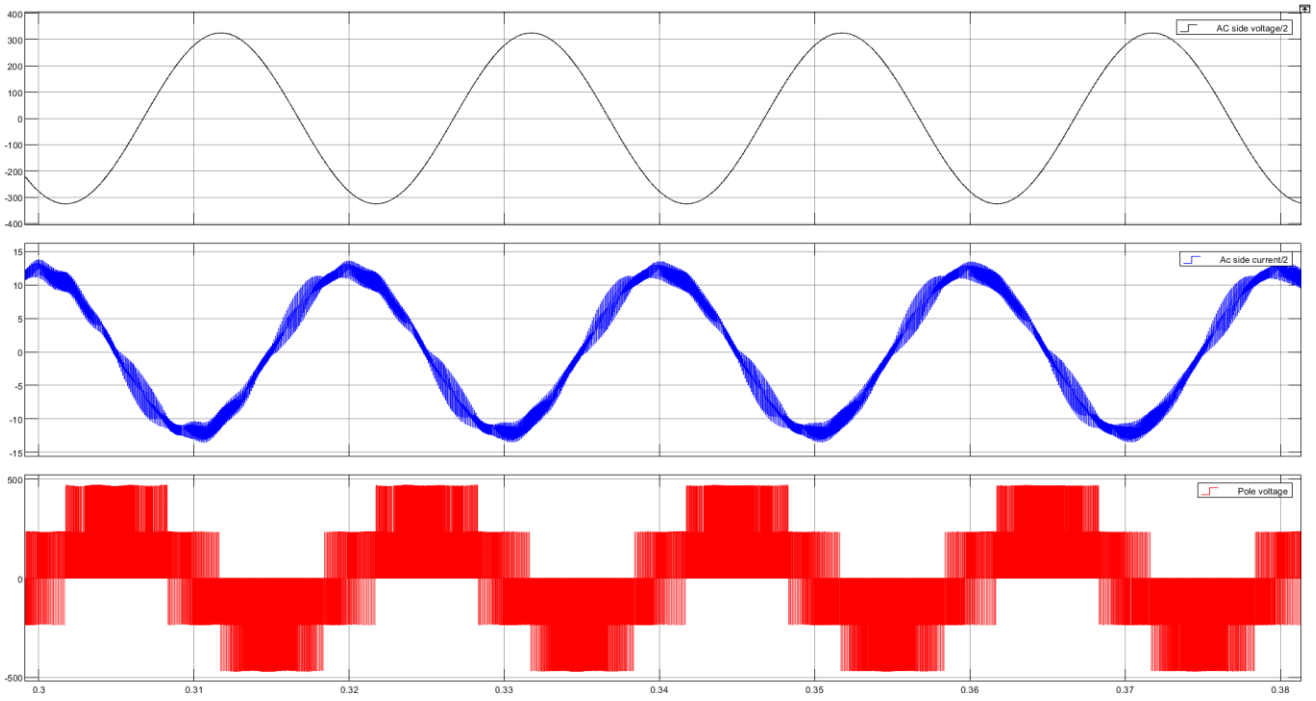

Figure 11 AC side voltage, AC side current and Pole voltage

Phase difference between AC voltage and current: ΔT = 1.668 msec, ϕ = 30.024°

P.F. = 0.8658

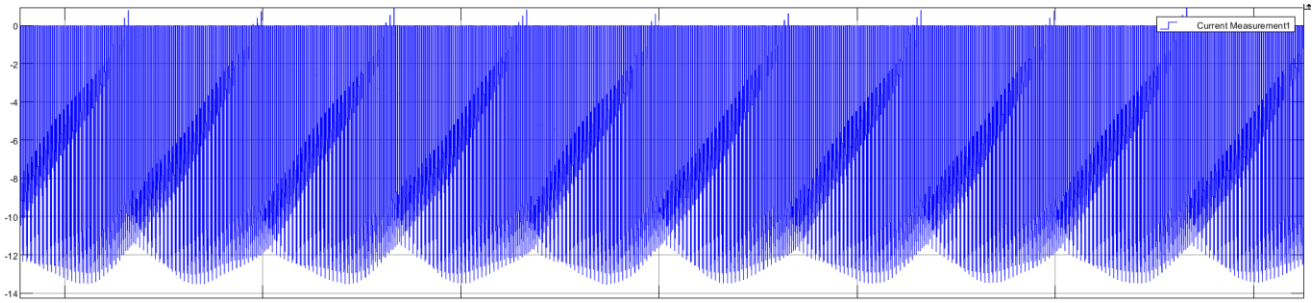

Figure 12 DC side current iD

For 3rd quadrant (P = -5000 W, Q = -3000 VAR)

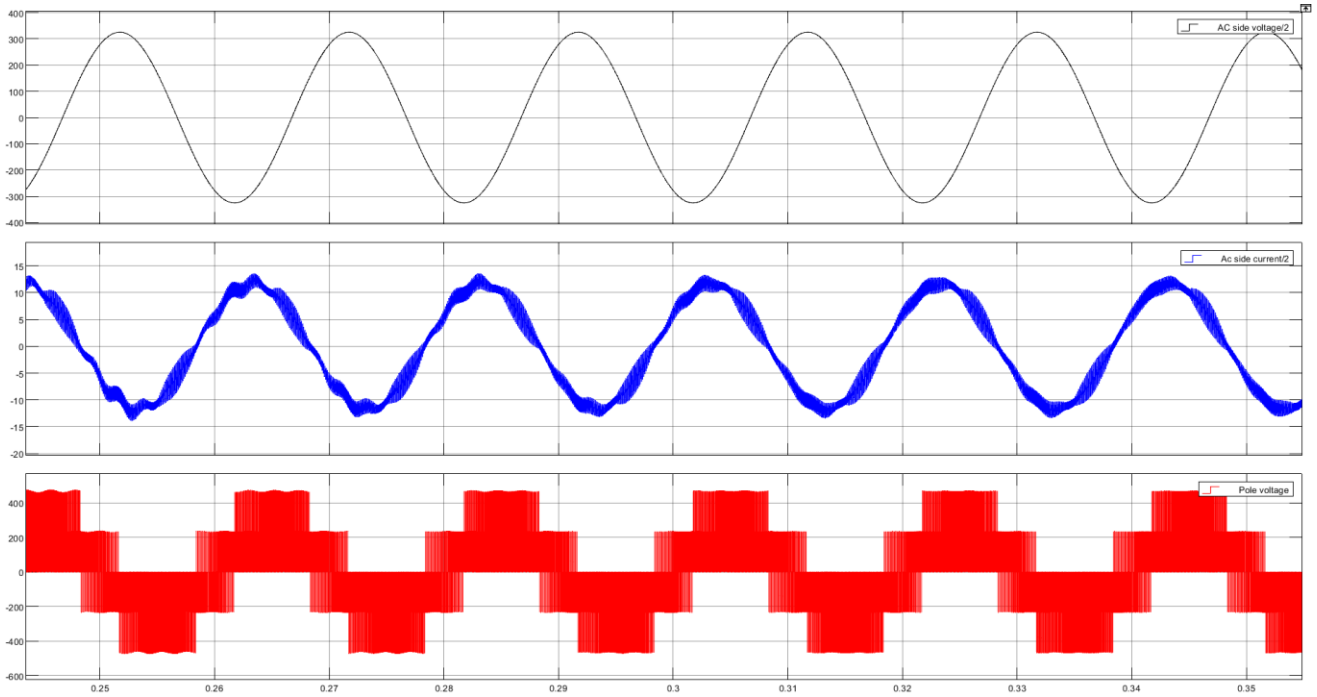

Figure 13 AC side voltage, AC side current and Pole voltage

Phase difference between AC voltage and current: ΔT = 1.830 msec, ϕ = 32.94°

P.F. = 0.8392

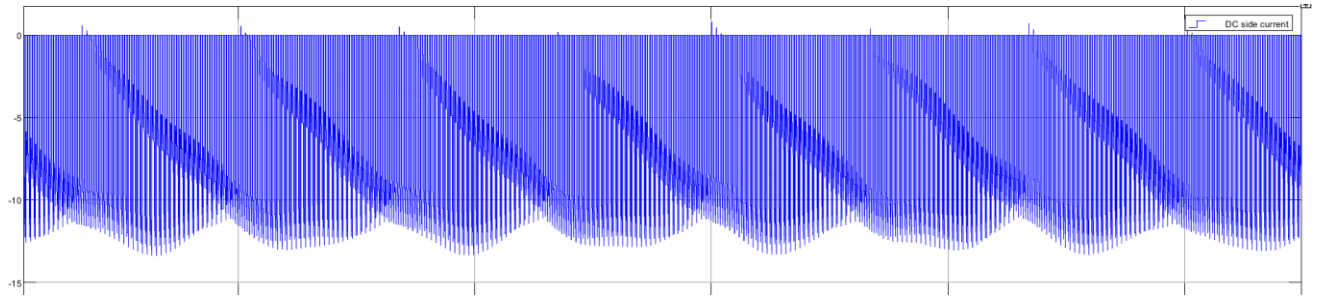

Figure 14 DC side current iD

Quad	P	Q	Vn (ph, rms)	delta(degree)	Min Vdc	MI	I (l-l, rms)	Idc	power factor
1	5000	3000	227.2691	0.9348	556.6934	0.9784	8.4507	7.1429	0.936
2	-5000	3000	228.066	-1.0505	558.645	0.9215	8.4507	-7.1429	0.8658
3	-5000	-3000	232.791	-0.9126	570.218	0.9406	8.4507	-7.1429	0.8392
4	5000	-3000	232.009	1.0326	568.306	0.9375	8.4507	7.1429	0.8935

Min Vdc for any P and Q = 556.69 volts

For 4th quadrant (P = 5000 W, Q = -3000 VAR)

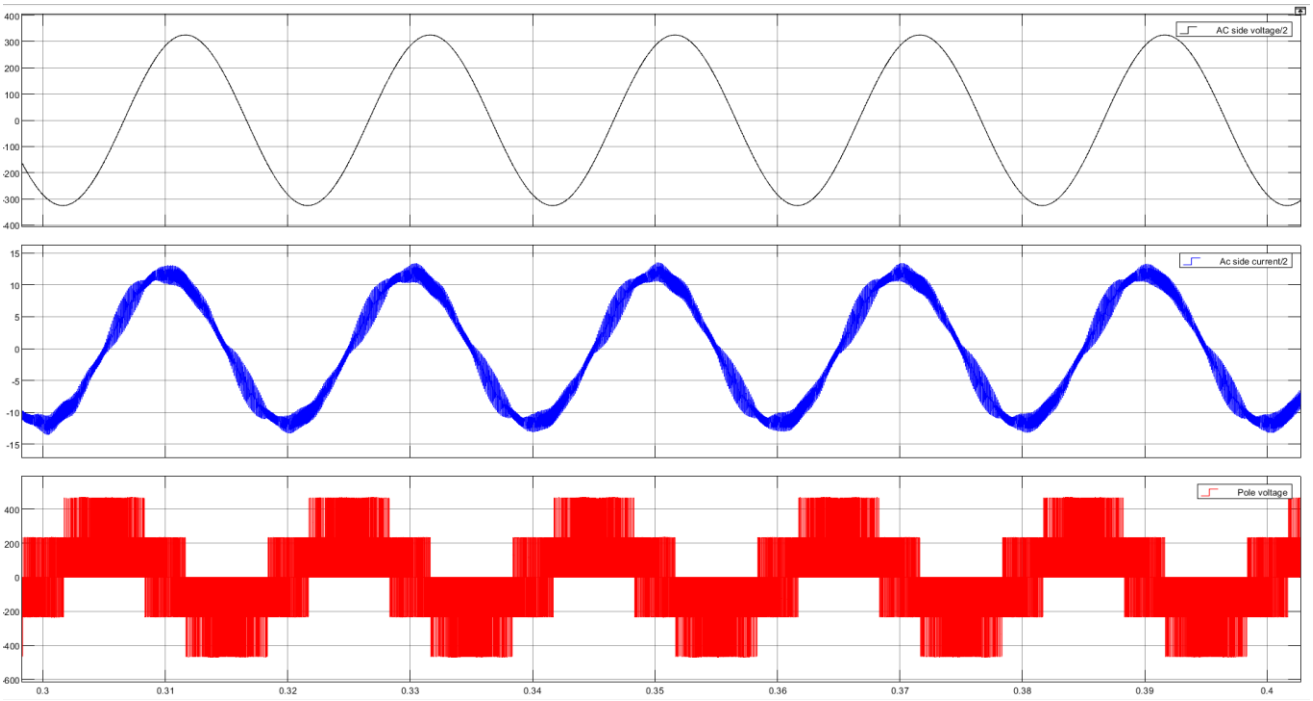

Figure 15 AC side voltage, AC side current and Pole voltage

Phase difference between AC voltage and current: ΔT = 1.482 msec, ϕ = 26.676°

P.F. = 0.8935

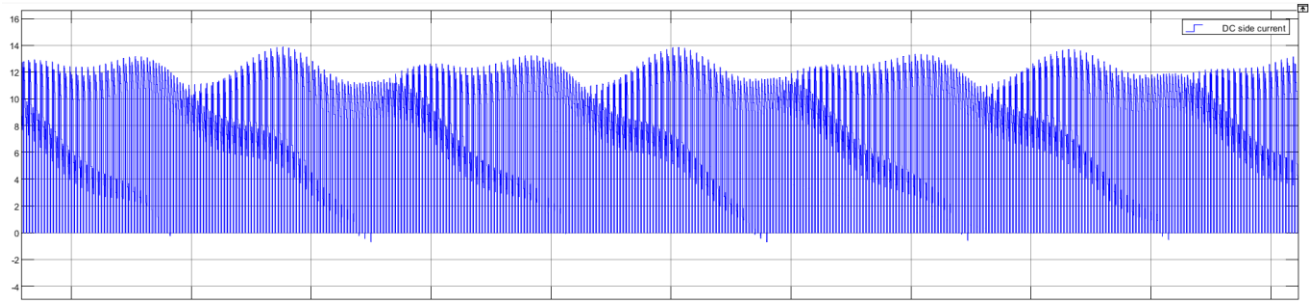

Figure 16 DC side current iD

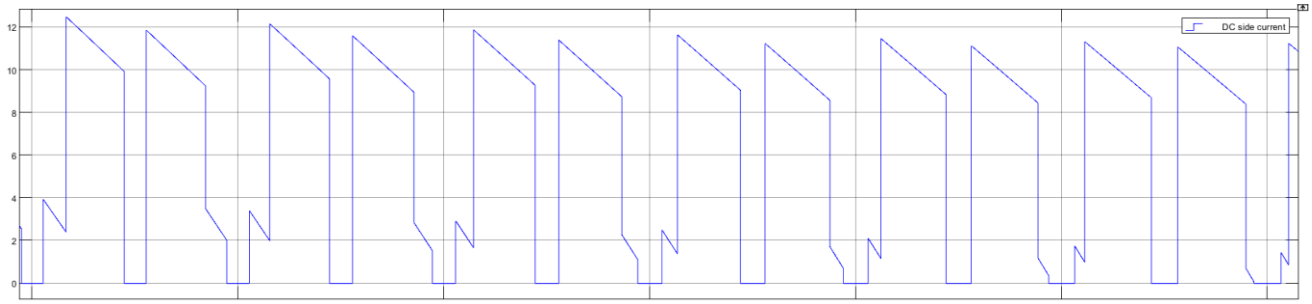

Figure 17 DC side current iD -Enlarged view

Q.3) Power flow between AC source and load (Two level back-to-back VSCs):-

For 1st quadrant (P = 5000 W, Q = 3000 VAR)

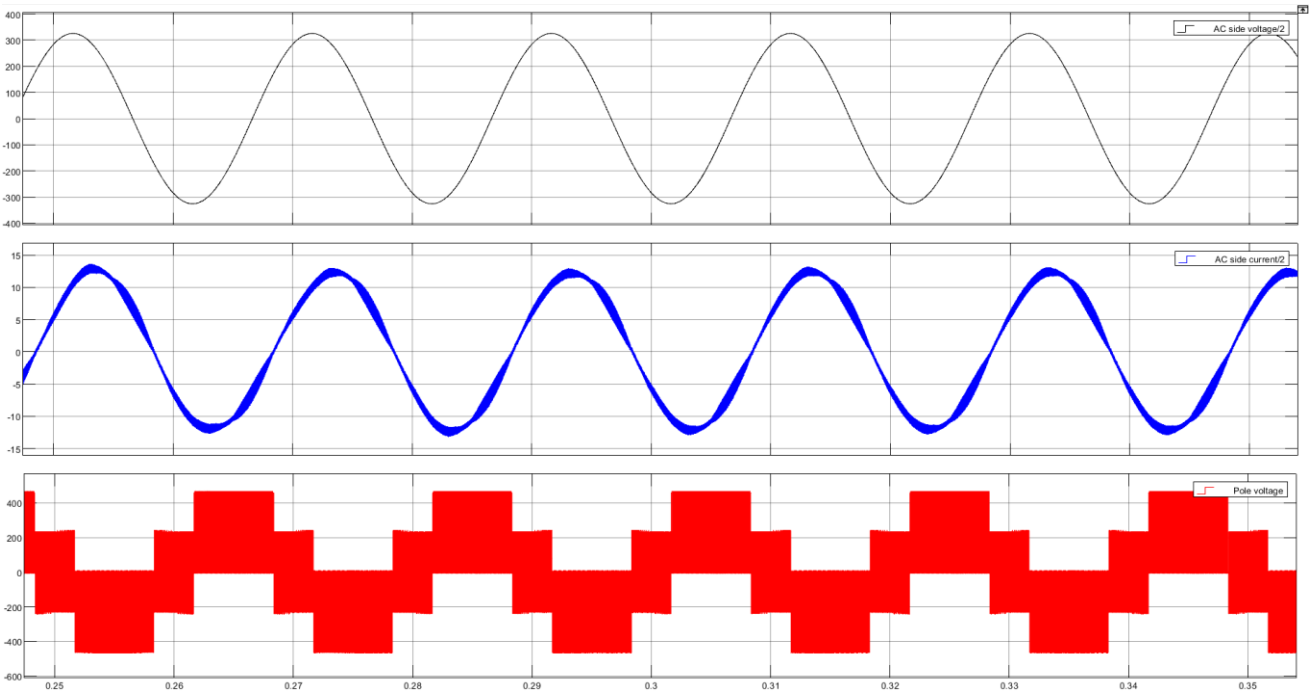

Figure 18 AC side voltage, AC side voltage and Pole voltage

Phase difference between AC voltage and current: $\Delta T = 1.838$ msec, $\phi = 33.084°$

P.F. = 0.8378

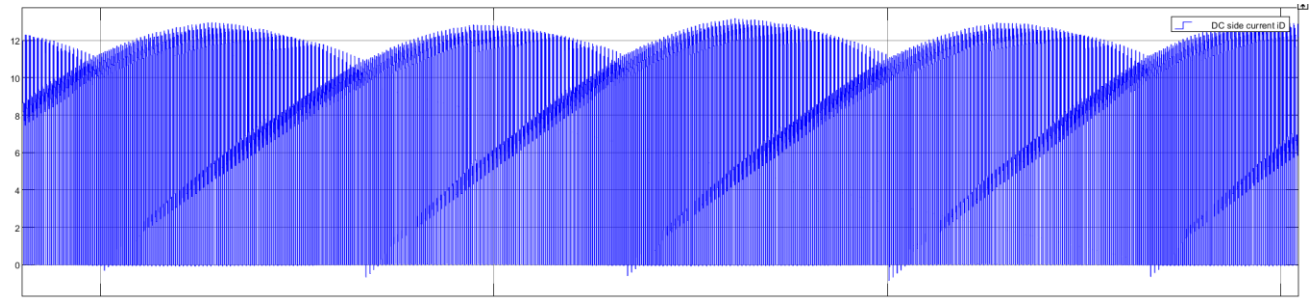

Figure 19 DC side current iD

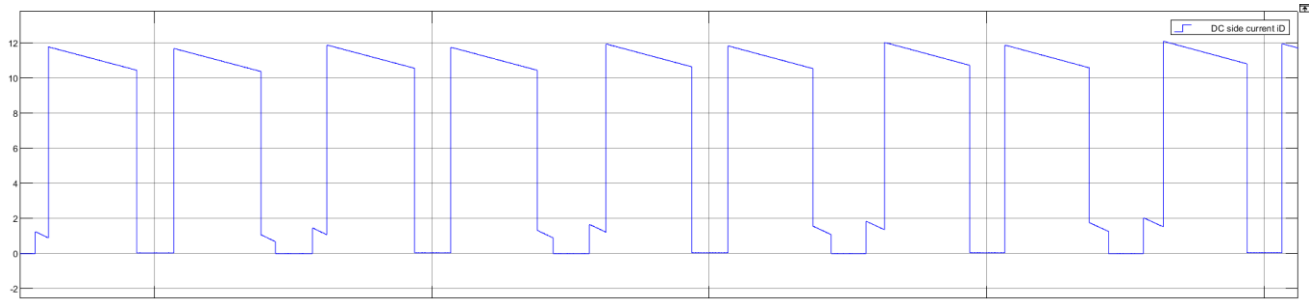

Figure 20 DC side current iD - Enlarged view

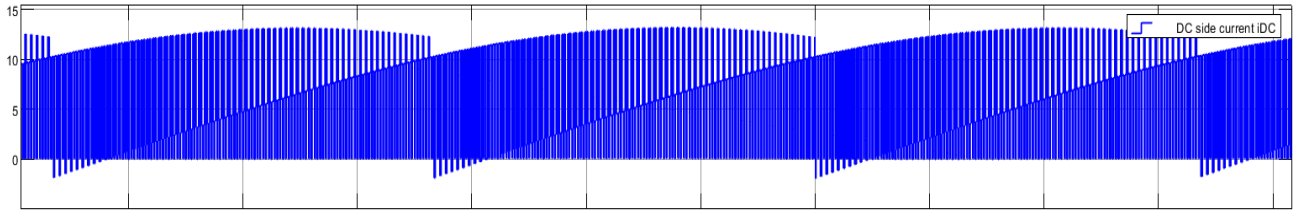

Figure 21 DC side current iDC

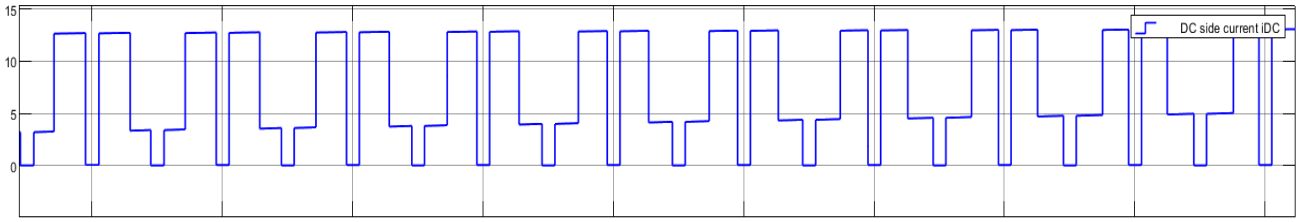

Figure 22 DC side current iDC - Enlarged view

For 2nd quadrant (P = -5000 W, Q = 3000 VAR)

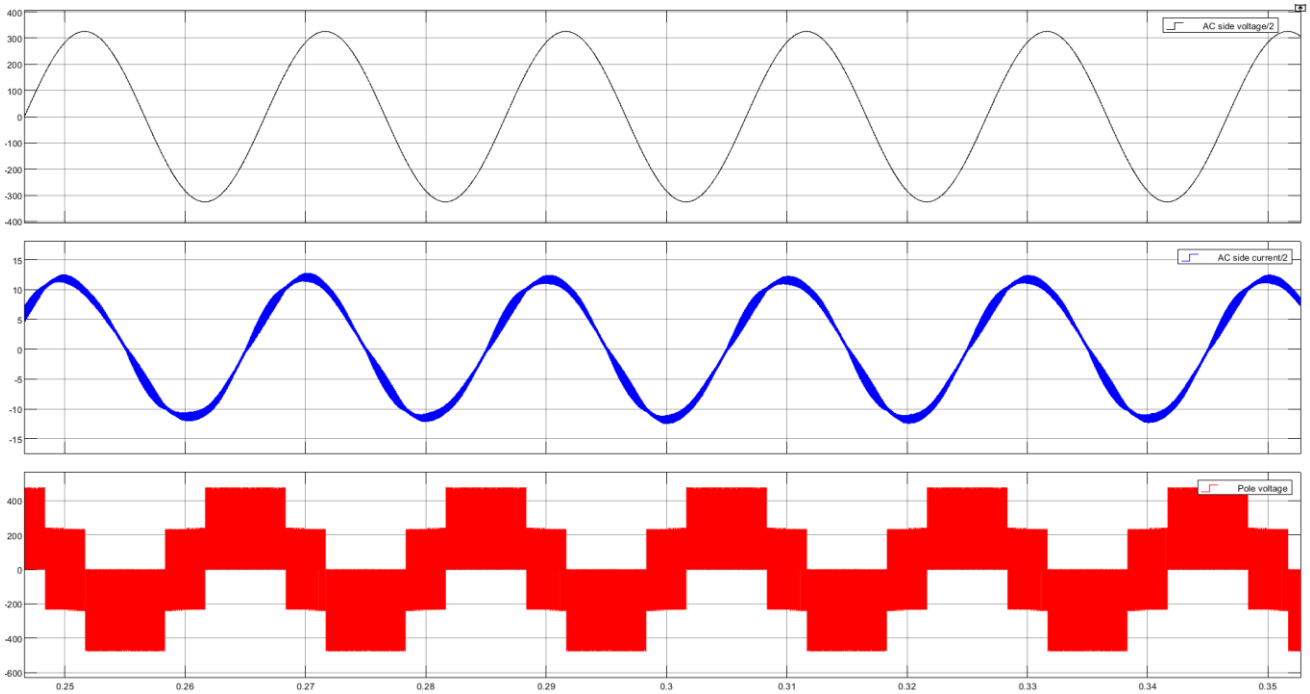

Figure 23 AC side voltage, AC side current and Pole voltage

Phase difference between AC voltage and current: $\Delta T = 1.489$ msec, $\phi = 26.802°$

P.F. = 0.8926

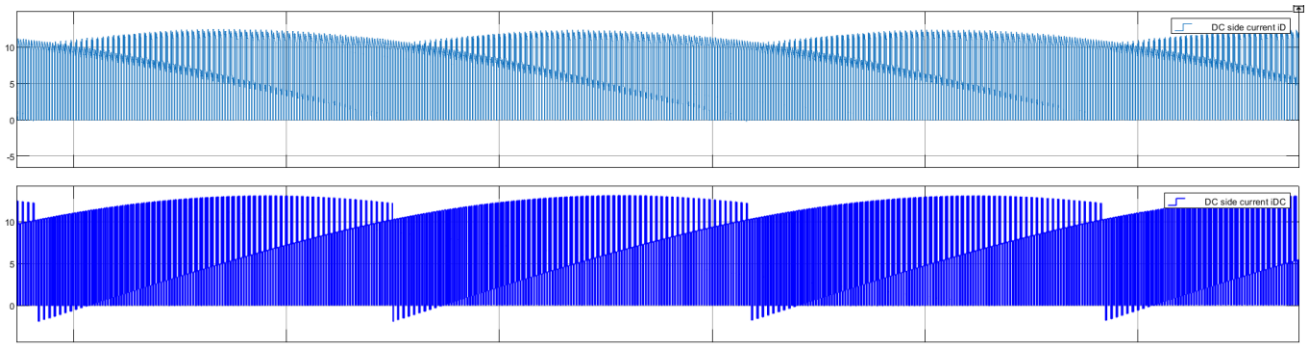

Figure 24 DC side current iD and iDC

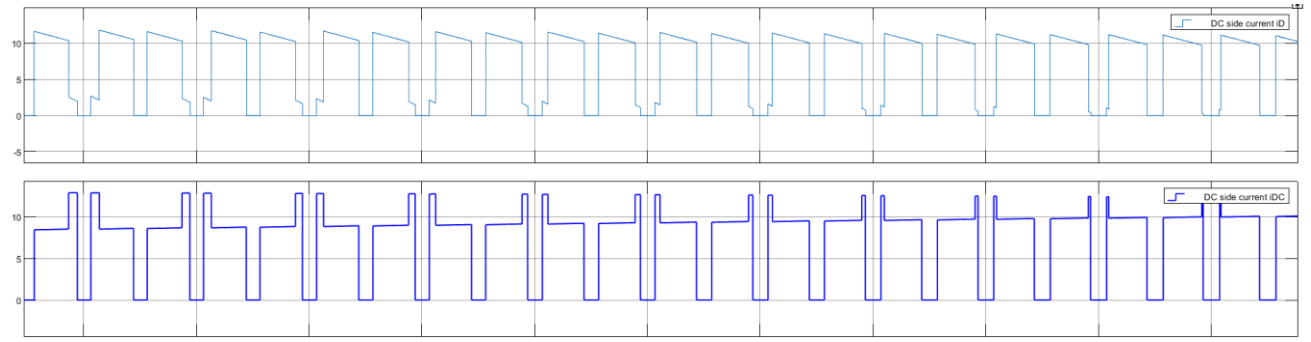

Figure 25 DC side current iD and iDC - Enlarged view

For 3rd quadrant (P = -5000 W, Q = -3000 VAR)

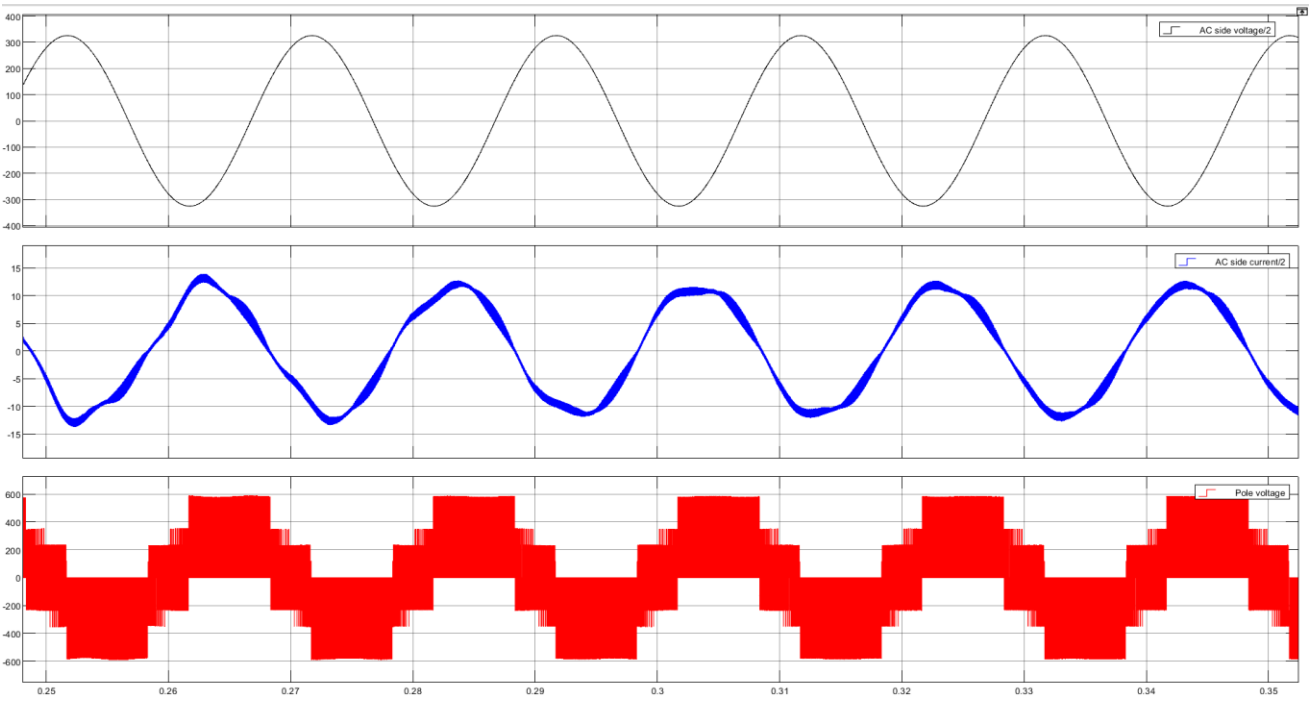

Figure 26 AC side voltage, AC side current and Pole voltage

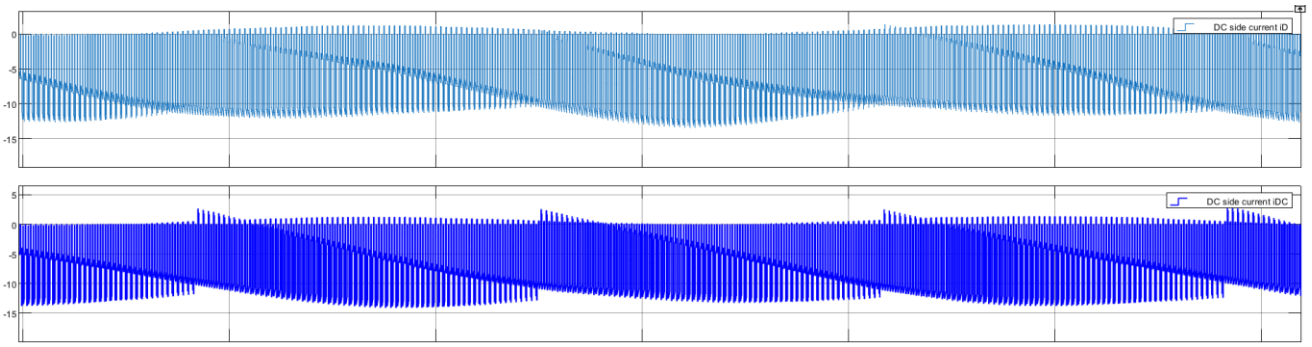

Figure 27 DC side current iD and IdC

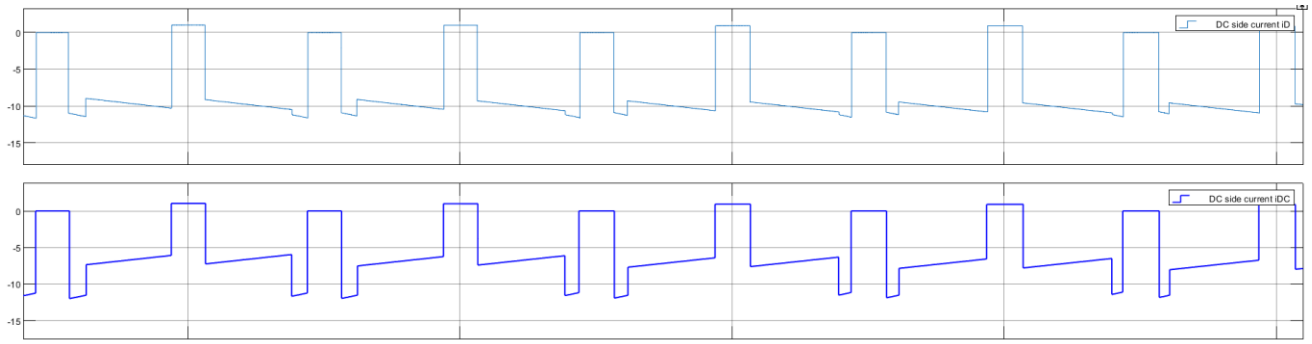

Figure 28 DC side current iD and iDC - Enlarged view

For 4th quadrant (P = 5000 W, Q = -3000 VAR)

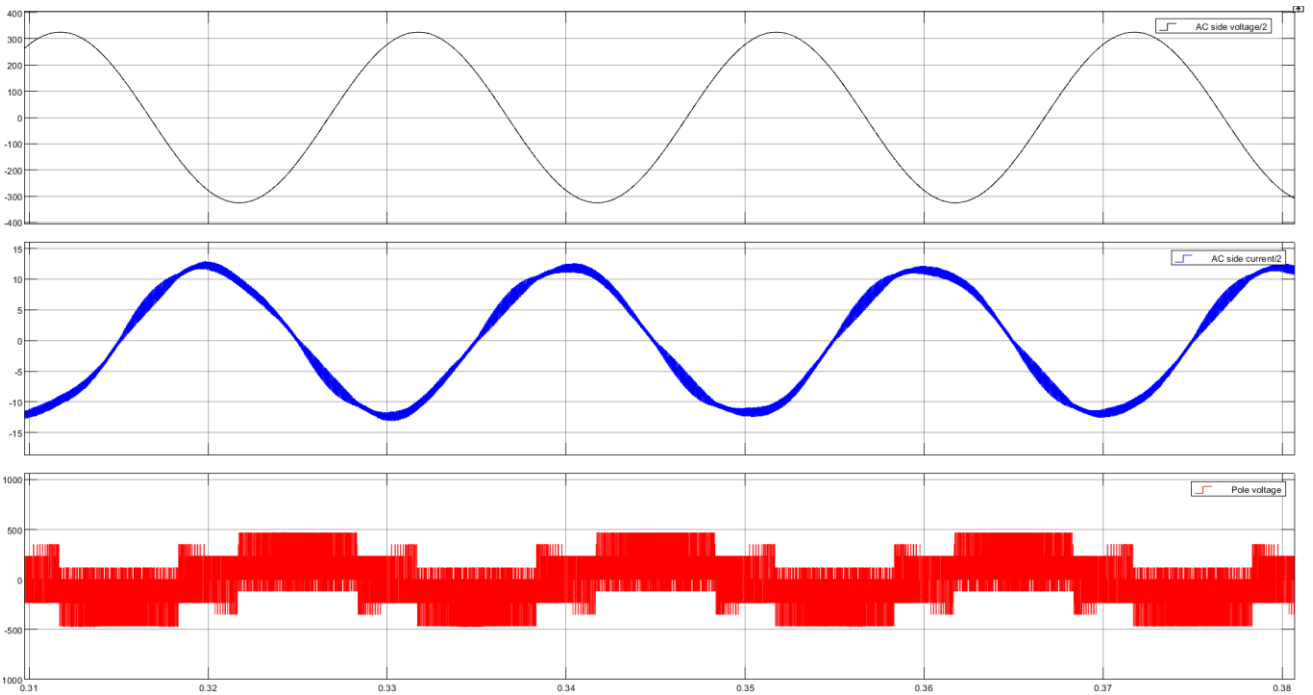

Figure 29 AC side voltage, AC side current and Pole voltage

Phase difference between AC voltage and current: ΔT = 1.736 msec, ϕ = 31.248°

P.F. = 0.855

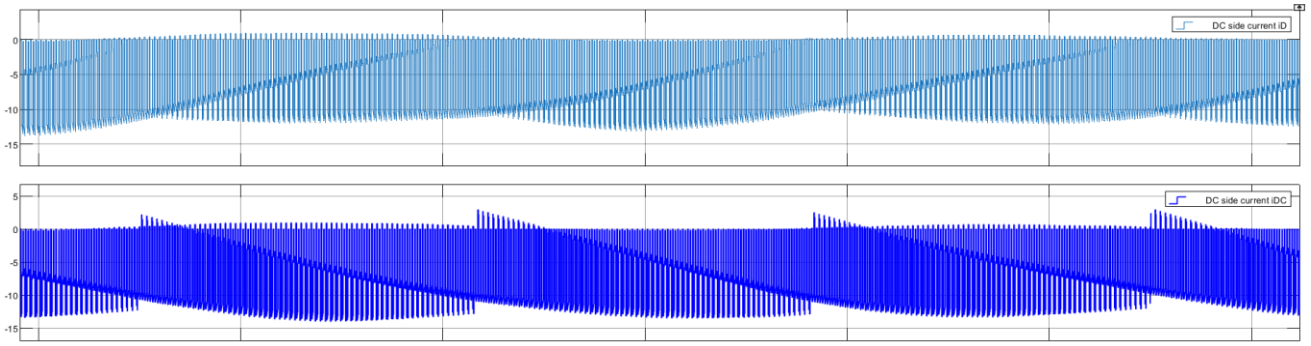

Figure 30 DC side current iD and iDC

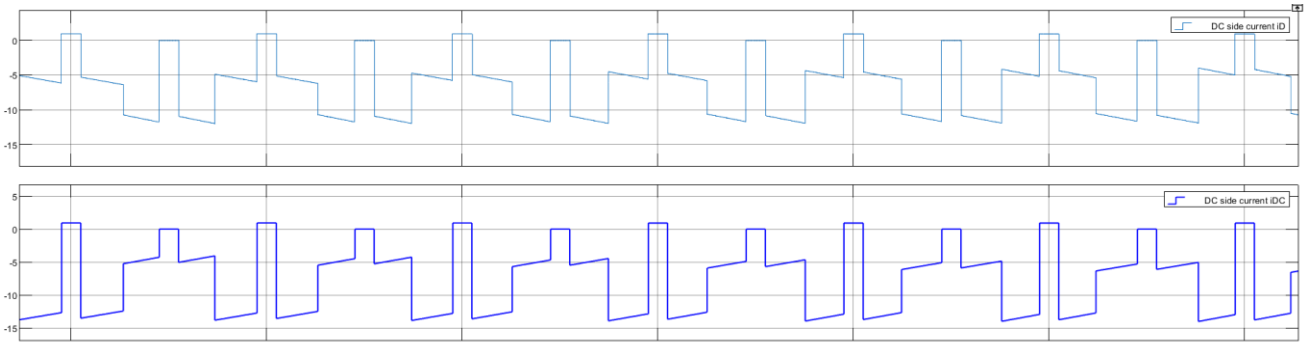

Figure 31 DC side current iD and iDC - Enlarged view

Quad	P	Q	Vn (ph, rms)	delta(degree)	Min Vdc	MI	I (l-l, rms)	Idc	power factor
1	5000	3000	227.2691	0.9348	556.6934	0.9784	8.4507	7.1429	0.8378
2	-5000	3000	228.066	-1.0505	558.645	0.9215	8.4507	-7.1429	0.855
3	-5000	-3000	232.791	-0.9126	570.218	0.9406	8.4507	-7.1429	0.847
4	5000	-3000	232.009	1.0326	568.306	0.9375	8.4507	7.1429	0.8926

Min Vdc for any P and Q = 556.6934 Volts