Contents **Page**

General	7/2
Structure and Functions	7/2
Forms of Internal Separation	7/2
Module Spectrum and Module Configuration in the Cubicle	7/3
Selection Table for Connecting Cables and Back-Up Fuses	7/4
Calculating and Determining the Required Capacitor Power	7/5
Table for Determining the Required Compensation Power	7/5

General

Choked or non-choked control units are used for reactive power compensation depending on the type of the load. There may be a need to install a fan assembly (improved convection) depending on the built-in power and the ambient temperature. The capacitor modules are set up with fuse switch-disconnectors.

Non-choked reactive power control units

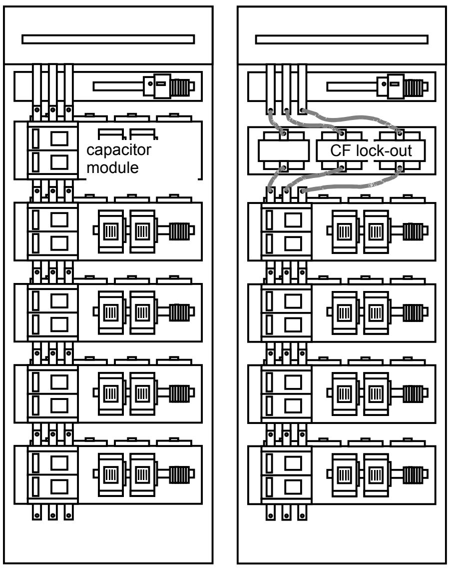
Non-choked reactive power control units are used for central compensation of reactive power in networks with predominantly linear loads. They are subdivided into several capacitor stages that can be switched easily. The reactive power controller 4RY84, which is installed in the door, makes it possible to keep to the specified nominal cos φ_2, even under changing load conditions, by activating or deactivating the stages. Converter power < 20 % of the total power.

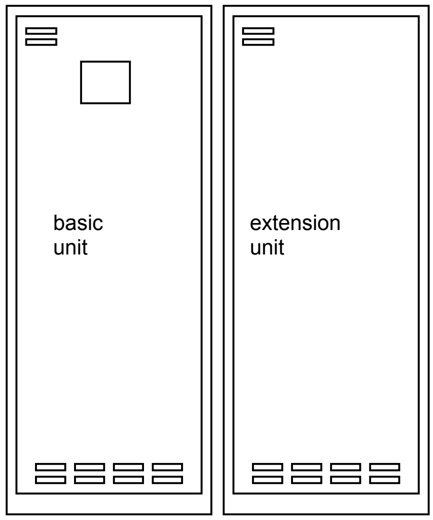
Choked reactive power control units

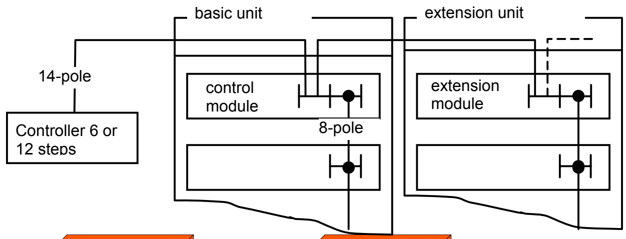
Choked reactive power control units can be used for central compensation of reactive power in networks with non-linear loads and, at the same time, non-linear loads may amount to > 20 % of the total load.

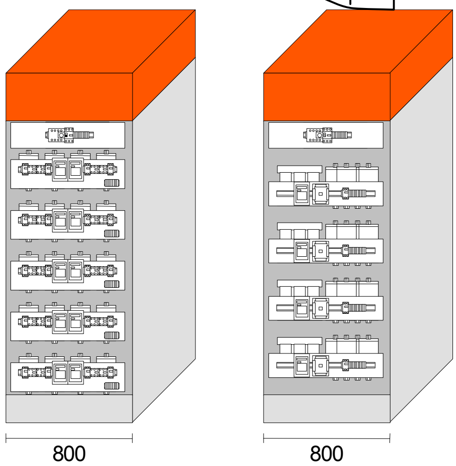
Structure and Functions

Reactive power compensation cubicles consist of one controller module and one or more capacitor module(s). The capacitor modules are connected to one another via connecting busbars and to the horizontal busbar system (no cable/busbar connection compartment). The cubicles generally feature ventilation slots.





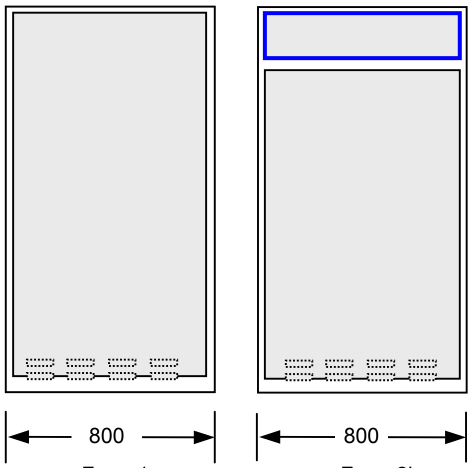




non-choked up to 500 kvar **PFC**

choked up to 300 kvar **PFC**

Forms of Internal Separation



Form 1
≤ IP 42, ventilated

Form 2b
≤ IP 42, ventilated

Module Spectrum and Module Configuration in the Cubicle

The choice of the capacitor modules (power and stages) depends on total power of the cubicle, number of steps and control series.

Rated operating voltage [V]	Fre-quency [Hz]	Power/ cubicle [kvar]	Number of steps [kvar]	Control series	Number of controller modules (control steps) [kvar]				Admissible ambient temperatures [°C] (ventilated)						
Controller module without and with fan assembly (control transformer required if no 230 V control voltage is available)															
up to 690	50	-	-	-	1 x per cubicle (basic unit)				-						
Controller															
-	-	-	-	-	1 x per cubicle (basic unit)				-						
Expansion unit without and with fan assembly (control transformer required if no 230 V control voltage is available)															
up to 690	50	-	-	-	1 x per cubicle (expansion unit)				-						
					50 (2x25)	**50 (1x50)**	**100 (2 x 50)**	**100 (1 x 100)**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Capacitor modules non-choked without parallel audio frequency blocking circuit															
400/525/690	50	50	2 x 25	1 : 1	1	-	-	-							
		100	4 x 25	1 : 1 : 2	1	1	-	-	+	+	+	+	+	+	+
		150	6 x 25	1 : 1 : 2 : 2	1	-	1	-							
		200	4 x 50	1 : 1 : 2	-	-	1	1							
		250	5 x 50	1 : 2 : 2	-	1	-	2	+	+	+	+	+	+	o
		300	6 x 50	1 : 1 : 2 : 2	-	-	1	2	+	+	+	+	+	o	o
		350	7 x 50	1 : 2 : 2 : 2	-	1	-	3	+	+	+	+	o	o	o
		400	8 x 50	1 : 1 : 2 : 2 : 2	-	-	1	3	+	+	+	+	o	o	o
		450	9 x 50	1 : 2 : 2 : 2 : 2	-	1	-	4	+	+	+	o	o	o	o
		500	10 x 50	1 : 1 : 2 : 2 : 2 : 2	-	-	1	4	+	+	o	o	o	o	o
Capacitor modules non-choked with parallel audio frequency blocking circuit															
400/525/690	50	100	4 x 25	1 : 1 : 2	1	1	-	-	+	+	+	+	+	+	+
		150	6 x 25	1 : 1 : 2 : 2	1	-	1	-	+	+	+	+	+	+	+
		200	4 x 50	1 : 1 : 2	-	-	1	1	+	+	+	+	+	+	o
		250	5 x 50	1 : 2 : 2	-	1	-	2	+	+	+	+	+	o	o
		300	6 x 50	1 : 1 : 2 : 2	-	-	1	2	+	+	+	+	o	o	o
Parallel audio frequency blocking circuit for audio frequencies 217 Hz- 1350 Hz (The audio frequency to be blocked must be specified in plain text)															
400/525/690	50	up to **300**	-	-	1 x per cubicle				-						
Capacitor modules choked 5,67 % (blocking effect >350Hz) and 7% (... >250Hz) and 14% (…>160 Hz) without parallel audio frequency blocking circuit															
400/525/690	50	50	2 x 25	1 : 1	1	-	-	-	+	+	+	+	+	+	o
		100	4 x 25	1 : 1 : 2	1	1	-	-	+	+	+	+	+	o	o
		150	6 x 25	1 : 1 : 2 : 2	1	-	1	-	+	+	+	+	o	o	o
		200	4 x 50	1 : 1 : 2	-	-	1	1	+	+	+	o	o	o	-
		250	5 x 50	1 : 2 : 2	-	1	-	2	+	+	o	o	o	-	-
		300	6 x 50	1 : 1 : 2 : 2	-	-	1	2	+	o	o	o	-	-	-
		350	7 x 50	1 : 2 : 2 : 2	-	1	-	3	o	o	o	-	-	-	-
		400	8 x 50	1 :1 : 2 : 2 : 2	-	-	1	3	o	o	o	-	-	-	-
Capacitor modules choked 7 % with parallel audio frequency blocking circuit															
400/525/690	50	100	4 x 25	1 : 1 : 2	1	1	-	-	+	+	+	+	+	o	o
		150	6 x 25	1 : 1 : 2 : 2	1	-	1	-	+	+	+	+	o	o	o
		200	4 x 50	1 : 1 : 2	-	-	1	1	+	+	+	o	o	o	-
		250	5 x 50	1 : 2 : 2	-	1	-	2	+	+	o	o	o	-	-
		300	6 x 50	1 : 1 : 2 : 2	-	-	1	2	+	o	o	o	-	-	-
Parallel audio frequency blocking circuit for audio frequencies > 160 Hz - 228 Hz (The audio frequency to be blocked must be specified in plain text)															
400/525/690	50	up to **300**	-	-	1 x per cubicle				-						
Connecting lugs for capacitor modules															
400/525/690	50	Number in the cubicle = number of capacitor modules in the cubicle - 1													

+ : no fan required
o : fan required
- : not possible

Selection Table for Connecting Cables and Back-Up Fuses

Power per cabinet or housing	System voltage AC 400 V 50 Hz			System voltage AC 525 V 50 Hz			System voltage AC 690 V 50 Hz		
	Rated current	Fuse per phase L1, L2, L3	Cable cross-section per phase L1, L2, L3	Rated current	Fuse per phase L1, L2, L3	Cable cross-section per phase L1, L2, L3	Rated current	Fuse per phase L1, L2, L3	Cable cross-section per phase L1, L2, L3
[kvar]	[A]	[A]	[mm²]	[A]	[A]	[mm²]	[A]	[A]	[mm²]
up to 21	30.3	35	10	-	-	-	-	-	-
25	36.1	63	16	27.5	50	10	20.9	50	10
30	43.3			-	-	-	-	-	-
35	50.5	80	25	-	-	-	-	-	-
40	57.7	100	35	-	-	-	-	-	-
45	64.9			-	-	-	-	-	-
50	72.2	100	35	54.9	100	35	41.8	63	16
60	86.6	160	70	-	-	-	-	-	-
70	101			-	-	-	-	-	-
75	108			82.5	125	35	62.7	100	25
80	115	200	95	-	-	-	-	-	-
100	144	250	120	110	200	95	83,6	125	35
125	180	300	150	137	200	95	105	160	70
150	217	355	2 x 70	165	250	120	126	200	95
160	231			-	-	-	-	-	-
175	253	400	2 x 95	192	300	150	146	250	120
200	289	500	2 x 120	220	355	185	167		
250	361	630	2 x 150	275	400	2 x 95	209	315	185
300	433	2 x 355[1)]	2 x 185	330	500	2 x 120	251	400	2 x 95
350	505	2 x 400[1)]	4 x 95	385	630	2 x 150	293	500	2 x 120
400	577	2 x 500[1)]	4 x 120	440	2 x 355[1)]	2 x 185	335		
450	650			495	4 x 400[1)]	4 x 95	377	2 x 315[1)]	2 x 185
500	722	2 x 630[1)]	4 x 150	550	2 x 500[1)]	4 x 120	418		

[1)] With this fusing the following warning notice is recommended **"Warning, feedback voltage due to parallel cable"**.

Calculating and Determining the Required Capacitor Power

1. The electricity invoice from the power supply corporation indicates the consumed active power demand in kWh and the reactive energy in kvarh; the power supply corporation demands a cos φ from 0.9 to 0.95; to save costs, reactive energy should be compensated to a value that approximates cos φ = 1.
2. Determining $\tan \varphi_1 = \frac{\text{Reactive energy}}{\text{Active power}} = \frac{\text{kvarh}}{\text{kWh}}$
3. Find the conversion factor "F" in the table and multiply it by the average power consumption P_m.
   In the case of tan φ_1, cos φ_1 shows the power factor **before** compensation whereas, in the case of factor "F", cos φ_2 shows the required power factor for compensation.
4. The required compensation power is specified in kvar.

Example:

Reactive energy W_b = 19.000 kvarh per month
Active power demand W_w = 16.660 kWh per month

Average power consumption

$$\frac{\text{Active power}}{\text{Working time}} = \frac{16.660 \text{ kWh}}{180 \text{ h}} = 92.6 \text{ kW}$$

$$\tan \varphi_1 = \frac{\text{Reactive energy}}{\text{Active power}} = \frac{19.000 \text{ kWh}}{16.660 \text{ kWh}} = 1.4$$

Power factor cos φ_1 = 0.66 (in the case of tan φ_1 = 1.14)
Power factor cos φ_2 = 0.95 (desired)
Conversion factor "F" = 0.81 (from tan φ_1 and cos φ_2)
Compensation power = Average power x factor "F"
= 92.6 kW x 0.81

Required compensation power: 75 kvar

Table for Determining the Required Compensation Power

Actual value (given)		Conversion factor "F"										
tan φ_1	cos φ_1	cos φ_2 = 0,70	cos φ_2 = 0,75	cos φ_2 = 0,80	cos φ_2 = 0,82	cos φ_2 = 0,85	cos φ_2 = 0,87	cos φ_2 = 0,90	cos φ_2 = 0,92	cos φ_2 = 0,95	cos φ_2 = 0,97	cos φ_2 = 1,00
4.90	0.20	3.88	4.02	4.15	4.20	4.28	4.33	4.41	4.47	4.57	4.65	4.90
3.87	0.25	2.85	2.99	3.12	3.17	3.25	3.31	3.39	3.45	3.54	3.62	3.87
3.18	0.30	2.16	2.30	2.43	2.48	2.56	2.61	2.70	2.75	2.85	2.93	3.18
2.68	0.35	1.66	1.79	1.93	1.98	2.06	2.11	2.19	2.25	2.35	2.43	2.68
2.29	0.40	1.27	1.41	1.54	1.59	1.67	1.72	1.81	1.87	1.96	2.04	2.29
2.16	0.42	1.14	1.28	1.41	1.46	1.54	1.59	1.68	1.74	1.83	1.91	2.16
2.04	0.44	1.02	1.16	1.29	1.34	1.42	1.47	1.56	1.62	1.71	1.79	2.04
1.93	0.46	0.91	1.05	1.18	1.23	1.31	1.36	1.45	1.50	1.60	1.68	1.93
1.83	0.48	0.81	0.95	1.08	1.13	1.21	1.26	1.34	1.40	1.50	1.58	1.83
1.73	0.50	0.71	0.85	0.98	1.03	1.11	1.17	1.25	1.31	1.40	1.48	1.73
1.64	0.52	0.62	0.76	0.89	0.94	1.02	1.08	1.16	1.22	1.31	1.39	1.64
1.56	0.54	0.54	0.68	0.81	0.86	0.94	0.99	1.07	1.13	1.23	1.31	1.56
1.48	0.56	0.46	0.60	0.73	0.78	0.86	0.91	1.00	1.05	1.15	1.23	1.48
1.40	0.58	0.38	0.52	0.65	0.71	0.78	0.84	0.92	0.98	1.08	1.15	1.40
1.33	0.60	0.31	0.45	0.58	0.64	0.71	0.77	0.85	0.91	1.00	1.08	1.33
1.27	0.62	0.25	0.38	0.52	0.57	0.65	0.70	0.78	0.84	0.94	1.01	1.27
1.20	0.64	0.18	0.32	0.45	0.50	0.58	0.63	0.72	0.77	0.87	0.95	1.20
1.14	0.66	0.12	0.26	0.39	0.44	0.52	0.57	0.65	0.71	0.81	0.89	1.14
1.08	0.68	0.06	0.20	0.33	0.38	0.46	0.51	0.59	0.65	0.75	0.83	1.08
1.02	0.70	-	0.14	0.27	0.32	0.40	0.45	0.54	0.59	0.69	0.77	1.02
0.96	0.72		0.08	0.21	0.27	0.34	0.40	0.48	0.54	0.63	0.71	0.96
0.91	0.74		0.03	0.16	0.21	0.29	0.34	0.42	0.48	0.58	0.66	0.91
0.86	0.76		-	0.11	0.16	0.24	0.29	0.37	0.43	0.53	0.60	0.86
0.80	0.78			0.05	0.10	0.18	0.24	0.32	0.38	0.47	0.55	0.80
0.75	0.80			-	0.05	0.13	0.18	0.27	0.32	0.42	0.50	0.75
0.70	0.82				-	0.08	0.13	0.21	0.27	0.37	0.45	0.70
0.65	0.84					0.03	0.08	0.16	0.22	0.32	0.40	0.65
0.59	0.86					-	0.03	0.11	0.17	0.26	0.34	0.59
0.54	0.88						-	0.06	0.11	0.21	0.29	0.54
0.48	0.90							-	0.06	0.16	0.23	0.48
0.43	0.92								-	0.10	0.18	0.43
0.36	0.94									0.03	0.11	0.36
0.29	0.96									-	0.01	0.29
0.20	0.98										-	0.20