DUCATI energia

HISTORY DRIVES THE FUTURE

Since 1926

Low voltage power factor correction: capacitors, components, fixed & automatic equipment and active harmonic filters

EQUIPMENT

SELECTION CRITERIA

PFC: why?

There are many objectives to be pursued in the planning of an electrical system. Among the measures that enable electricity use to be optimized, improving the power factor of electrical systems is undoubtedly one of the most important. If we quantify this aspect from the utility company's point of view, raising the average operating power factor of the network from 0.7 to 0.95 means:

- Cutting costs due to ohmic losses in the network by 45%
- Increasing the potential of production and distribution plants by 35%

The user which corrects the power factor in his plants gets these advantages:

- To avoid the fees by the supplier
- It reduces the absorbed current and it optimizes the electrical system
- It reduces the voltage drops and the losses due to Joule effect

How to correct

The most appropriate technical solution is to put on each load its own power factor correction capacitor to be included with the drive switch (distributed PFC).
The most effective power factor correction, however, is the one that involves the installation of an automatic battery on the bars of the distribution panel (Centralized PFC) and, if necessary, the installation of fixed capacitor banks for the correction of transformers, asynchronous motors and any loads that absorb significate amount of reactive power.
For electrical machines such as induction motors and transformers it is often used a fixed power factor correction, most of the time sized on values obtained from tables.

How to compute

The calculation of the capacitor bank to be installed in an installation is simple: given the cosφ of the system without any correction (often obtainable from electric bills) and the cosφ that has to be reached, the reactive power necessary to achieve the wanted Power factor is obtained by few calculations:

$Qc = P \cdot (\tan\varphi_0 - \tan\varphi_1) = P \cdot K$
P = active power of the system
$\cos\varphi_0 = \cos\varphi$ of the system without PFC
$\cos\varphi_1 = \cos\varphi$ target
Qc = reactive power of PFC system to be installed
K = given $\cos\varphi_0$ and $\cos\varphi_1$ K is derived from the table below

If the system's coφs value should be unknown, the calculation of the reactive power necessary for the compensation can be done starting from the data found on the energy utility's bills or read directly from the utility's energy meter.

Knowing the active power [kW] P and the reactive power [kVAr] Q of the system, or the active energy [kWh] and the reactive energy [kVArh], the following formula can be used:
$Q / P = \tan\varphi$
The tanφ value thus calculated can be used with the table to calculate the reactive power of the PFC equipment necessary to correct the PF to the desired value.
For the monitoring of the system's electrical parameters we suggest the installation of one or more Network Analysers, providing measurements of all parameters characterising the system and the loads. DUCATI Energia offers a comprehensive range of Energy Analysers and Monitoring Systems.

Reference notes

The capacitors and the automatic power factor correction equipment must be installed in well-ventilated areas.
The air should be able to circulate freely through the air vents. The ambient temperature must comply with EN 60831-1/2 standards.
When the system subject to power factor correction has AC/DC static conversion systems (e.g. for the operation of DC motors, uninterrupted power systems, etc.), harmonic currents are generated and may cause either current or voltage overloads which the capacitors are unable to withstand.
DUCATI energia can provide properly protected equipment suitable for use in such systems as well as filter systems designed to eliminate harmonic components.
When the capacitors are used in automatic equipment, be sure to check that the regulator response time is greater than the capacitor discharge time. If this is not the case, suitable discharge resistors should be installed.
The use of rigid connections should be avoided with cylindrical capacitors in order to avoid blocking the intervention of the overpressure device.
For this reason at least 3 cm should be left between the terminals and any surface above the upper capacitor.
In the automatic equipment the integrity of the pre-charging resistors should be checked every 10.000 operations or at least once a year.
Plan to replace the contactors every 100.000 operations.
The guarantee does not cover problems arising from operation:

- In the presence of excessive harmonic overloads (> 1.3 In, > 1.1 Un.)
- Contactors with worn-out electrical contacts or interrupted precharging resistors

Installation notes

As required by the standards, it is necessary to ensure an appropriate protection against short-circuit and overload (via magnetic/thermic circuit breaker or fuses) for the line supplying the PFC units. The protection must be dimensioned for capacitive currents (approx. 1,45 times the equipment's nominal current) and taking into account the short-time short-circuit current values expected in the point of installation and sustainable by the PFC equipment.

K FACTOR

See the full table at page 64.

Existing values		Target cosφ										
tgφ	**cosφ**	**0.90**	**0.91**	**0.92**	**0.93**	**0.94**	**0.95**	**0.96**	**0.97**	**0.98**	**0.99**	**1.00**
0.72	0.81	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.70	0.82	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.556	0.698
0.67	0.83	0.188	0.216	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.530	0.672
0.65	0.84	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646

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Criteria for choosing equipment according to network conditions

Once the maximum necessary power has been determined as directed in the previous sections, the choice of which type of equipment to adopt must be based on the conditions of the electrical network and the types of loads present.The selection table below, drawn up on the basis of general plant characteristics (and thus not usable for planning purposes), aims to provide an indication of the power factor correction system generally suited to the most frequently encountered conditions; electrical systems with mains voltage of 400V-50Hz, characterized by the presence of distorting loads with a spectrum composed of 5th, 7th, 11th and 13th harmonics.

SERIES	THDi < 12% (THDic <50%)	THDi < 20% (THDic < 70%)	THDi < 27% (THDic < 85%)	THDi < 80% (THDic < 95%)	THDi < 80% (THDic <100%)	PV system
Fixed PFC equipment						
DUCATI F120 (5 - 120 kVAr) 	Un = 415 V	Un = 450 V	Un = 525 V	Un = 525 V	Un = 525 V	
Automatic PFC equipment						
DUCATI 50-M (5 - 50 kVAr) 	Un = 415 V	Un = 450 V	Un = 525 V			Un ≥ 450 V
DUCATI 200-M (60 - 200 kVAr) 	Un = 415 V	Un = 450 V	Un = 525 V			Un ≥ 450 V
DUCATI 400-M (220 - 400 kVAr) 	Un = 415 V	Un = 450 V	Un = 525 V			Un ≥ 450 V
DUCATI 1600-R (240-1600 kVAr) 	Un = 415 V	Un = 450 V	Un = 525 V			Un ≥ 450 V
Automatic PFC equipment with detuning reactors						
DUCATI 170-ML (25,5-170 kVAr) 	✔	✔	✔	✔		✔
DUCATI 1000-RL (150 -1000 kVAr) 	✔	✔	✔	✔		✔
DUCATI 1000-RL/HP (132 - 1056 kVAr) 	✔	✔	✔	✔	✔	✔
Real time automatic PFC equipment						
DUCATI 1000-RL/S (250 - 600 kVAr) 	✔	✔	✔	✔		✔

DUCATI F120

Fixed power factor correction equipment

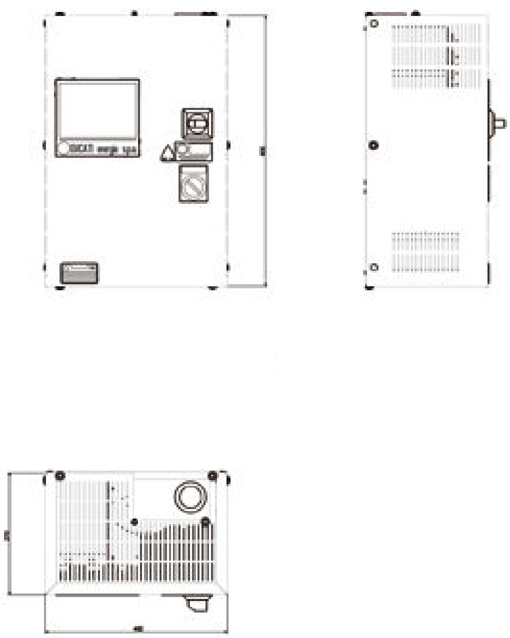
Technical details

- Single-phase capacitors **MONO Long Life 4I$_N$** in PPMh, for a continuous duty under highly demanding condition in harmonic rich environments. Rated voltage 415V, 450V, 525V
- External steel structure painted with epoxy powder color RAL 7035
- Omni pole disconnecting switch, with door lock, and rated current 1.45In according to the CEI EN standard

General Characteristics

Rated voltage	400 V
Rated frequency	50 Hz
Insulating voltage	690 V
Ventilation	Natural
Usage	Indoor
Protection degree	IP 30
Duty	Continuous
Temperature range	-5 +40 °C
Power supply	3F + PE
Cable entry	Top
Internal connection	FS17
Discharge devices	On each capacitor
Fuse	NH-00 GL
Standards	IEC 61439 IEC 61921

TECHNICAL DRAWING DUCATI F120



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DUCATI F120 Un cond = 415 V

Part n. 415.04.	Qn (kVAr)	Q (400 V) (kVAr)	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
8005	5	4.6	7	40	400x270x400	15
8007	10	9.3	13	40	400x270x400	15
8010	20	18.6	27	63	400x270x400	17
8015	40	37.2	54	80	400x270x400	17
8020	60	55.7	80	125	400x270x400	21
8025	80	74.3	107	125	400x270x600	30
8030	100	92.9	134	250	400x270x1000	32
8035	120	111.5	161	250	400x270x1000	33

DUCATI F120 Un cond = 450V

Part n. 415.04.	Qn (kVAr)	Q (400 V) (kVAr)	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
8105	5	4.0	6	40	400x270x400	15
8107	10	7.9	11	40	400x270x400	15
8110	20	15.8	23	63	400x270x400	17
8115	40	31.6	46	80	400x270x400	17
8120	60	47.4	68	125	400x270x400	21
8125	80	63.2	91	125	400x270x600	30
8130	100	79.0	114	250	400x270x1000	32
8135	120	94.8	137	250	400x270x1000	33

DUCATI F120 Un cond = 525 V

Part n. 415.04.	Qn (kVAr)	Q (400 V) (kVAr)	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
8205	5	2.9	4	40	400x270x400	15
8207	10	5.8	8	40	400x270x400	15
8210	20	11.6	17	63	400x270x400	17
8215	40	23.2	34	80	400x270x400	17
8220	60	34.8	50	125	400x270x400	21
8225	80	46.4	67	125	400x270x600	30
8230	100	58.0	84	250	400x270x1000	32
8235	120	69.7	101	250	400x270x1000	33

DUCATI 50-M

Automatic power factor correction equipment

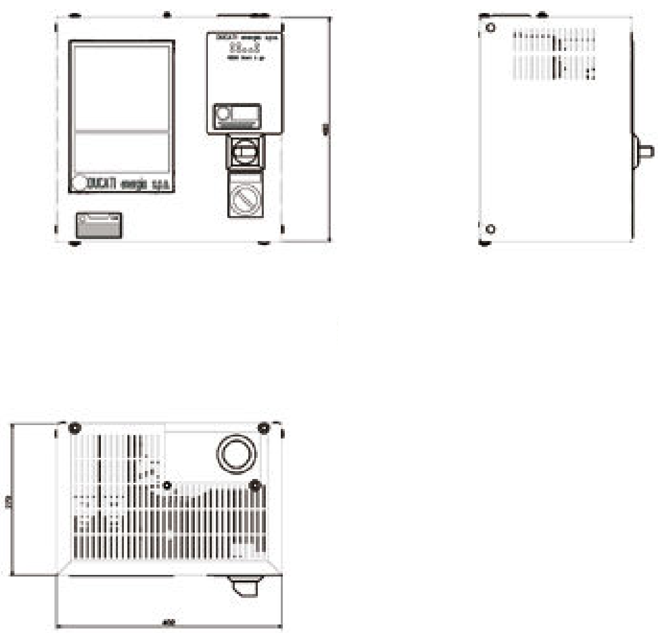
Technical details

- Single-phase capacitors **MONO Long Life $4I_N$** in PPMh, for a continuous duty under highly demanding condition in harmonic rich environments. Rated voltage 415 V, 450 V, 525 V
- Power Factor controller series **START&GO**. No setup required (TC autosensing and automatic start), fast and user friendly. Suitable for cogeneration plants as PV
- External steel structure painted with epoxy powder color RAL 7035
- Omni pole disconnecting switch, with door lock, and rated current 1.45In according to the CEI EN standard
- Contactors designed for controlling capacitive loads, equipped with an inrush current limiting device with 230 V 50-60 Hz power supply

General Characteristics

Rated voltage	400 V
Rated frequency	50 Hz
Insulating voltage	690 V
Ventilation	Natural
Usage	Indoor
Protection degree	IP 30
Duty	Continuous
Temperature range	-5 +40 °C
Power supply	3F + PE + N
Cable entry	Top
Internal connection	FS17
Discharge devices	On each capacitor
Fuse	NH-00 GL
Standards	IEC 61439 where applicable IEC 61921
I_{SH}	50 kA (conditioned by the upstream protective device)

TECHNICAL DRAWING DUCATI 50-M



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DUCATI 50-M Un - Cond = 415 V

$THD_{I\,MAX\text{-}C}$ % ≤ 50% THD_I% ≤ 12% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0010	5	4.7	0.7 + 1.4 + 2.9	7	7	40	400x270x400	15
0015	7.5	7.0	1.1 + 2.1 + 4.3	7	10	40	400x270x400	15
0020	10	9.3	1.4 + 2.9 + 5.7	7	13	40	400x270x400	16
0025	12.5	11.6	2.5 + 2 x 5	5	17	40	400x270x400	16
0030	17.5	16.3	2.5 + 5 + 10	7	23	40	400x270x400	16
0035	20	18	2 x 5 + 10	4	27	63	400x270x400	17
0040	25	23	5 + 2 x 10	5	34	63	400x270x400	17
0045	35	32	5 + 10 + 20	7	47	80	400x270x400	18
0050	40	37	2 x 10 + 20	4	54	80	400x270x400	18
0055	50	46	10 + 2 x 20	5	68	80	400x270x400	19

DUCATI 50-M Un - Cond = 450 V

$THD_{I\,MAX\text{-}C}$ % ≤ 70% THD_I% ≤ 20% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0210	20	15	2 x 5 + 10	4	23	63	400x270x400	17
0215	25	19	5 + 2 x 10	5	29	63	400x270x400	17
0220	35	27	5 + 10 + 20	7	40	80	400x270x400	18
0225	40	31	2 x 10 + 20	4	46	80	400x270x400	18
0230	50	39	10 + 2 x 20	5	57	80	400x270x400	19

DUCATI 50-M Un - Cond = 525 V

$THD_{I\,MAX\text{-}C}$ % ≤ 85% THD_I% ≤ 27% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0310	20	11	2 x 5 + 10	4	17	63	400x270x400	17
0315	25	14	5 + 2 x 10	5	21	63	400x270x400	17
0320	35	20	5 + 10 + 20	7	29	80	400x270x400	18
0325	40	23	2 x 10 + 20	4	34	80	400x270x400	18
0330	50	29	10 + 2 x 20	5	42	80	400x270x400	19

DUCATI 200-M

Automatic power factor correction equipment

Technical details

- Single-phase capacitors **MONO Long Life 4I$_N$** in PPMh, for a continuous duty under highly demanding condition in harmonic rich environments. Rated voltage 415 V, 450 V, 525 V
- Power Factor Controller series **rEvolution R5**. NFC connection for the exchange of the configuration with **"DUCATI Smart Energy" App.** Auto-sensing of the direction and the position of the TC, to ease the opertaions of the setup. Suitable for cogeneration plants as PV
- External steel structure painted with epoxy powder color RAL 7035
- Omni pole disconnecting switch, with door lock, and rated current 1.45In according to the CEI EN standard
- Contactors designed for controlling capacitive loads, equipped with an inrush current limiting device with 230 V 50 - 60 Hz power supply

General Characteristics

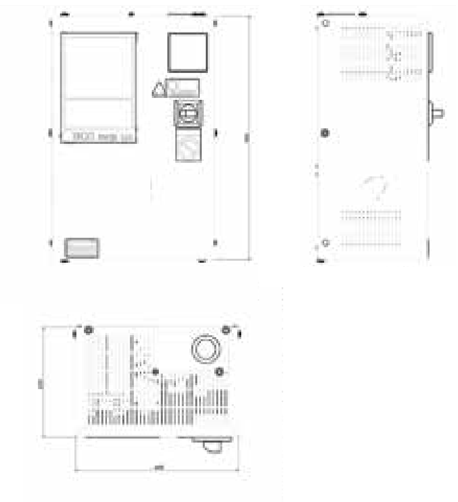
Rated voltage	400 V
Rated frequency	50 Hz
Insulating voltage	690 V
Ventilation	Natural
Usage	Indoor
Protection degree	IP30 - IP54
Duty	Continuous
Temperature range	-5 +40 °C
Power supply	3PH + PE + N (Up to 80 kVAr) 3PH + PE (Q_n > 80 kVAr)
Cable entry	Top
Internal connection	FS17
Discharge devices	On each capacitor
Fuse	NH-00 GL
Standards	IEC 61439 where applicable IEC 61921
I_{SH}	50 kA (conditioned by the upstream protective device)

DUCATI 200-M Un - Cond = 415 V IP30

THD$_{I\ MAX\text{-}C}$ % ≤ 50% THD$_I$% ≤ 12% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0060	60	55	2 x 10 + 2 x 20	6	80	125	400x270x600	30
0065	70	65	10 + 3 x 20	7	94	125	400x270x600	35
0070	80	74	2 x 10 + 20 + 40	8	107	125	400x270x600	35
0075	90	83	10 + 2 x 20 + 40	9	121	250	400x270x1000	40
0080	100	92	2 x 10 + 2 x 20 + 40	10	134	250	400x270x1000	45
0085	120	111	2 x 10 + 20 + 2 x 40	12	161	250	400x270x1200	50
0090	140	130	20 + 3 x 40	7	188	400	400x270x1200	55
0095	160	148	2 x 20 + 3 x 40	8	215	400	400x270x1200	60
0100	180	167	20 + 4 x 40	9	241	400	400x270x1400	65
0105	200	185	2 x 20 + 2 x 40 + 80	10	268	400	400x270x1400	70

TECHNICAL DRAWING DUCATI 200-M IP30
60 ÷ 80 kVAr

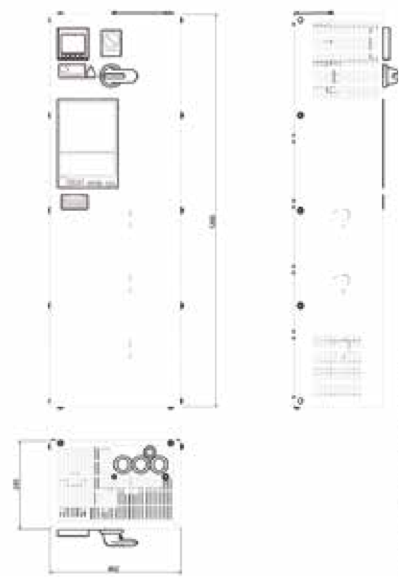


DUCATI 200-M Un - Cond = 450 V IP30

THD$_{I\ MAX\text{-}C}$ % ≤ 70% THD$_I$% ≤ 20% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0235	60	47	2 x 10 + 2 x 20	6	68	125	400x270x600	30
0240	70	55	10 + 3 x 20	7	80	125	400x270x600	35
0245	80	63	2 x 10 + 20 + 40	8	91	125	400x270x600	35
0250	90	71	10 + 2 x 20 + 40	9	103	250	400x270x1000	40
0255	100	79	2 x 10 +2 x 20+40	10	114	250	400x270x1000	45
0260	120	94	2 x 10 + 20 + 2 x 40	12	137	250	400x270x1200	50
0265	140	110	20 + 3 x 40	7	160	400	400x270x1200	55
0270	160	126	2 x 20 + 3 x 40	8	182	400	400x270x1200	60
0275	180	142	20 + 4 x 40	9	205	400	400x270x1400	65
0280	200	158	2 x 20 + 2 x 40 + 80	10	228	400	400x270x1400	70

TECHNICAL DRAWING DUCATI 200-M IP30
90 ÷ 200 kVAr



DUCATI 200-M Un - Cond = 525 V IP30

THD$_{I\ MAX\text{-}C}$ % ≤ 85% THD$_I$% ≤ 27% Un 400 V - 50 Hz

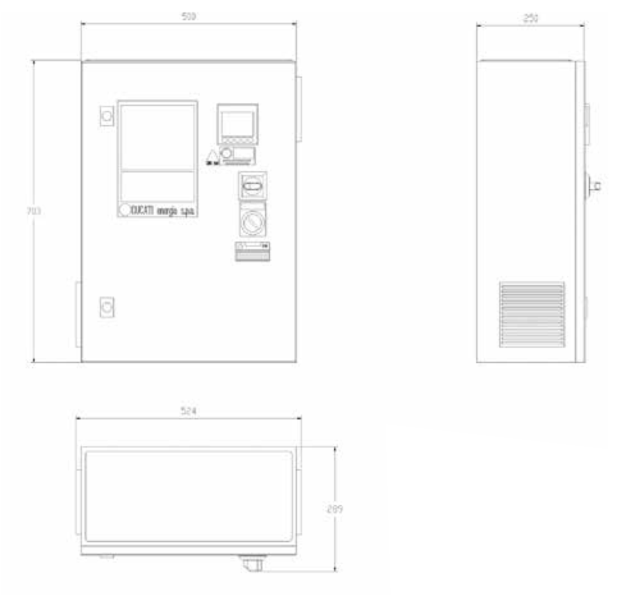
Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0335	60	34	2 x 10 + 2 x 20	6	50	125	400x270x600	30
0340	70	40	10 + 3 x 20	7	59	125	400x270x600	35
0345	80	46	2 x 10 + 20 + 40	8	67	125	400x270x600	35
0350	90	52	10 + 2 x 20 + 40	9	75	250	400x270x1000	40
0355	100	58	2 x 10 + 2 x 20 + 40	10	84	250	400x270x1000	45
0360	120	69	2 x 10 + 20 + 2 x 40	12	101	250	400x270x1200	50
0365	140	81	20 + 3 x 40	7	117	400	400x270x1200	55
0370	160	92	2 x 20 + 3 x 40	8	134	400	400x270x1200	60
0375	180	104	20 + 4 x 40	9	151	400	400x270x1400	65
0380	200	116	2 x 20 + 2 x 40 + 80	10	168	400	400x270x1400	70

DUCATI 200-M Un - Cond = 415 V IP54

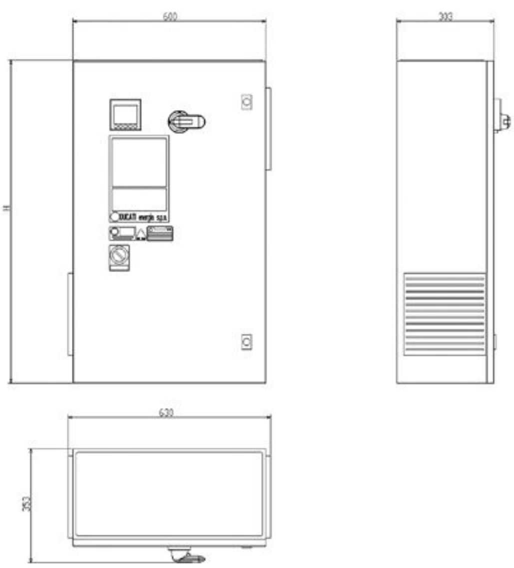
$THD_{I\ MAX\text{-}C}$ % ≤ 50% THD_I% ≤ 12% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0011	5	4.7	0.7 + 1.4 + 2.9	7	7	40	500x250x700	39
0016	7.5	7.0	1.1 + 2.1 + 4.3	7	10	40	500x250x700	39
0021	10	9.3	1.4 + 2.9 + 5.7	7	13	40	500x250x700	39
0026	12.5	11.6	2.5 + 2 x 5	5	17	40	500x250x700	40
0031	17.5	16.3	2.5 + 5 +10	7	23	40	500x250x700	40
0036	20	18	2 x 5	4	27	63	500x250x700	41
0041	25	23	5 + 2 x 10	5	34	63	500x250x700	41
0046	35	32	5 + 10 + 20	7	47	80	500x250x700	42
0051	40	37	2 x 10 + 20	4	54	80	500x250x700	42
0056	50	46	10 + 2 x 20	5	67	80	500x250x700	43
0061	60	55	2 x 10 + 2 x 20	6	80	125	500x250x700	54
0067	70	65	10 + 3 x 20	7	94	125	500x250x700	59
0071	80	74	2 x 10 + 20 +40	8	107	125	500x250x700	59
0076	90	83	10 + 2 x 20+40	9	121	250	600x300x1000	77
0081	100	92	2 x 10 + 2 x 20+40	10	134	250	600x300x1000	82
0086	120	111	2 x 10 + 20 + 2 x 40	12	161	250	600x300x1000	93
0091	140	130	20 + 3 x 40	7	188	400	600x300x1000	98
0096	160	148	2 x 20 + 3 x 40	8	215	400	600x300x1200	109
0101	180	167	20 + 4 x 40	9	241	400	600x300x1400	114
0106	200	185	2 x 20 + 2 x 40 + 80	10	268	400	600x300x1400	119

TECHNICAL DRAWING DUCATI 200-M IP54
5-80kVAr



TECHNICAL DRAWING DUCATI 200-M IP54
90-200kVAr



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DUCATI 200-M Un - Cond = 450 V IP54

$THD_{I\ MAX\text{-}C}$ % ≤ 70% THD_I% ≤ 20% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0211	20	15	2 x 5 + 10	4	23	63	500x250x700	41
0216	25	19	5 + 2 x 10	5	29	63	500x250x700	41
0221	35	27	5 + 10 + 20	7	40	80	500x250x700	42
0226	40	31	2 x 10 + 20	4	46	80	500x250x700	42
0231	50	39	10 + 2 x 20	5	57	80	500x250x700	43
0236	60	47	2 x 10 + 2 x 20	6	68	125	500x250x700	54
0241	70	55	10 + 3 x 20	7	80	125	500x250x700	59
0246	80	63	2 x 10 + 20 + 40	8	91	125	500x250x700	59
0251	90	71	10 + 2 x 20 + 40	9	103	250	600x300x1000	77
0256	100	79	2 x 10 + 2 x 20 + 40	10	114	250	600x300x1000	82
0261	120	94	2 x 10 + 20 + 2 x 40	12	137	250	600x300x1200	93
0266	140	110	20 + 3 x 40	7	160	400	600x300x1200	98
0271	160	126	2 x 20 + 3 x 40	8	182	400	600x300x1200	109
0276	180	142	20 + 4 x 40	9	205	400	600x300x1400	114
0281	200	158	2 x 20 + 2 x 40 + 80	10	228	400	600x300x1400	119

DUCATI 200-M Un - Cond = 525 V IP54

$THD_{I\ MAX\text{-}C}$ % ≤ 85% THD_I% ≤ 27% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0311	20	11	2 x 5 + 10	4	17	63	500x250x700	41
0316	25	14	5 + 2 x 10	5	21	63	500x250x700	41
0321	35	20	5 + 10 + 20	7	29	80	500x250x700	42
0326	40	23	2 x 10 + 20	4	34	80	500x250x700	42
0331	50	29	10 + 2 x 20	5	42	80	500x250x700	43
0336	60	34	2 x 10 + 2 x 20	6	50	125	500x250x700	54
0341	70	40	10 + 3 x 20	7	59	125	500x250x700	59
0346	80	46	2 x 10 + 20 + 40	8	67	125	500x250x700	59
0351	90	52	10 + 2 x 20 + 40	9	75	250	500x250x1000	77
0356	100	58	2 x 10 + 2 x 20 + 40	10	84	250	500x250x1000	82
0361	120	69	2 x 10 + 20 + 2 x 40	12	101	250	500x250x1200	93
0366	140	81	20 + 3 x 40	7	117	400	500x250x1200	98
0371	160	92	2 x 20 + 3 x 40	8	134	400	500x250x1200	109
0376	180	104	20 + 4 x 40	9	151	400	500x250x1400	114
0381	200	116	2 x 20 + 2 x 40 + 80	10	168	400	500x250x1400	119

DUCATI 400-M

Automatic power factor correction equipment

Technical details

- Single-phase capacitors **MONO Long Life 4I$_N$** series in PPMh, for a continuous duty under highly demanding condition in harmonic rich environments. Rated voltage 415 V, 450 V, 525 V
- Power Factor Controller series **rEvolution R5 485 radio**. Auto-sensing of the direction and the position of the TC, to ease the opertaions of the setup. Suitable for cogeneration plants as PV. NFC connection for the exchange of the configurations with **"DUCATI Smart Energy" App**. Optional integration with cloud data sharing system **DUCNET**, through RS485 connection or radio 868 MHz transmission
- External steel structure painted with epoxy powder color RAL 7035
- Omni pole disconnecting switch, with door lock, and rated current 1.45 In according to the CEI EN standard
- Contactors designed for controlling capacitive loads, equipped with an inrush current limiting device with 230 V 50 - 60 Hz power supply

General Characteristics

Rated voltage	400 V
Rated frequency	50 Hz
Insulating voltage	690 V
Ventilation	Forced
Usage	Indoor
Protection degree	IP 30
Duty	Continuous
Temperature range	-5 +40 °C
Power supply	3F + PE
Cable entry	Top
Internal connection	FS17
Discharge devices	On each capacitor
Fuse	NH-00 GL
Standards	IEC 61439 where applicable IEC 61921
I_{SH}	50 kA (conditioned by the upstream protective device)

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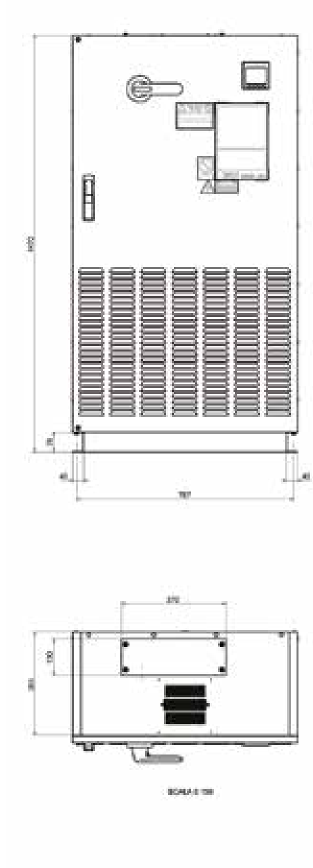
DUCATI 400-M Un - Cond = 415 V

$THD_{I\ MAX\text{-}C}$ % ≤ 50% THD_{I}% ≤ 12% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0510N	220	204	20 + 3 x 40 + 80	11	295	630	800x400x1470	115
0515N	240	223	2 x 20 + 40 + 2 x 80	12	322	630	800x400x1470	120
0520N	260	241	20 + 2 x 40 + 2 x 80	13	349	630	800x400x1470	125
0525N	280	260	3 x 40 + 2 x 80	7	375	630	800x400x1470	130
0527N	300	278	20 + 40 + 3 x 80	15	402	630	800x400x1470	135
0530N	320	297	2 x 40 + 3 x 80	8	429	800	800x400x1470	140
0535N	360	334	40 + 4 x 80	9	483	800	800x400x1470	145
0540N	400	371	5 x 80	5	536	800	800x400x1470	150

TECHNICAL DRAWING DUCATI 400-M



DUCATI 400-M Un - Cond = 450 V

$THD_{I\ MAX\text{-}C}$ % ≤ 70% THD^{I}% ≤ 20% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0610N	220	173	20 + 3 x 40 + 80	11	251	630	800x400x1470	115
0615N	240	189	2 x 20 + 40 +2 x 80	12	274	630	800x400x1470	120
0620N	260	205	20 + 2 x 40 + 2 x 80	13	297	630	800x400x1470	125
0625N	280	221	3 x 40 + 2 x 80	7	319	630	800x400x1470	130
0627N	300	237	20 + 40 + 3 x 80	15	342	630	800x400x1470	135
0630N	320	252	2 x 40 + 3 x 80	8	365	800	800x400x1470	140
0635N	360	284	40 + 4 x 80	9	411	800	800x400x1470	145
0640N	400	316	5 x 80	5	456	800	800x400x1470	150

DUCATI 400-M Un - Cond = 525 V

$THD_{I\ MAX\text{-}C}$ % ≤ 85% THD_{I}% ≤ 27% Un 400 V - 50 Hz

Part n. 415.04	Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	LxPxH (mm)	Weight (kg)
0710N	220	127	20 + 3 x 40 + 80	11	184	630	800x400x1470	115
0715N	240	139	2 x 20 + 40 + 2 x 80	12	201	630	800x400x1470	120
0720N	260	150	20 + 2 x 40 + 2 x 80	13	218	630	800x400x1470	125
0725N	280	162	3 x 40 + 2 x 80	7	235	630	800x400x1470	130
0727N	300	174	20 + 40 + 3 x 80	15	251	630	800x400x1470	135
0730N	320	185	2 x 40 + 3 x 80	8	268	800	800x400x1470	140
0735N	360	209	40 + 4 x 80	9	302	800	800x400x1470	145
0740N	400	232	5 x 80	5	335	800	800x400x1470	150

DUCATI 1600-R

Automatic power factor correction equipment

Technical details

- Single-phase capacitors **MONO Long Life 4I_N** series in PPMh, for a continuous duty under highly demanding condition in harmonic rich environments. Rated voltage 415 V, 450 V, 525 V
- Power Factor Controller series **rEvolution R8** with 868 MHz radio module and RS485 and Bluetooth connection. In addition of the NFC module, there's the BT connection to exchange configuration files and status information with **"DUCATI Smart Energy" App**. Auto-sensing of the direction and the position of the TC, to ease the operations of setup. Suitable for cogeneration plants as PV. NFC connection for the exchange of the configurations with **"DUCATI Smart Energy" App**. Optional integration with cloud data sharing system **DUCNET**, through radio 868 MHz transmission
- External steel structure painted with epoxy powder color RAL 7035
- Omni pole disconnecting switch, with door lock, and rated current 1.45 In according to the CEI EN standard
- Contactors designed for controlling capacitive loads, equipped with an inrush current limiting device with 230 V 50 - 60 Hz power supply

General Characteristics

Rated voltage	450 V - 525 V
Rated frequency	50 Hz
Insulating voltage	690 V
Ventilation	Forced
Usage	Indoor
Protection degree	IP30 - IP54
Duty	Continuous
Temperature range	-5 +40 °C
Power supply	3F + PE
Cable entry	Top or bottom
Internal connection	FS17
Discharge devices	On each capacitor
Fuse	NH-00 GL
Standards	IEC 61439 where applicable IEC 61921
I_{SH}	50 kA (0.5 s)

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DUCATI 1600-R Un - Cond = 415 V

THD$_{I\,MAX\text{-}C}$ % ≤ 50% THD$_I$% ≤ 12% Un 400 V - 50 Hz

Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	Top Cable entry			Bottom cable entry		
						Part n. 415.04.	LxPxH (mm)	Weight (kg)	Part n. 415.04.	LxPxH (mm)	Weight (kg)
240	223	6 x 40	6	322	630	**1010**	800x600x2250	265	**1010B**	800x600x2250	265
280	260	7 x 40	7	375	630	**1012**	800x600x2250	270	**1012B**	800x600x2250	270
320	297	6 x 40 + 80	8	429	630	**1015**	800x600x2250	275	**1015B**	800x600x2250	275
360	334	5 x 40 + 2 x 80	9	483	1000	**1017**	800x600x2250	285	**1017B**	800x600x2250	295
400	371	4 x 40 + 3 x 80	10	536	1000	**1020**	800x600x2250	290	**1020B**	800x600x2250	298
440	408	3 x 40 + 4 x 80	11	590	1000	**1022**	800x600x2250	295	**1022B**	800x600x2250	300
480	445	2 x 40 + 5 x 80	12	644	1000	**1025**	800x600x2250	300	**1025B**	800x600x2250	305
520	483	3 x 40 + 5 x 80	13	697	1250	**1027**	800x600x2250	310	**1027B**	800x600x2250	310
560	520	2 x 40 + 6 x 80	14	751	1250	**1030**	800x600x2250	315	**1030B**	800x600x2250	315
600	557	3 x 40 + 6 x 80	15	805	1250	**1032**	800x600x2250	320	**1032B**	800x600x2250	320
640	594	2 x 40 + 7 x 80	16	858	1250	**1035**	800x600x2250	325	**1035B**	800x600x2250	325
680	631	3 x 40 + 7 x 80	17	912	1600	**1037**	800x600x2250	335	**1037B**	1600x600x2250	580
720	668	2 x 40 + 8 x 80	18	965	1600	**1040**	800x600x2250	345	**1040B**	1600x600x2250	582
800	743	2 x 40 + 7 x 80 + 160	20	1073	1600	**1045**	800x600x2250	350	**1045B**	1600x600x2250	585
880	817	2 x 40 + 6 x 80 + 2 x 160	22	1180	1000 + 1000	**1050**	1600x600x2250	580	**1050B**	1600x600x2250	588
960	891	8 x 80 + 2 x 160	12	1287	1000 + 1000	**1055**	1600x600x2250	590	**1055B**	1600x600x2250	590
1040	966	7 x 80 + 3 x 160	13	1395	1000 + 1250	**1060**	1600x600x2250	605	**1060B**	1600x600x2250	605
1120	1040	6 x 80 + 4 x 160	14	1502	1000 + 1250	**1065**	1600x600x2250	615	**1065B**	1600x600x2250	615
1200	1114	5 x 80 + 5 x 160	15	1609	1250 + 1250	**1070**	1600x600x2250	630	**1070B**	1600x600x2250	630
1280	1189	4 x 80 + 6 x 160	16	1716	1250 + 1250	**1075**	1600x600x2250	635	**1075B**	1600x600x2250	635
1360	1263	3 x 80 + 7 x 160	17	1824	1250 + 1600	**1080**	1600x600x2250	650	**1080B**	2400x600x2250	850
1440	1337	2 x 80 + 8 x 160	18	1931	1250 + 1600	**1085**	1600x600x2250	665	**1085B**	2400x600x2250	855
1520	1412	3 x 80 + 6 x 160 + 320	19	2038	1600 + 1600	**1090**	1600x600x2250	680	**1090B**	2400x600x2250	860
1600	1486	2 x 80 + 7 x 160 + 320	20	2145	1600 + 1600	**1095**	1600x600x2250	700	**1095B**	2400x600x2250	865

DUCATI 1600-R Un - Cond = 450 V

$THD_{I\,MAX\text{-}C}$ % ≤ 70% THD_I% ≤ 20% Un 400 V - 50 Hz

Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	Top cable entry			Bottom cable entry		
						Part n. 415.04.	LxPxH (mm)	Weight (kg)	Part n. 415.04.	LxPxH (mm)	Weight (kg)
240	189	6 x 40	6	274	630	**1110**	800x600x2250	265	**1110B**	800x600x2250	265
280	221	7 x 40	7	319	630	**1112**	800x600x2250	270	**1112B**	800x600x2250	270
320	252	6 x 40 + 80	8	365	630	**1115**	800x600x2250	275	**1115B**	800x600x2250	275
360	284	5 x 40 + 2 x 80	9	411	1000	**1117**	800x600x2250	285	**1117B**	800x600x2250	295
400	316	4 x 40 + 3 x 80	10	456	1000	**1120**	800x600x2250	290	**1120B**	800x600x2250	298
440	347	3 x 40 + 4 x 80	11	502	1000	**1122**	800x600x2250	295	**1122B**	800x600x2250	300
480	379	2 x 40 + 5 x 80	12	547	1000	**1125**	800x600x2250	300	**1125B**	800x600x2250	305
520	410	3 x 40 + 5 x 80	13	593	1250	**1127**	800x600x2250	310	**1127B**	800x600x2250	310
560	442	2 x 40 + 6 x 80	14	639	1250	**1130**	800x600x2250	315	**1130B**	800x600x2250	315
600	474	3 x 40 + 6 x 80	15	684	1250	**1132**	800x600x2250	320	**1132B**	800x600x2250	320
640	505	2 x 40 + 7 x 80	16	730	1250	**1135**	800x600x2250	325	**1135B**	800x600x2250	325
680	537	3 x 40 + 7 x 80	17	776	1600	**1137**	800x600x2250	335	**1137B**	1600x600x2250	580
720	568	2 x 40 + 8 x 80	18	821	1600	**1140**	800x600x2250	345	**1140B**	1600x600x2250	582
800	632	2 x 40+7 x 80+160	20	912	1600	**1145**	800x600x2250	350	**1145B**	1600x600x2250	585
880	695	2 x 40+ 6 x 80 + 2 x 160	22	1004	1000 + 1000	**1150**	1600x600x2250	580	**1150B**	1600x600x2250	588
960	758	8 x 80 + 2 x 160	12	1095	1000 + 1000	**1155**	1600x600x2250	590	**1155B**	1600x600x2250	590
1040	821	7 x 80 + 3 x 160	13	1186	1000 + 1250	**1160**	1600x600x2250	605	**1160B**	1600x600x2250	605
1120	884	6 x 80 + 4 x 160	14	1277	1000 + 1250	**1165**	1600x600x2250	615	**1165B**	1600x600x2250	615
1200	948	5 x 80 + 5 x 160	15	1369	1250 + 1250	**1170**	1600x600x2250	630	**1170B**	1600x600x2250	630
1280	1011	4 x 80 + 6 x 160	16	1460	1250 + 1250	**1175**	1600x600x2250	635	**1175B**	1600x600x2250	635
1360	1074	3 x 80 + 7 x 160	17	1551	1250 + 1600	**1180**	1600x600x2250	650	**1180B**	2400x600x2250	850
1440	1137	2 x 80 + 8 x 160	18	1642	1250 + 1600	**1185**	1600x600x2250	665	**1185B**	2400x600x2250	855
1520	1201	3 x 80 + 6 x 160 + 320	19	1733	1600 + 1600	**1190**	1600x600x2250	680	**1190B**	2400x600x2250	860
1600	1264	2 x 80 + 7 x 160 + 320	20	1825	1600 + 1600	**1195**	1600x600x2250	700	**1195B**	2400x600x2250	865

IP54 on demand (same sizes as the previous table).

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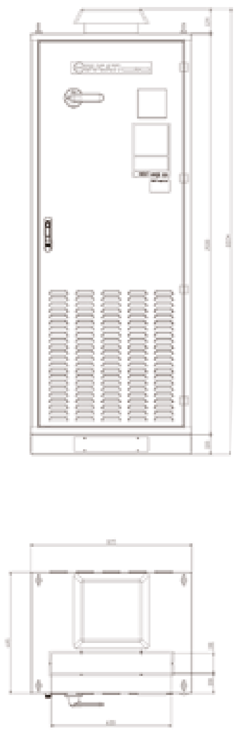
DUCATI 1600-R Un - Cond = 525 V

$THD_{I\ MAX-C}$ % ≤ 85% THD_I% ≤ 27% Un 400 V - 50 Hz

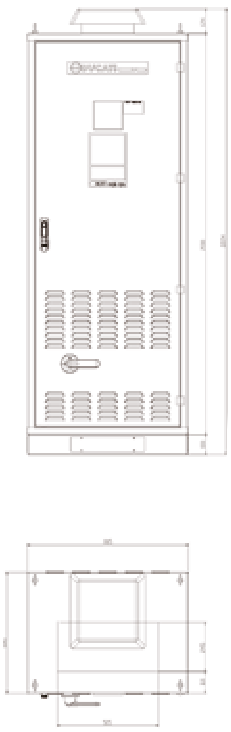
Qn (kVAr)	Q (400 V) (kVAr)	Bank Power (kVAr)	Steps	In (A)	In sw. (A)	Top cable entry			Bottom cable entry		
						Part n. 415.04.	LxPxH (mm)	Weight (kg)	Part n. 415.04.	LxPxH (mm)	Weight (kg)
240	139	6 x 40	6	201	630	**1210**	800x600x2250	265	**1210B**	800x600x2250	265
280	162	7 x 40	7	235	630	**1212**	800x600x2250	270	**1212B**	800x600x2250	270
320	185	6 x 40 + 80	8	268	630	**1215**	800x600x2250	275	**1215B**	800x600x2250	275
360	209	5 x 40 + 2 x 80	9	302	1000	**1217**	800x600x2250	285	**1217B**	800x600x2250	295
400	232	4 x 40 + 3 x 80	10	335	1000	**1220**	800x600x2250	290	**1220B**	800x600x2250	298
440	255	3 x 40 + 4 x 80	11	369	1000	**1222**	800x600x2250	295	**1222B**	800x600x2250	300
480	278	2 x 40 + 5 x 80	12	402	1000	**1225**	800x600x2250	300	**1225B**	800x600x2250	305
520	301	3 x 40 + 5 x 80	13	436	1250	**1227**	800x600x2250	310	**1227B**	800x600x2250	310
560	325	2 x 40 + 6 x 80	14	469	1250	**1230**	800x600x2250	315	**1230B**	800x600x2250	315
600	348	3 x 40 + 6 x 80	15	503	1250	**1232**	800x600x2250	320	**1232B**	800x600x2250	320
640	371	2 x 40 + 7 x 80	16	536	1250	**1235**	800x600x2250	325	**1235B**	800x600x2250	325
680	394	3 x 40 + 7 x 80	17	570	1600	**1237**	800x600x2250	335	**1237B**	1600x600x2250	580
720	418	2 x 40 + 8 x 80	18	603	1600	**1240**	800x600x2250	345	**1240B**	1600x600x2250	582
800	464	2 x 40 + 7 x 80 + 160	20	670	1600	**1245**	800x600x2250	350	**1245B**	1600x600x2250	585
880	510	2 x 40 + 6 x 80 + 2 x 160	22	737	1000 + 1000	**1250**	1600x600x2250	580	**1250B**	1600x600x2250	588
960	557	8 x 80 + 2 x 160	12	804	1000 + 1000	**1255**	1600x600x2250	590	**1255B**	1600x600x2250	590
1040	603	7 x 80 + 3 x 160	13	871	1000 + 1250	**1260**	1600x600x2250	605	**1260B**	1600x600x2250	605
1120	650	6 x 80 + 4 x 160	14	938	1000 + 1250	**1265**	1600x600x2250	615	**1265B**	1600x600x2250	615
1200	696	5 x 80 + 5 x 160	15	1005	1250 + 1250	**1270**	1600x600x2250	630	**1270B**	1600x600x2250	630
1280	743	4 x 80 + 6 x 160	16	1072	1250 + 1250	**1275**	1600x600x2250	635	**1275B**	1600x600x2250	635
1360	789	3 x 80 + 7 x 160	17	1140	1250 + 1600	**1280**	1600x600x2250	650	**1280B**	2400x600x2250	850
1440	835	2 x 80 + 8 x 160	18	1207	1250 + 1600	**1285**	1600x600x2250	665	**1285B**	2400x600x2250	855
1520	882	3 x 80 + 6 x 160 + 320	19	1274	1600 + 1600	**1290**	1600x600x2250	680	**1290B**	2400x600x2250	860
1600	928	2 x 80 + 7 x 160 + 320	20	1341	1600 + 1600	**1295**	1600x600x2250	700	**1295B**	2400x600x2250	865

IP54 on demand (same sizes as the previous table).

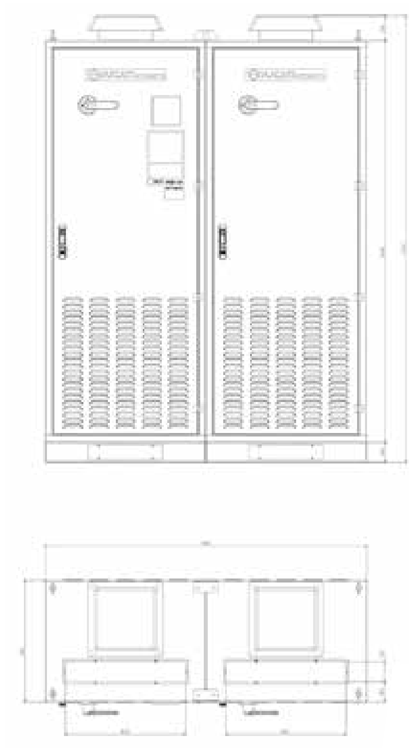
TECHNICAL DRAWING DUCATI 1600-R



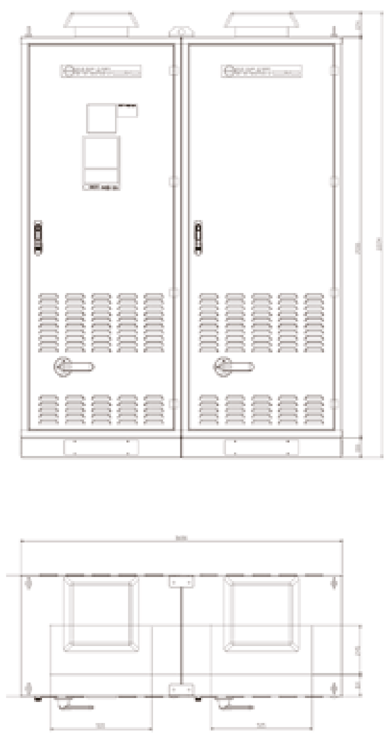
1 Door top cable entry



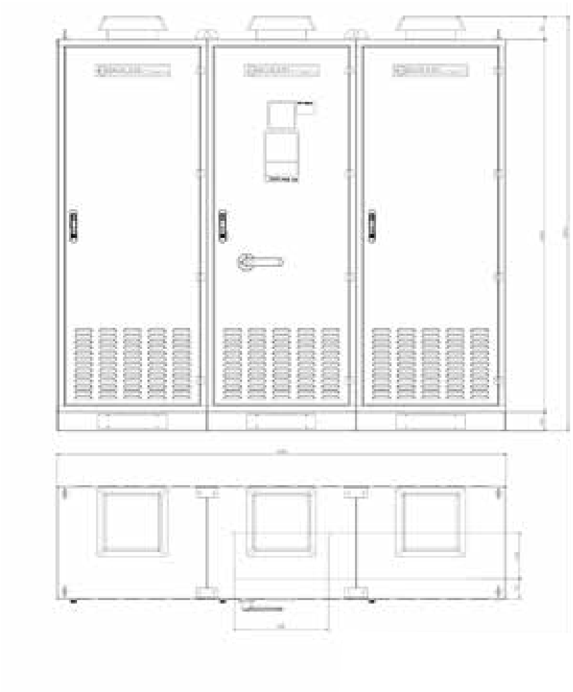
1 Door bottom cable entry



2 Doors top cable entry



2 Doors bottom cable entry



3 Doors bottom cable entry

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APPENDIX

Glossary

Cosφ. In an electrical system the phi (φ) is the phase shift between voltage and current at the fundamental frequency of 50Hz. The cosφ is a dimensionless number between 0 and 1 that represent this shift.

Power Factor. It's a ratio between the active power and the apparent power and as cosφ has value between 0 and 1. In a system without harmonics, cosφi and Power Factor are the same; in a system with harmonic, the power factor is always less than the cosφ.

Nominal Voltage of the capacitor (Un) it's the rated voltage or the capacitor, at which its output rated power is given. This is the maximum effective value of the alternating sinusoidal voltage for which the capacitor was designed.

Nominal Power of the Capacitor (Qn) it's the reactive power delivered by the capacitor at the rated voltage and frequency applied.

Rated capacitance (Cn) This is the value of the capacitance which permits the delivery of the rated power when the rated voltage and frequency are applied to the terminals.

Rated current (In) this is the effective value of the alternating current that circulates through the capacitor when the rated voltage and frequency are applied at the rated capacitance.

Insulation voltage. For a PFC system that complies with IEC 60429-1/2, the insulation voltage is indicative of the maximum voltage that the entire system can withstand.

Short circuit current I_{SH}. As indicated in the IEC 61429-1 it the prospective short circuit current that the cabinet can endure for a specified time. It's a value stated by the manufacturer based on laboratory tests. It can be increased by installing fuses in this case the data must indicate the presence of the fuses.

Steps of an automatic PFC unit. They are the physical units of the bank, each of them controlled by a dedicated switching device.

Combinations it's the number of the different configurations that the PFC unit can made with the combinations of the physical steps For example, a 160 kvar unit with steps 20-20-40-40-40 can use 8 different combinations: 20-40-60-80-100-120-140-160. The more combinations can be used, the better flexibility to use the PFC unit.

THD (Total Harmonic Distorsion). For a periodic non-sinusoidal wave, the THD is the ratio between the rms value of all harmonic components and the rms value of the fundamental 50 Hz.

THD_{IC} it's the maximum THD that a capacitor can bear in terms of current passing through it.

THD_{IR} it' the maximum THD present in the plant without any PFC unit on. It's useful to define the type of the capacitor to install.

THD_{V} it's the voltage THD that a PFC bank with harmonic blocking reactors can bear.

Operating conditions

Unlike most electrical equipment, power factor correction capacitors, each time they are energized, continuously operate at full load or at loads which differ from this value only as a consequence of variations in voltage and frequency. Overstressing and overheating shorten the lifespan of the capacitor. For this reason the operating conditions (temperature, voltage and current) must be carefully controlled in order to obtain optimum results as regards the lifespan of the capacitor.

Voltage

The capacitors are produced in accordance with standards EN 60831-1/2, which regulate their manufacture, testing, installation and application of capacitors, indicating the following maximum overvoltages:

- +10% for 8 hours every 24 hours
- +15% for 30 minutes every 24 hours
- +20% for 5 minutes
- +30% for 1 minute

Overvoltages in excess of 15% should not occur more than 200 times during the life of a capacitor.
When overload conditions may be assumed to occur during service – in the presence of a moderate harmonic load for example – it is common to use capacitors that are oversized in terms of voltage.
In such cases the output power at the operating voltage will be reduced in comparison with the rated load. It is advisable to evaluate the reduction occurring in the output power on the basis of the ratio between the operating voltage and the rated voltage.

$Q_{resa} = Qn \times (Ue/Un)^2$

Where:
Ue= Operating voltage Q_{resa} = Output power at Ue
The table below shows the power output by a 100 kvar capacitor used on a 400 V network having a rated voltage respectively of 415, 450 and 525 V.

U_n [V]	415	450	525
Q_{resa} [kVAr]	93	79	58

Temperature

The temperature of the capacitor during operation is the parameter that, along with the voltage, has the greatest influence on the lifespan of a capacitor.
It is important that the capacitor always be placed in a position where cooling air can freely circulate and away from the radiant heat of hot surfaces of other components.
When capacitors are placed in closed cabinets it is necessary to have air vents which allow for an easy exchange of air between the interior and exterior of the cabinet. Where the degree of protection of the cabinet does not permit such an exchange to take place, the positioning of the capacitors must be carefully planned so as to provide the necessary channels for the circulation of cooling air. In this case, suitable fans will have to be installed to force cooling air through the cabinet. As a rule, the temperature of the cooling air inside the cabinet should not differ from the outside air temperature by more than 5 °C.

Cooling air temperature

This is the temperature of the cooling air measured at the hottest point of the capacitor bank, under working conditions, halfway between two capacitors or on the surface of one of them.

Ambient temperature class

This represents the range of cooling air temperatures in which the capacitor is designed to operate. There are 4 standard categories represented by a number and a letter or by two numbers as shown in the table.

Category		Category Ambient air temperature		
		Max	Highest mean over any period of:	
			24 h	1 Year
-25/A	-25 +40 °C	40	30	20
-25/B	-25 +45 °C	45	35	25
-25/C	-25 +50 °C	50	40	30
-25/D	-25 +55 °C	55	45	35

The first number represents the minimum cooling air temperature at which the capacitor can be energized (- 25°C; on request -40°C). The letter or second number represents the upper limit of the temperature range and precisely. the max. value indicated in the table.

Residual voltage

This is the voltage that remains after the capacitor is disconnected from the network. This voltage must be eliminated in order to avoid exposing the operator to dangerous conditions. All three-phase capacitors are equipped with discharge devices that reduce residual voltage to less than 75 V in 3 minutes.

It is important to bear in mind that the capacitors cannot be energized if there is a residual voltage of more than 10% across them. Particular care must thus be taken to harmonise the capacitor discharge times with the response times of the control devices (Power control relays). In cases where the lag time of the controllers is shorter than the capacitor discharge time, additional discharge devices must be provided so that the connection will occur with a residual voltage not exceeding 10%.

Max current

In accordance with standard EN 60831-1/2, the capacitors are designed to function continuously at an effective current that is 1.3 times the current at the rated voltage and frequency. Bearing in mind the capacitance tolerance, the maximum current may reach 1.5 In, value to which it is necessary to refer in the sizing of the lines of control and protection devices. This overcurrent factor can be determined by the combined effect of harmonics, overvoltages and capacitance tolerance.

Max inrush current

Transient overcurrents having elevated amplitudes and high frequencies occur when the capacitors are switched in to the circuit. This is especially true when a capacitor bank is put in a parallel connection with other already energized banks.

It may therefore be necessary to reduce these transient overcurrents to values acceptable both for the capacitor and the contactor used by connecting the capacitor using suitable devices (resistors or reactors) in the power circuit of the bank.

The crest value of overcurrents caused during switching operations must be limited to a maximum of 100 In (crest value of the 1st cycle).

Protection and safety

To ensure protection, the capacitor elements making up the unit are individually fitted with an overpressure safety device.

The function of this device is to interrupt a short circuit when the capacitor reaches the end of its useful life and is no longer able to regenerate itself. This device breaks the connections of the terminal by exploiting the internal pressure that builds during the film's decomposition, which results from the overheating caused by the short circuit.

It should be noted that an external fuse is not as reliable since the short circuit current, being strongly limited by the metallized surface, may vary widely.

All the capacitors are built with environmentally friendly materials conforming to standards EN 60831-1/2.

The effect of harmonics in electrical systems

A harmonic is defined as one of the components obtained from the breakdown of a periodic wave in the Fourier series. The order of a harmonic is further defined as the ratio between the frequency of the harmonic and the fundamental frequency of the periodic wave considered.

In the case of a perfectly sinusoidal waveform (as should characterize the voltage supplied by the utility) only the fundamental harmonic of the first order will be present, which in Europe has a frequency of 50 Hz.

If a sinusoidal voltage is applied to a load, the circulating current will also have a sinusoidal waveform only in the presence of loads with "linear characteristics".

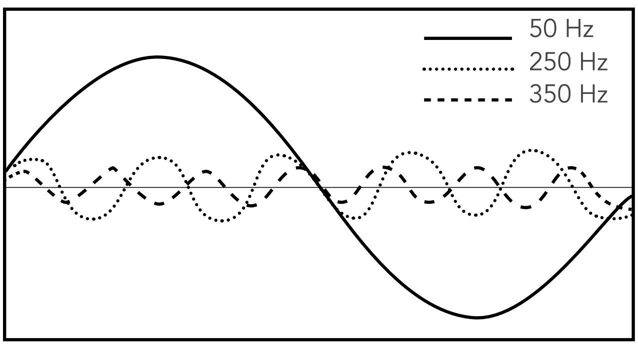
In the presence of a "non-linear" load the current waveform will deviate from the ideal pattern and breaking down the wave according to the Fourier theorem will show evidence of harmonics whose number and amplitude will increase with the degree of distortion in the current waveform.

The increasingly frequent use of non-linear loads in industrial facilities (inverters, fluorescent lamps, welders, etc.) creates elevated distorsions in the waveform of circulating current.

This is true in the case of ac/dc converters, for which the input current theoretically displays only harmonics of the order:

$h = mp \pm 1$

where m is an integer other than 0 (thus 1, 2, 3, 4, ...) and p is the number of solid-state switches of the bridge. Therefore, a converter with six-phase reaction (p= 6) generates characteristic harmonics of the 5th and 7th order (m= 1), 11th and 13th order (m= 2), 17th and 19th order (m= 3) etc., whereas a converter with twelve-phase reaction (p= 12) generates characteristic harmonics of the 11th and 13th order (m= 1), 23rd and 25th order (m= 2).



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The parameter used to determine the level of harmonic distortion presents in an electrical network is THDI% (Total Harmonic Distortion), defined as:

$$TDH_i\% = \frac{\sqrt{\sum_{k=2}^{\infty} I_k^2}}{I_1}$$

Where I_1 is the effective value of the fundamental and Ik represents the effective values of harmonics of order k.

The presence of current harmonics in the system is therefore an indication of a distortion (deviation from a sinusoidal pattern) in the waveform of the current itself.
This results in increased losses due to the Joule effect and the skin effect in the cables and increased losses due to hysteresis and parasite currents in the iron of transformers and motors. In addition, because of the equivalent cable impedances, the mains voltage may also be distorted.

Installing power factor correction capacitors in the network serves to create a condition of parallel resonance between the equivalent capacitance of the capacitors and the equivalent inductance of the system (which may usually be approximated by calculating the equivalent inductance of the transformer) in correspondence to a frequency fr.

$$\int_r = \int_1 \cdot \sqrt{\frac{Scc}{\Omega}}$$

Where S_{cc} indicates the short circuit power of the system (expressed in MVA) at the point where the capacitors are connected and Ω is the installed reactive power (expressed in Mvar), the parallel resonance frequency fr is thus determined:

$$S_{cc} = \frac{A}{V_{cc}\%} \cdot 100$$

Where A is the rated power of the transformer (expressed in MVA) and Vcc% is the percentage short circuit voltage of the transformer.
The voltage harmonics present in the system - having a frequency close to the parallel resonance frequency fr - are amplified. For this reason, an extremely high voltage comes to be created at the capacitor terminals, which causes the dielectric to age rapidly and hence significantly shortens the lifespan of the capacitor.

Risk of Explosion and Fire
All capacitors consists mainly of polypropylene. They can rupture and ignite cause of internal faults (malfunction of safety system, if present) or external overload (Overvoltage, overcurrent, high temperature, etc.).
It must be ensured, by appropriate measures, to avoid any risk of explosion, fire and hazard to their environment in the event of malfunction.

Correcting the power factor of MV/LV transformers
It is always a good idea to ensure a power factor correction for MV/LV transformers, since even when they are operating loadless (e.g. during the night) they absorb reactive power, which must be compensated.
The exact capacitor power necessary may be calculated using the formula below:
Ω = Io% · Pn/100
Io = loadless current (specified by the transformer manufacturer)
Pn= rated power of the transformer.
Alternatively, if the required data is not available, you can refer to the table below, which differentiates among types of transformers with NORMAL losse

Power transformer	Oil transformer	Resin transformer kVAr
10	1	1.5
20	2	1.7
50	4	2
75	5	2.5
100	5	2.5
160	7	4
200	7.5	5
250	8	7.5
315	10	7.5
400	12.5	8
500	15	10
630	17.5	12.5
800	20	15
1000	25	17.5
1250	30	20
1600	35	22
2000	40	25
2500	50	35
3150	60	50

Power factor correction of three-phase asynchronous motors
One of the most commonly occurring loads is the three-phase asynchronous motor. The table below shows the power factor correction in the case of squirrel-cage motors. An additional 5% is recommended for motors with wound armatures.
The table shows the approximate powers of the capacitor banks to be installed according to motor power.

Reactive power to be installed - Three-phase motor: 230/400 V					
Rated power		**Rotation speed (rpm)**			
(kW)	**(Cv)**	**3000**	**15000**	**1000**	**750**
22	30	6	8	9	10
30	40	7.5	10	11	12.5
37	50	9	11	12.5	16
45	60	11	13	14	17
55	75	13	17	18	21
75	100	17	22	25	28
90	125	20	25	27	30
110	150	24	29	33	37
132	180	31	36	38	43
160	218	35	41	44	52
200	274	43	47	53	61
250	340	52	57	63	71
280	385	57	63	70	79
355	482	67	76	86	98
400	544	78	82	97	106
450	610	87	93	107	117

Minimum cable cross section for equipment power supply

Main voltage 400 V – 50 Hz – 3F		
Qn kVAr	**In A**	**Minimum cablecross-section suggested for phase[1] (mm²)**
5	7	2.5
10	14	4
15	22	6
20	29	10
30	43	16
40	58	16
50	72	35
100	144	70
200	288	185 opp./or2x70
300	433	2x150
400	576	2x240
500	722	3x185
600	864	3x240
700	1010	4x240
800	1154	4x240
900	1300	6x185
1000	1443	6x240

(1) = Values reported for single-core PVC cables in free air laid not separated on horizontal shelves. For other types of cables and/or installation refer to IEC 60364-5, CEI 64-8 and table UNEL 35024/1.

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K FACTOR

Existing values		Target cosφ															
tgφ	**cosφ**	**0.85**	**0.86**	**0.87**	**0.88**	**0.89**	**0.90**	**0.91**	**0.92**	**0.93**	**0.94**	**0.95**	**0.96**	**0.97**	**0.98**	**0.99**	**1.00**
3.18	**0.30**	2.560	2.586	2.613	2.640	2.667	2.695	2.724	2.754	2.785	2.817	2.851	2.888	2.929	2.977	3.037	3.180
3.07	**0.31**	2.447	2.474	2.500	2.527	2.555	2.583	2.611	2.641	2.672	2.704	2.738	2.775	2.816	2.864	2.924	3.067
2.96	**0.32**	2.341	2.367	2.394	2.421	2.448	2.476	2.505	2.535	2.565	2.598	2.632	2.669	2.710	2.758	2.818	2.961
2.86	**0.33**	2.241	2.267	2.294	2.321	2.348	2.376	2.405	2.435	2.465	2.498	2.532	2.569	2.610	2.657	2.718	2.861
2.77	**0.34**	2.146	2.173	2.199	2.226	2.254	2.282	2.310	2.340	2.371	2.403	2.437	2.474	2.515	2.563	2.623	2.766
2.68	**0.35**	2.057	2.083	2.110	2.137	2.164	2.192	2.221	2.250	2.281	2.313	2.348	2.385	2.426	2.473	2.534	2.676
2.59	**0.36**	1.972	1.998	2.025	2.052	2.079	2.107	2.136	2.166	2.196	2.229	2.263	2.300	2.341	2.388	2.449	2.592
2.51	**0.37**	1.891	1.918	1.944	1.971	1.999	2.027	2.055	2.085	2.116	2.148	2.182	2.219	2.260	2.308	2.368	2.511
2.43	**0.38**	1.814	1.841	1.867	1.894	1.922	1.950	1.979	2.008	2.039	2.071	2.105	2.143	2.184	2.231	2.292	2.434
2.36	**0.39**	1.741	1.768	1.794	1.821	1.849	1.877	1.905	1.935	1.966	1.998	2.032	2.069	2.110	2.158	2.219	2.361
2.29	**0.40**	1.672	1.698	1.725	1.752	1.779	1.807	1.836	1.865	1.896	1.928	1.963	2.000	2.041	2.088	2.149	2.291
2.22	**0.41**	1.605	1.631	1.658	1.685	1.712	1.740	1.769	1.799	1.829	1.862	1.896	1.933	1.974	2.022	2.082	2.225
2.16	**0.42**	1.541	1.567	1.594	1.621	1.648	1.676	1.705	1.735	1.766	1.798	1.832	1.869	1.910	1.958	2.018	2.161
2.10	**0.43**	1.480	1.506	1.533	1.560	1.587	1.615	1.644	1.674	1.704	1.737	1.771	1.808	1.849	1.897	1.957	2.100
2.04	**0.44**	1.421	1.448	1.474	1.501	1.529	1.557	1.585	1.615	1.646	1.678	1.712	1.749	1.790	1.838	1.898	2.041
1.98	**0.45**	1.365	1.391	1.418	1.445	1.472	1.500	1.529	1.559	1.589	1.622	1.656	1.693	1.734	1.781	1.842	1.985
1.93	**0.46**	1.311	1.337	1.364	1.391	1.418	1.446	1.475	1.504	1.535	1.567	1.602	1.639	1.680	1.727	1.788	1.930
1.88	**0.47**	1.258	1.285	1.311	1.338	1.366	1.394	1.422	1.452	1.483	1.515	1.549	1.586	1.627	1.675	1.736	1.878
1.83	**0.48**	1.208	1.234	1.261	1.288	1.315	1.343	1.372	1.402	1.432	1.465	1.499	1.536	1.577	1.625	1.685	1.828
1.78	**0.49**	1.159	1.186	1.212	1.239	1.267	1.295	1.323	1.353	1.384	1.416	1.450	1.487	1.528	1.576	1.637	1.779
1.73	**0.50**	1.112	1.139	1.165	1.192	1.220	1.248	1.276	1.306	1.337	1.369	1.403	1.440	1.481	1.529	1.590	1.732
1.69	**0.51**	1.067	1.093	1.120	1.147	1.174	1.202	1.231	1.261	1.291	1.324	1.358	1.395	1.436	1.484	1.544	1.687
1.64	**0.52**	1.023	1.049	1.076	1.103	1.130	1.158	1.187	1.217	1.247	1.280	1.314	1.351	1.392	1.440	1.500	1.643
1.60	**0.53**	0.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.458	1.600
1.56	**0.54**	0.939	0.965	0.992	1.019	1.046	1.074	1.103	1.133	1.163	1.196	1.230	1.267	1.308	1.356	1.416	1.559
1.52	**0.55**	0.899	0.925	0.952	0.979	1.006	1.034	1.063	1.092	1.123	1.156	1.190	1.227	1.268	1.315	1.376	1.518
1.48	**0.56**	0.860	0.886	0.913	0.940	0.967	0.995	1.024	1.053	1.084	1.116	1.151	1.188	1.229	1.276	1.337	1.479
1.44	**0.57**	0.822	0.848	0.875	0.902	0.929	0.957	0.986	1.015	1.046	1.079	1.113	1.150	1.191	1.238	1.299	1.441
1.40	**0.58**	0.785	0.811	0.838	0.865	0.892	0.920	0.949	0.979	1.009	1.042	1.076	1.113	1.154	1.201	1.262	1.405
1.37	**0.59**	0.749	0.775	0.802	0.829	0.856	0.884	0.913	0.942	0.973	1.006	1.040	1.077	1.118	1.165	1.226	1.368
1.33	**0.60**	0.714	0.740	0.767	0.794	0.821	0.849	0.878	0.907	0.938	0.970	1.005	1.042	1.083	1.130	1.191	1.333
1.30	**0.61**	0.679	0.706	0.732	0.759	0.787	0.815	0.843	0.873	0.904	0.936	0.970	1.007	1.048	1.096	1.157	1.299
1.27	**0.62**	0.646	0.672	0.699	0.726	0.753	0.781	0.810	0.839	0.870	0.903	0.937	0.974	1.015	1.062	1.123	1.265
1.23	**0.63**	0.613	0.639	0.666	0.693	0.720	0.748	0.777	0.807	0.837	0.870	0.904	0.941	0.982	1.030	1.090	1.233
1.20	**0.64**	0.581	0.607	0.634	0.661	0.688	0.716	0.745	0.775	0.805	0.838	0.872	0.909	0.950	0.998	1.058	1.201
1.17	**0.65**	0.549	0.576	0.602	0.629	0.657	0.685	0.714	0.743	0.774	0.806	0.840	0.877	0.919	0.966	1.027	1.169
1.14	**0.66**	0.519	0.545	0.572	0.599	0.626	0.654	0.683	0.712	0.743	0.775	0.810	0.847	0.888	0.935	0.996	1.138
1.11	**0.67**	0.488	0.515	0.541	0.568	0.596	0.624	0.652	0.682	0.713	0.745	0.779	0.816	0.857	0.905	0.966	1.108
1.08	**0.68**	0.459	0.485	0.512	0.539	0.566	0.594	0.623	0.652	0.683	0.715	0.750	0.787	0.828	0.875	0.936	1.078
1.05	**0.69**	0.429	0.456	0.482	0.509	0.537	0.565	0.593	0.623	0.654	0.686	0.720	0.757	0.798	0.846	0.907	1.049
1.02	**0.70**	0.400	0.427	0.453	0.480	0.508	0.536	0.565	0.594	0.625	0.657	0.692	0.729	0.770	0.817	0.878	1.020
0.99	**0.71**	0.372	0.398	0.425	0.452	0.480	0.508	0.536	0.566	0.597	0.629	0.663	0.700	0.741	0.789	0.849	0.992
0.96	**0.72**	0.344	0.370	0.397	0.424	0.452	0.480	0.508	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.94	**0.73**	0.316	0.343	0.370	0.396	0.424	0.452	0.481	0.510	0.541	0.573	0.608	0.645	0.686	0.733	0.794	0.936
0.91	**0.74**	0.289	0.316	0.342	0.369	0.397	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.88	**0.75**	0.262	0.289	0.315	0.342	0.370	0.398	0.426	0.456	0.487	0.519	0.553	0.590	0.631	0.679	0.739	0.882
0.86	**0.76**	0.235	0.262	0.288	0.315	0.343	0.371	0.400	0.429	0.460	0.492	0.526	0.563	0.605	0.652	0.713	0.855
0.83	**0.77**	0.209	0.235	0.262	0.289	0.316	0.344	0.373	0.403	0.433	0.466	0.500	0.537	0.578	0.626	0.686	0.829
0.80	**0.78**	0.183	0.209	0.236	0.263	0.290	0.318	0.347	0.376	0.407	0.439	0.474	0.511	0.552	0.599	0.660	0.802
0.78	**0.79**	0.156	0.183	0.209	0.236	0.264	0.292	0.320	0.350	0.381	0.413	0.447	0.484	0.525	0.573	0.634	0.776
0.75	**0.80**	0.130	0.157	0.183	0.210	0.238	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.608	0.750
0.72	**0.81**	0.104	0.131	0.157	0.184	0.212	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.70	**0.82**	0.078	0.105	0.131	0.158	0.186	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.556	0.698
0.67	**0.83**	0.052	0.079	0.105	0.132	0.160	0.188	0.216	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.530	0.672
0.65	**0.84**	0.026	0.053	0.079	0.106	0.134	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.62	**0.85**		0.026	0.053	0.080	0.107	0.135	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.59	**0.86**			0.027	0.054	0.081	0.109	0.138	0.167	0.198	0.230	0.265	0.302	0.343	0.390	0.451	0.593
0.57	**0.87**				0.027	0.054	0.082	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.54	**0.88**					0.027	0.055	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.51	**0.89**						0.028	0.057	0.086	0.117	0.149	0.184	0.221	0.262	0.309	0.370	0.512
0.48	**0.90**							0.029	0.058	0.089	0.121	0.156	0.193	0.234	0.281	0.342	0.484
0.46	**0.91**								0.030	0.060	0.093	0.127	0.164	0.205	0.253	0.313	0.456
0.43	**0.92**									0.031	0.063	0.097	0.134	0.175	0.223	0.284	0.426
0.40	**0.93**										0.032	0.067	0.104	0.145	0.192	0.253	0.395
0.36	**0.94**											0.034	0.071	0.112	0.160	0.220	0.363
0.33	**0.95**												0.037	0.078	0.126	0.186	0.329
0.29	**0.96**													0.041	0.089	0.149	0.292
0.25	**0.97**														0.048	0.108	0.251
0.20	**0.98**															0.061	0.203
0.14	**0.99**																0.142

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