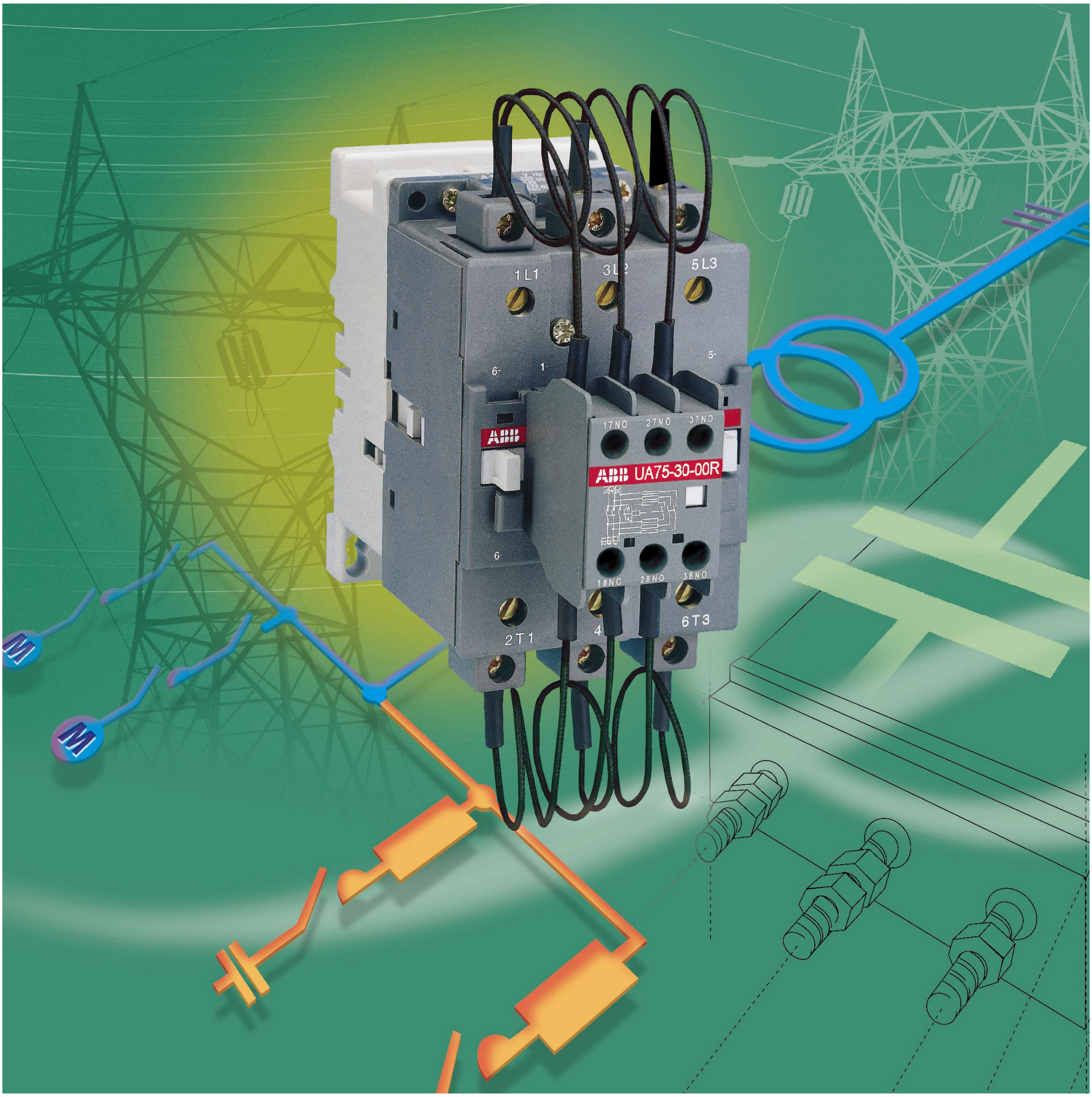
使用說明
Application guide

切換電容器用接觸器

Contactors for Capacitor Switching

CNABB / 1SBC 0064 99 R1002 / CE 08-2001



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Contactors for Capacitor Switching

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電容器瞬態條件提示

在低壓工業設施中，電容器主要用於無功能量補償 (提高功率因數)。當這些電容器通電時，將在瞬變過程期間 (1 至 2ms) 產生大幅度 (達 180 I_n) 及高頻率 (3 至 15 KHz) 的過電流。

這種電流峰值的幅度稱為 "浪湧電流峰值"，其大小與以下因素有關：

- 網絡電感
- 變壓器功率和短路電壓
- 功率因數補償類型

功率因數補償類型有兩種：固定的或自動的。

進行固定功率因數補償時插入一與網絡並聯的電容器組，它的總功率來自相同或不同單位功率的電容器。

電容器組由一接觸器充電，後者同時對所有電容器充電 (一步到位)。

固定校正時的浪湧電流峰值可達電容器組額定電流的30倍。

另一方面，自動功率因數補償系統包括幾個相同或不同功率的電容器組 (幾步到位)，各組按待補功率因數數值分別充電。

由一電子裝置自動決定各步的充電功率並啟動相應的接觸器。

自動補償時的浪湧電流峰值與所執行的各步功率有關，可達該步充電的電容器組的額定電流的 180 倍。

Reminder of capacitor transient conditions

In Low Voltage industrial installations, capacitors are mainly used for reactive energy correction (raising the power factor). When these capacitors are energized, overcurrents of high amplitude (up to 180 I_n) and high frequencies (3 to 15 kHz) occur during the transient period (1 to 2 ms).

The amplitude of these current peaks, also known as "inrush current peaks", depends on the following factors :

- The network inductances
- The transformer power and short-circuit voltage
- The type of power factor correction

There are 2 types of power factor correction: fixed or automatic.

Fixed power factor correction consists of inserting, in parallel on the network, a capacitor bank whose total power is provided by the assembly of capacitors of identical or different unit powers.

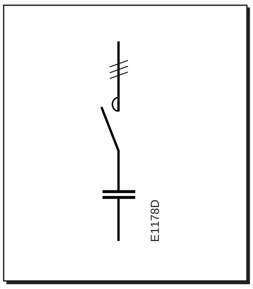
The bank is energized by a contactor that simultaneously supplies all the capacitors (a single step).

The inrush current peak, in the case of fixed correction, can reach 30 times the nominal current of the capacitor bank.

An automatic power factor correction system, on the other hand, consists of several capacitor banks of identical or different powers (several steps), energized separately according to the value of the power factor to be corrected.

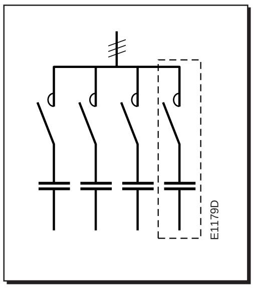
An electronic device automatically determines the power of the steps to be energized and activates the relevant contactors.

The inrush current peak, in the case of automatic correction, depends on the power of the steps already on duty, and can reach 180 times the nominal current of the step to be energized.



固定功率因數補償

Fixed power factor correction



自動功率因數補償

Automatic power factor correction

穩態條件數據

諧波和網絡電壓誤差的出現導致電路中產生一個永久性流動的電流，其值約為電容器額定電流I_n 的 1.3 倍。

考慮到製造誤差，電容器的確切功率可達其額定功率的 1.15 倍。

因此，IEC 831-1 標準 (04/97版) 規定電容器的最大熱電流I_T 必須為：

Steady state condition data

The presence of harmonics and the network's voltage tolerance lead to a current, estimated to be 1.3 times the nominal current I_n of the capacitor, permanently circulating in the circuit.

Taking into account the manufacturing tolerances, the exact power of a capacitor can reach 1.15 times its nominal power.

Standard IEC 831-1 Edition 04/97 specifies that the capacitor must therefore have a maximum thermal current I_T of:

$$I_T = 1.3 \times 1.15 \times I_n = 1.5\ I_n$$

對接觸器的要求

為避免功率失常 (主接點熔結，異常升溫等)，切換電容器組用接觸器必須能承受：

- **達到電容器組額定電流 1.5 倍的永久性電流。**
- **接點閉合時短暫而大的峰值電流** (最大容許峰值電流 Î)。

Consequences for the contactors

To avoid malfunctions (welding of main poles, abnormal temperature rise, etc.), contactors for capacitor bank switching must be sized to withstand :

- **A permanent current that can reach 1.5 times the nominal current of the capacitor bank**.
- **The short but high peak current on pole closing** (maximum permissible peak current Î).

切換電容器用接觸器 - 選擇表
Contactors for Capacitor Switching - Selection Table

UA 接觸器

UA接觸器專門開發用於浪湧電流峰值小於或等於額定有效值電流 100 倍的電容器組。下表根據工作電壓及靠近接觸器處的溫度得出了容許功率。表中還規定了接觸器容許的最大峰電流 **Î** 值。

在這些條件下，接觸器的電氣壽命為 100 000 個工作循環。

UA.. contactors

The UA.. contactors have been specially developed for the switching of capacitor banks whose inrush current peaks are less than or equal to 100 times nominal rms current. The table below gives the permissible powers according to operational voltage and temperature close to the contactor. It also specifies the maximum peak current **Î values** accepted by the contactor.

In these conditions, electrical durability of contactors is equal to 100 000 operating cycles.

功率 (單位為 kvar) 及最大容許峰值電流

Powers in kvar and maximum permissible peak current

型號 **Type**	50/60 Hz 時的功率 (kvar) **Powers in kvar 50/60 Hz**															最大容許峰值電流 **Î (kA)** **Max. permissible peak current Î (kA)**	
	230/240 V			**400/415 V**			**440 V**			**500/550 V**			**660/690 V**			**U_e**	**U_e**
	40 °C	55 °C	70 °C	**40 °C**	55 °C	70 °C	**40 °C**	55 °C	70 °C	**40 °C**	55 °C	70 °C	**40°C**	55°C	70 °C	≤ 500 V	> 500 V
UA 26	**12**	11	8.5	**20**	18.5	14.5	**22**	20	16	**22**	22	19.5	**30**	30	25	**3**	**2.7**
UA 30	**16**	16	11	**27.5**	27.5	19	**30**	30	20	**34**	34	23.5	**45**	45	32	**3.5**	**3.1**
UA 50	**20**	20	19	**33**	33	32	**36**	36	35	**40**	40	40	**55**	55	52	**5**	**4.5**
UA 63	**25**	25	21	**45**	43	37	**50**	48	41	**50**	50	45	**70**	70	60	**6.5**	**5.8**
UA 75	**30**	30	22	**50**	50	39	**55**	53	43	**62**	62	47.5	**75**	75	65	**7.5**	**6.75**
UA 95	**35**	35	29	**60/65***	60/65*	50/55*	**65**	65	55	**70**	70	60	**86**	86	70	**9.3**	**8**
UA 110	**40**	39	34	**74**	70/75*	65	**75**	75	67	**80**	80	75	**90**	90	85	**10.5**	**9**

* U_e = 415 V 時使用這些值

* Use these values for U_e = 415 V

分別將**230V**及**400 V**時之相應值乘以**0.9**即得220V及380V時之值。

例：50kvar/400V 對應於 0.9 x 50 ＝ **45kvar/380V** 。

如果某應用中的電流峰值大於表中最後一列所規定的最大峰值電流 **Î**，請選用更高額定值，並請參閱UA ... -R接觸器 (見第 4 頁) 或增加電感 (見第 10 頁)。

電容器組將由 gG 型熔絲保護，熔絲的額定值為額定電流的 1.5 ... 1.8 倍。

For **220 V** and **380 V**, multiply by **0.9** the rated values at 230 V and 400 V respectively.

Example: 50 kvar/400 V corresponding to 0.9 x 50 = **45 kvar/380 V**.

If, in an application, the current peak is greater than the maximum peak current **Î** specified in the table above, select a higher rating, refer to the UA...-R contactors (see page 4) or add inductances (see page 10).

The capacitor bank will be protected by gG type fuses whose rating is equal to 1.5 ... 1.8 times nominal current.

切換電容器用的接觸器 - 選擇表
Contactors for Capacitor Switching - Selection Table

帶阻尼電阻的 UA...-R 接觸器

UA...-R 接觸器配有一個特制的前端安裝組件，確保將阻尼電阻串聯接入電路以限制電容器組充電時的電流峰值。

接入阻尼電阻還能確保電容器先行充電以限制數毫秒後主接點接通時產生的第二次電流峰值。

工作原理

UA... -R 接觸器的前端安裝組件機制確保接觸器的輔助 "PA" 接點比主接點 "PP" 先通先斷。

綫圈通電時，先接通的輔助電極將電容器通過電阻接進網絡，從而限制電流峰值。數毫秒之後接觸器的主接點將使電阻短路而此時新的浪湧電流已減少。

接入的觸點保持閉合，準備用作下一斷開序列的先斷觸點。

線圈斷電時，輔助電極先斷開，從而確保電容器經主電極斷開。

UA…-R contactors equipped with damping resistors

The UA…-R contactors are fitted with a special front-mounted block ensuring the serial insertion in the circuit of damping resistors limiting current peak on energizing of the capacitor bank. Their connection also ensures capacitor precharging in order to limit the second current peak occurring on making of the main poles a few milliseconds later.

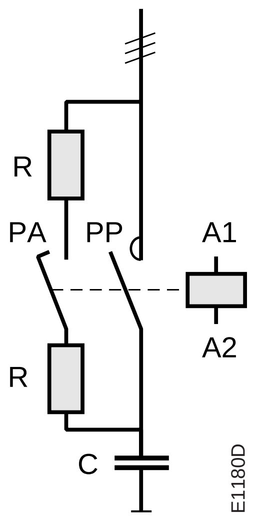
Operating principle

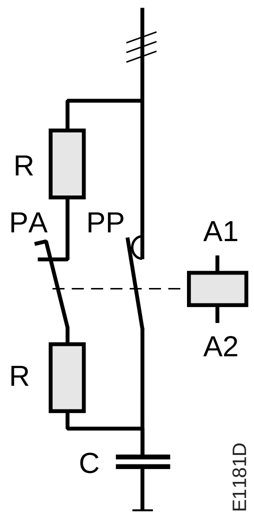
The front-mounted block mechanism of the UA…-R contactors alternately ensures early making and breaking of the auxiliary "PA" poles with respect to the main "PP" poles of the contactor.

When the coil is energized, the early making auxiliary poles connect the capacitor to the network via the set of resistors, thus attenuating the current peak. A few milliseconds later, the contactor main poles short-circuit the resistors with a new reduced inrush current.

The insertion contacts remain closed, ready to operate as early-breaking contacts for the next breaking sequence.

When the coil is de-energized, early breaking of the auxiliary poles ensures that the capacitor is disconnected via the main poles.





這些接觸器可用於峰值電流遠大於額定有效值電流 100 倍的設施中。接觸器與其阻尼電阻一起交付，使用時必須沒有附加電感 (見下表)

U_e < 500 V時其電氣壽命為250 000個工作循環，$U_e \geq$ 500 V 時為 100 000 個工作循環。

These contactors can be used in installations in which peak current far exceeds 100 times nominal rms current. The contactors are delivered complete with their damping resistors and must be used without additional inductances (see table below).

Their electrical durability is 250 000 operating cycles for U_e < 500 V and 100 000 operating cycles for $U_e \geq$ 500 V.

功率 (單位為 kvar)
Powers in kvar

型號 Type	50/60 Hz 時的功率 (kvar) Powers in kvar - 50/60 Hz															gG 型熔絲 gG type fuses 最大值 max. (*)
	220/240 V			380/400/415 V			440 V			500/550 V			660/690 V			
	40 °C	55 °C	70 °C	40 °C	55 °C	70 °C	40 °C	55 °C	70 °C	40 °C	55 °C	70 °C	40 °C	55 °C	70 °C	
UA 16-30-10-R	**8**	7.5	6	**12.5**	12.5	10	**15**	13	11	**18**	16	12.5	**22**	21	17	80
UA 26-30-10-R	**12.5**	11.5	9	**22**	20	15.5	**24**	20	17	**30**	25	20	**35**	31	26	125
UA 30-30-10-R	**16**	16	11	**30**	27.5	19.5	**32**	30	20.5	**34**	34	25	**42**	42	32	200
UA 50-30-00-R	**25**	24	20	**40**	40	35	**50**	43	37	**55**	50	46	**72**	65	60	200
UA 63-30-00-R	**30**	27	23	**50**	45	39	**55**	48	42.5	**65**	60	50	**80**	75	65	200
UA 75-30-00-R	**35**	30	25	**60**	50	41	**65**	53	45	**75**	65	55	**100**	80	70	200

(*) 此欄中的熔絲額定值為最大額定值，可確保符合 IEC 947-4-1標準中定義的類型 1。

(*) The fuse ratings given in this column represent the maximum ratings ensuring type 1 co-ordination according to the definition of standard IEC 947-4-1.

應用及可能性
Application and possibilities

應用說明
Description of the application

電容器組
Capacitor bank :
400V 、 20kvar ， 50Hz 、三相 (three-phase)

接觸器附近環境溫度
Ambient temperature around the contactor : **40 °C**

額定電流
Nominal current :

$$I_n = \frac{P}{\sqrt{3} \times U} = \frac{20000}{1.7 \times 400} \simeq 29\ A$$

熱電流
Thermal current :

$$I_T = I_n \times 1.5 = 29 \times 1.5 \simeq 43\ A$$

第 1 種情形 – 浪湧峰值電流：2500 Â
Case no. 1 - Inrush peak current: 2500 Â

可能性 1 見第 3 頁表

UA26 接觸器 (20kvar, 400V)。**此接觸器可承受 3000Â (U_e ≤ 500V)的最大峰值電流。**

Possibility no. 1 as per table on page 3

UA 26 contactor (20 kvar, 400 V). **This contactor accepts a maximum peak current of 3000 Â (U_e ≤ 500V).**

第 2 種情形 – 浪湧峰值電流：4500 Â
Case no. 2 - Inrush peak current: 4500 Â.

可能性 1 見第 4 頁表

UA26-R 接觸器 (22kvar, 400V)。**此接觸器可不加附加電感直接使用。**

Possibility no. 1 as per table on page 4

UA 26-R contactor (22 kvar, 400 V). **This contactor can be directly used without an additional inductance.**

可能性 2 見第 3 頁表

UA26 接觸器 + 附加電感將峰值電流限制為 **UA26 接觸器可承受的 3000Â(U_e ≤ 500 V)。**

Possibility no. 2 as per table on page 3

UA 26 contactor + additional inductances limiting peak current to a **peak of 3000 Â acceptable for the UA 26 contactor (U_e ≤ 500 V).**

第5及第6頁上的信息有助於用戶計算電流峰值並將其限制到接觸器能接受的值。因為這種計算不精確，所以電容器組生產商通過試驗優化其產品。
The information given on pages 5 and 6 will enable the user to calculate current peaks and to limit them to a value acceptable for the contactor. Since this calculation is never exact, capacitor bank manufacturers optimise their products by tests.

計算浪湧電流峰值和頻率
Calculation of Inrush Current Peak and Frequency

如果對電容器組充電時的浪湧電流峰值大於切換接觸器能承受的值，就有不能確保功率因數補償的風險。

這是因為在這種情況下，接觸器可能會因主結點熔接而永遠閉合。

以下公式用於估算瞬變過程期間的浪湧電流峰值及電流頻率。公式中使用的電感值可按第 8 及第 9 頁上所述方法確定。

小心：

只有當通電時，電容器組已完全放電完畢才可用這些公式(最大端電壓 ≤ 50 V）。

If the inrush current peak on energizing of a capacitor bank is greater than that acceptable for the switching contactor, there is a risk that power factor correction will no longer be ensured.

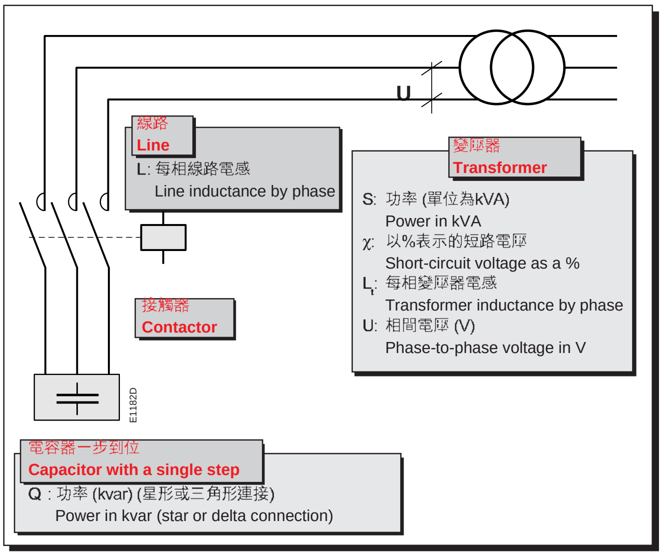
This is because, in this case, the contactor may remain permanently closed due to welding of its main poles.

The formulas given below are used to estimate inrush current peak as well as current frequency during the transient period. The values of the inductances used in the formulas can be determined by the methods described on pages 8 and 9.

Caution :

These formulas are applicable only if the capacitor bank is completely discharged at the time of energizing (maximum voltage at terminals ≤ 50 V).

三相電容器組一步到位
Three-phase capacitor bank with a single step



浪湧峰值電流 Î

Inrush peak current Î :

$$\hat{I} = \sqrt{\frac{10^9}{3\,\pi\, f}} \times \sqrt{\frac{Q}{L + L_t}}$$

$$\hat{I} = k_1 \sqrt{\frac{Q}{L + L_t}}$$

浪湧電流頻率 f_0 :

Inrush current frequency f_0:

$$f_0 = k_2\, U \sqrt{\frac{1}{Q\,(L + L_t)}}$$

Î : A

f : 交流電源頻率 mains current frequency : Hz

Q : kvar

L, L_t : µH

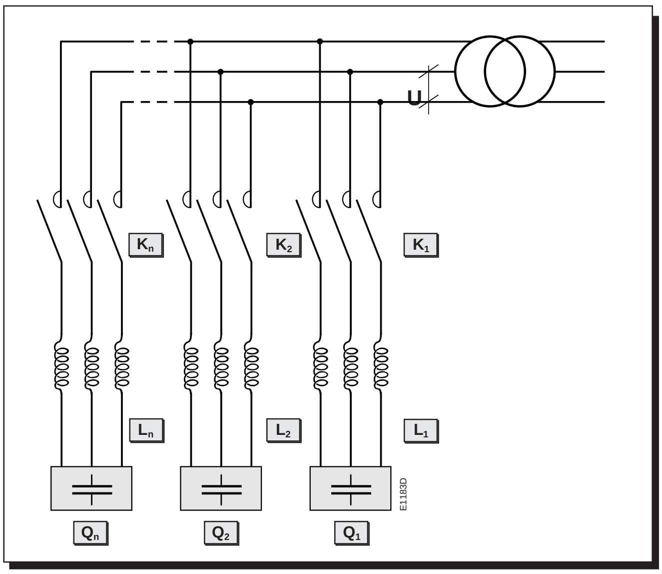
k_1 : 1457 (50 Hz) 或 or 1330 (60 Hz)

k_2 : 89.2 (50 Hz) 或 or 97.2 (60 Hz)

三相電容器組相同功率幾步到位
Three-phase capacitor bank with several steps of identical power.

已有 **"n – 1"** 個電容器在工作時給電容器**Q_n** 充電

Energizing of the capacitor **Q_n** with **"n – 1"** capacitors on duty.



浪湧峰值電流 Î

Inrush peak current Î :

$$\hat{I} = k_1 \frac{n-1}{n} \times \sqrt{\frac{Q_n}{L_n}}$$

浪湧電流頻率 f_0

Inrush current frequency f_0 :

$$f_0 = k_2\, U \sqrt{\frac{1}{L_n \times Q_n}}$$

Î : A

$L_1 = L_2 = L_{...} = L_n$: 每步一相的電感，單位為 µH
inductance by phase of a step in µH

$Q_1 = Q_2 = Q_{...} = Q_n$: 每步功率，單位為 kvar
power of a step in kvar

n : 電容器的步數 number of capacitor steps

U : 相間電壓，單位為V phase-to-phase voltage in V

k_1 = 1457 (50 Hz) 或 or 1330 (60 Hz)

k_2 = 89.2 (50 Hz) 或 or 97.2 (60 Hz)

計算浪湧電流峰值和頻率

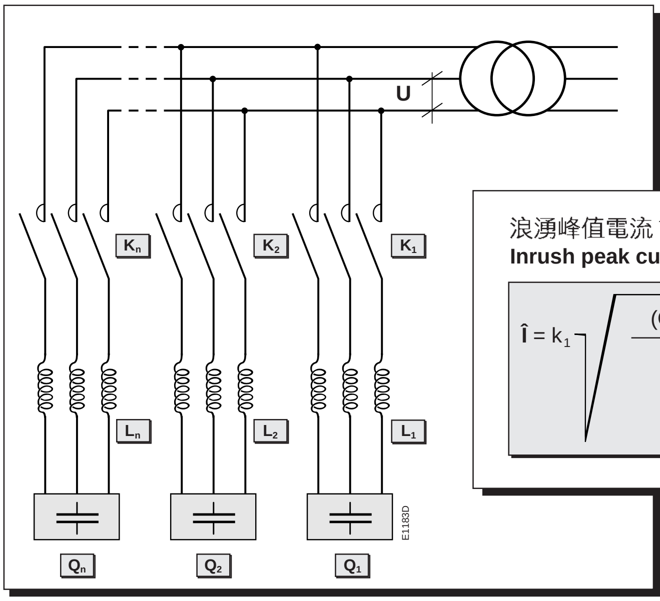
Calculation of Inrush Current Peak and Frequency

三相電容器組不同功率幾步到位

已有 "**n – 1**" 個電容器在工作時給電容器Q_n充電

Three-phase capacitor bank with several steps of different powers

Energizing of the capacitor Q_n with "**n – 1**" capacitors on duty



浪湧峰值電流 Î

Inrush peak current Î :

$$\hat{I} = k_1 \sqrt{\frac{(Q_1 + Q_2 + \ldots + \ldots + Q_{n-1})\,Q_n}{Q_1 + Q_2 + \ldots + \ \ldots + Q_n} \times \frac{1}{L_n + \dfrac{1}{\dfrac{1}{L_1} + \dfrac{1}{L_2} + \cdots + \dfrac{1}{L_{n-1}}}}}$$

Q_n 充電	Energizing of Q_n
– 假設步數 $n = \dfrac{\text{電容器組總功率}}{\text{最小步的功率}}$	– Fictitious number of steps $n = \dfrac{\text{Bank total power}}{\text{Power of smallest step}}$
– 如果電感L_1, L_2 .... L_n與這些步驟的功率成反比，則Q_n 的浪湧電流峰值與由**n**個相同步組成的電容器組是一樣的。 $L_{n\ 最小} = L_1 \dfrac{Q_1}{Q_n}$	– The inrush current peak of Q_n is the same as that of a capacitor bank made up of **n** identical steps provided that the inductances L_1, L_2 .... L_n are inversely proportional to the power of these steps. $L_{n\ mini} = L_1 \dfrac{Q_1}{Q_n}$

$Q_1 = a\,Q_n$ $L_1 = L_n / a$

$Q_2 = b\,Q_n$ $L_2 = L_n / b$

$Q_{..} = ..\,Q_n$ $L_{..} = L_n / ..$

⇓ ⇓

$Q_{n-1} = z\,Q_n$ $L_{n-1} = L_n / z$

確定變壓器電感

Determining the Transformer Inductance

以上各公式所用變壓器電感值 (L_t) 可按下述方法確定。

- 變壓器銘牌上標出值的提示

The value of the inductance (L_t) of the transformer used in the various formulas above can be determined by following the method described below.

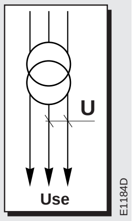
- **Reminder of the values marked on the transformer plate**

S : 功率，單位為 kVA
Power in kVA

χ : 以%表示的短路電壓
Short-circuit voltage as a %

U : 相間工作電壓，單位為 V
Phase-to-phase operating voltage in Volts

f : 電流頻率，單位為 Hz
Current frequency in Hertz



變壓器每相電感值L_t，單位為μH：
Value L_t of the inductance by phase of the transformer in μH :

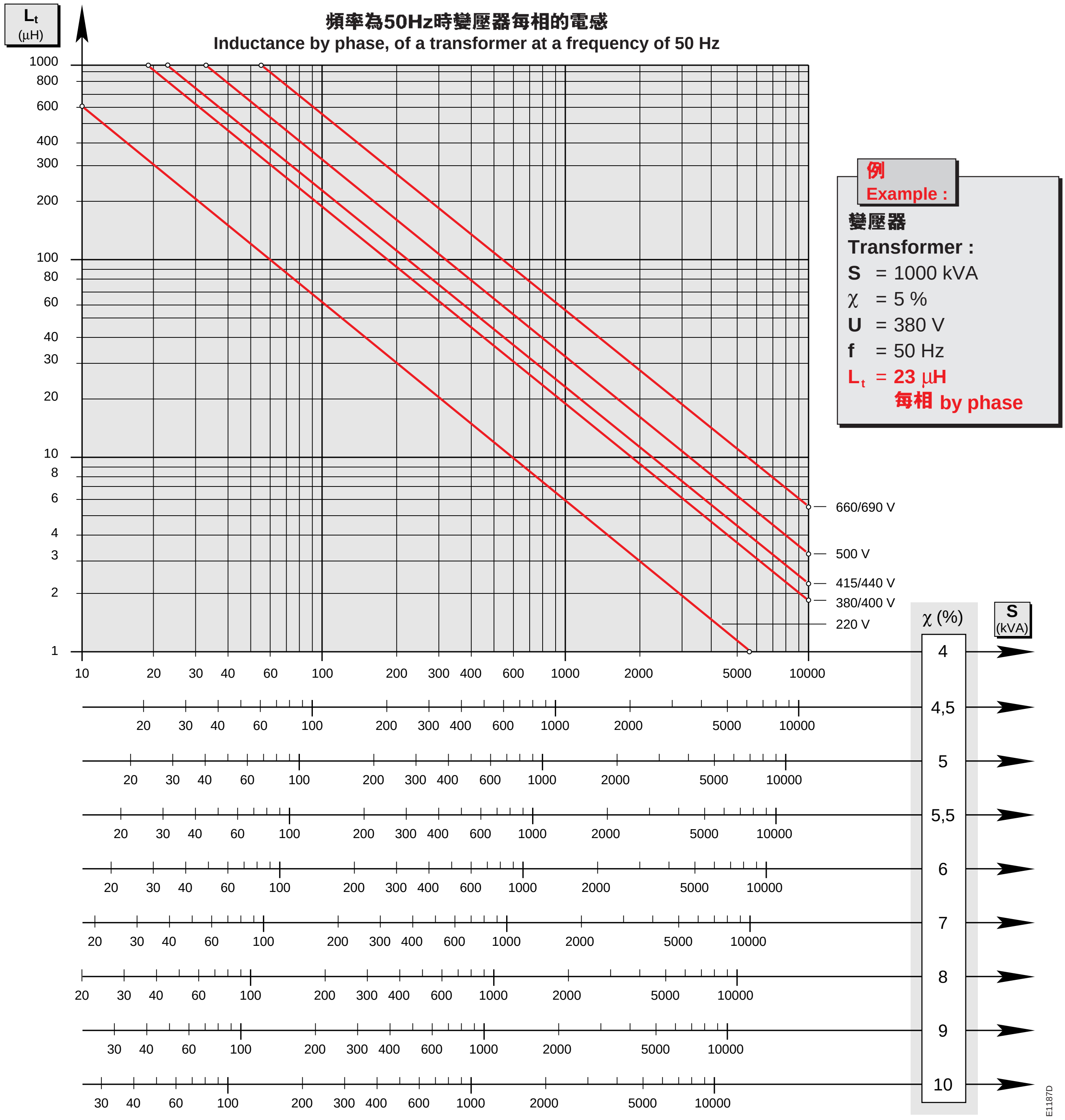
$$L_t = \frac{1}{200\,\pi\,f} \cdot \frac{\chi U^2}{S} \cdot 10^3$$

$$L_t = \frac{\chi\, U^2}{k_3\, S}$$

k_3 = 31.4 (50 Hz) 或or 37.68 (60 Hz)

此值可從下圖直接讀出
The following chart gives this value by direct reading

頻率為50Hz時變壓器每相的電感
Inductance by phase, of a transformer at a frequency of 50 Hz



例
Example :

變壓器
Transformer :

S = 1000 kVA
χ = 5 %
U = 380 V
f = 50 Hz
L_t = 23 μH
每相 by phase

確定電氣連接線電感

Determining the Electrical Connection Inductances

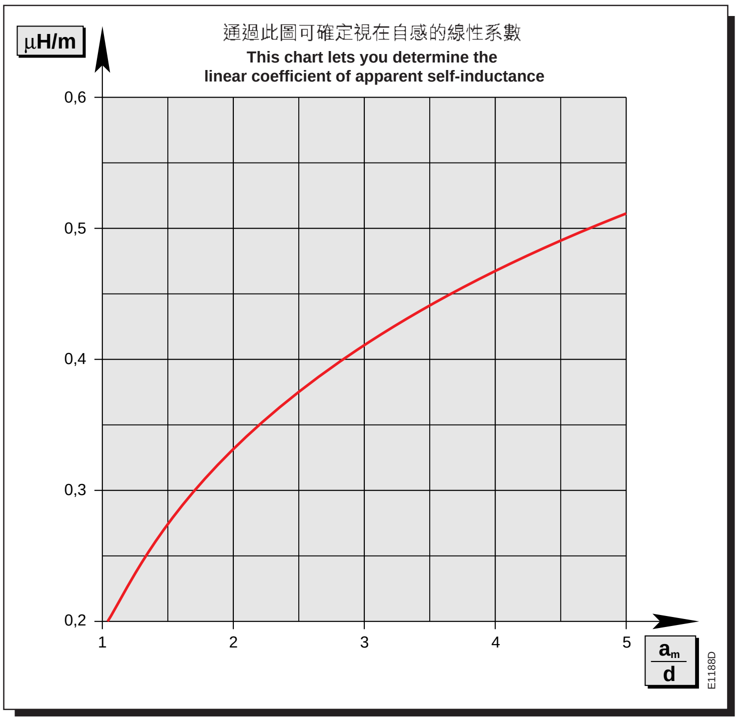
在由非磁性的導體形成對稱連接中，所有導體的視在自感的長度系數相同，其值為：

For a symmetrical connection formed by non-magnetic conductors, the linear coefficient of apparent self-inductance is the same for all the conductors and is given by :

$$L = [\,0.05 + 0.46 \log_{10} \frac{2\,a_m}{d}\,]\ \mu H/m$$

d = 導體心線直徑 (mm)
diameter of the conductive core (mm)

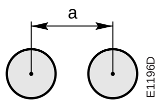
a_m = 導體軸間平均幾何距離 (mm)
geometric average of distances between the conductor axes (mm)



單相裝置

Single-phase installation

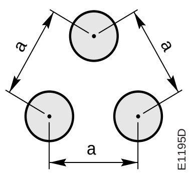
$a_m = a$



三相三角形裝置

Three-phase delta installation

$a_m = a$

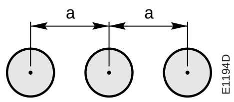


三相鄰近裝置

Three-phase adjacent installation

$a_m = a\sqrt[3]{2}$

$a_m = 1.26\ a$



參考值

Guideline values

導體截面積 Conductive cross-sectional area (mm²)	4	6	10	16	25	35	50	70	95	120
導體心線直徑 Conductive core Ø = d (mm)	2.26	2.92	3.9	4.9	6.1	7.2	8.4	10.1	11.9	13.4
外徑 Outer Ø U1000 RO2V	7.2	8.2	9.2	10.5	12.5	13.5	15	17	19	21

浪湧峰值的衰減
Attenuation of the Inrush Peak

如果電氣連接線電感很低，電容器組的浪湧電流峰值可能未經足夠衰減，從而可使接觸器主接點熔結在一起。

為避免此危險，用戶必須選擇能承受更高電流峰值 (UA 或 UA.....-R 範圍) 的接觸器，或者在電路中串聯接入“附加”電感。

確定電氣連接綫的最小電感

第6頁上用於計算浪湧電流峰值的公式也可用於確定將變壓器與電容器組分隔的電氣連接線電感的最小值，以免接觸器主接點熔結到一起。

● 一步到位電容器組
● **Capacitor bank with one step**

$$\hat{I} = k_1 \sqrt{\frac{Q}{L + L_t}} \quad \text{因此 thus } L^{最小}_{min} = \left(\frac{k_1^2}{I^2} Q\right) - L_t$$

● 幾個相同的幾步到位的電容器組
● **Capacitor bank with several identical steps**

$$\hat{I} = k_1 \frac{n-1}{n} \sqrt{\frac{Q_n}{L_n + L_t}} \quad \text{因此 thus } L^{最小}_{min} = \left(\frac{k_1^2}{I^2} \frac{(n-1)^2}{n^2} Q_n\right) - L_t$$

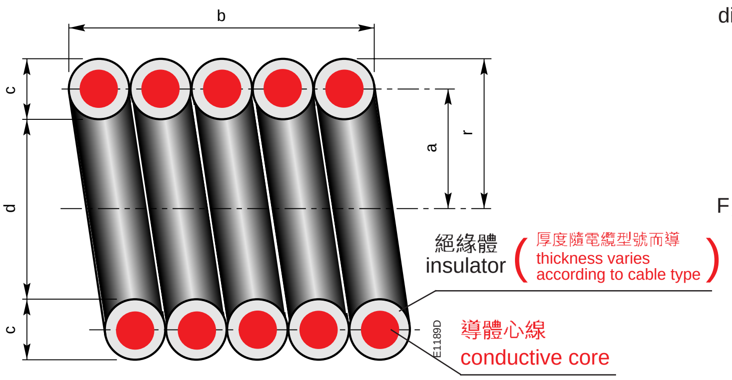
從第 13 頁的圖上可根據以下幾點直接讀出電感最小值：
- 接觸器型號
- 電容器組的功率，單位為 kvar
- 步數

增加電感的實用方法

如果電氣連接線電感過低 (電流峰值衰減不夠)，用戶可增加附加電感，只需將設計用於連至電容器組的電纜繞到一個圓柱體上。以下提供了增加附加電感的全部信息。

● **理論提示**

電導體之相鄰各圈線在直徑為 (d) 的一個圓柱體上構成一電感線圈，其電感值為：



● **圖**

根據以下幾點從第 12 頁和 13 頁的圖上直接讀出所需匝數：
- 用於連接電容器組的電纜截面積
- 用於制作電感線圈的圓柱體的直徑
- 所需電感值

If the electrical connection inductances are very low, the inrush current peak of the capacitor bank may not be sufficiently attenuated and thus cause welding of the main poles of the contactor.

To avoid this risk, the user must select a contactor that can withstand a higher current peak (UA or UA...-R range) or may serial-connect "additional" inductances in the circuit.

Determining electrical connection minimum inductances

The formulas given on page 6 to calculate the inrush current peak can also be used to determine the minimum value of the electrical connection inductances separating the transformer from the capacitor bank, without risk of welding the main poles of the contactor.

$L^{最小}_{min}$: 電氣連接線最小電感，單位為 μ**H**
minimum inductance of the electrical connection in μ**H**

Î : 接觸器能承受的最大峰值電流，單位為**A**
maximum peak, acceptable for the contactor in **A**

Q : 電容器組的功率，單位為 **kvar**
power of the capacitor bank in **kvar**

Q_n : 第 n 步的功率，單位為 **kvar**
power of the n[th] step in **kvar**

L_t : 變壓器的相電感，單位為 μ**H**
inductance by phase of the transformer in μ**H**

k_1=1457 (if f = 50 **Hz**) 或 or = 1330 (if f = 60 **Hz**)

The chart on page 11 allows, by direct reading, identification of the minimum value of the inductance according to :
- the type of contactor
- the power of the capacitor bank in kvar
- the number of steps

Practical method for making additional inductances

If the electrical connection inductances are too low (current peaks not sufficiently attenuated), the user can add additional inductances, simply made by winding the cables designed to be connected to the capacitor bank, onto a cylinder. The method below provides all the technical information required to make these additional inductances.

● **Theoretical reminder**

An electrical conductor wound with joining turns on a cylinder of a diameter (d), forms an inductance coil whose inductance is equal to:

$$L = 10^{-7} \frac{4\pi^2 . a^2 . N^2}{b + c + r} \cdot F_1 \cdot F_2$$

$$F_1 = \frac{10\,b + 12\,c + 2\,r}{10\,b + 10\,c + 1{,}4\,r} \qquad F_2 = 0.5 \log_{10}\left(100 + \frac{14\,r}{2\,b + 3\,c}\right)$$

L : 自感，單位為 **H** — self-inductance in **H**
N : 匝數 — number of circular turns
a, **b**, **c**, **d**, **r**: 尺寸，單位為 **m** — dimensions in **m**

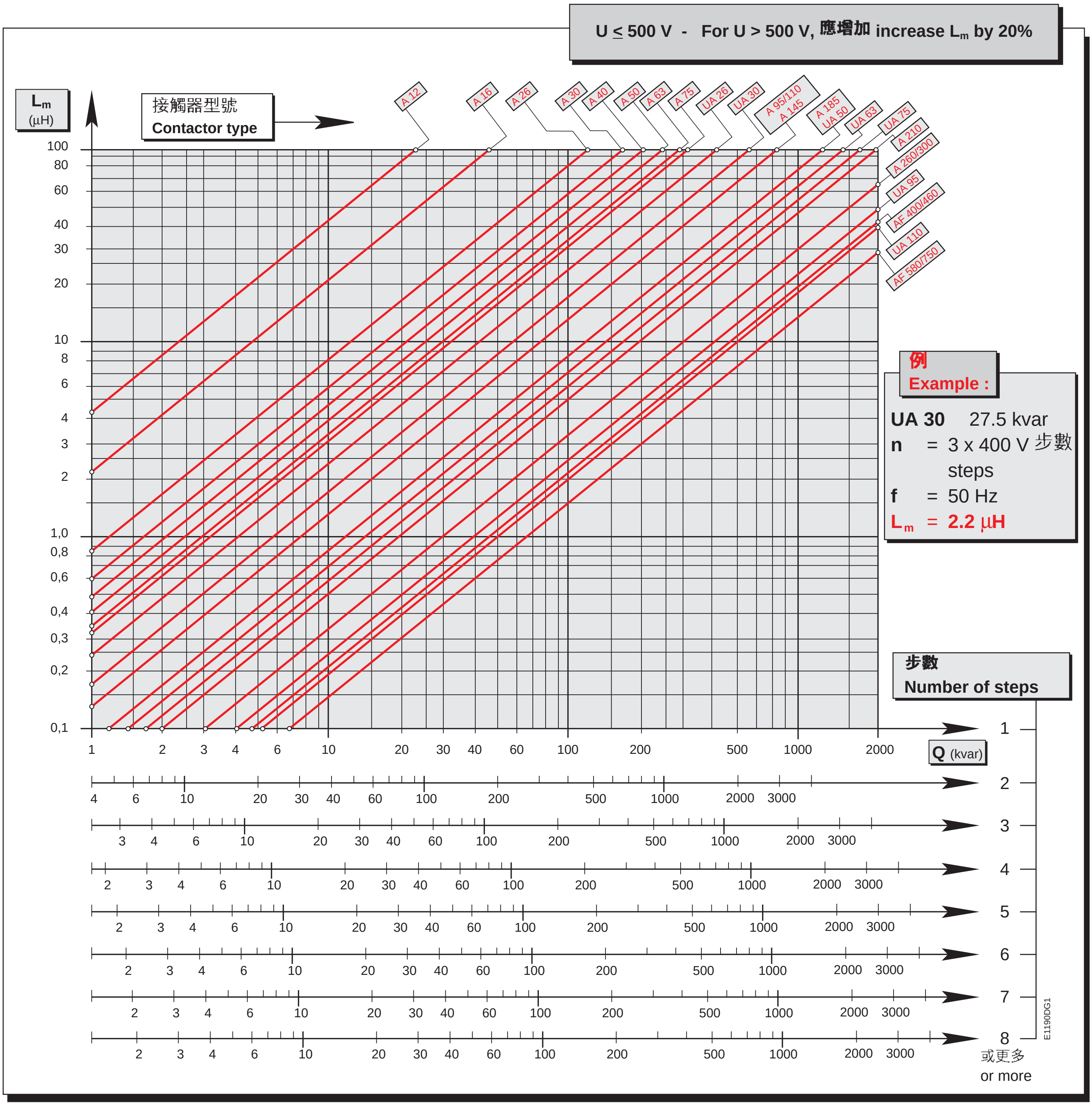
● **Charts**

The charts on pages 12 and 13 allow, by direct reading, identification of the number of turns to be made according to :
- the cable cross-sectional area that will be used to connect the capacitor bank
- the diameter of the cylinder used to make the inductance coil
- the necessary inductance value

浪湧峰值的衰減
Attenuation of the Inrush Peak

用於確定電氣連接線最小電感的圖

Chart used to determine electrical connection minimum inductances



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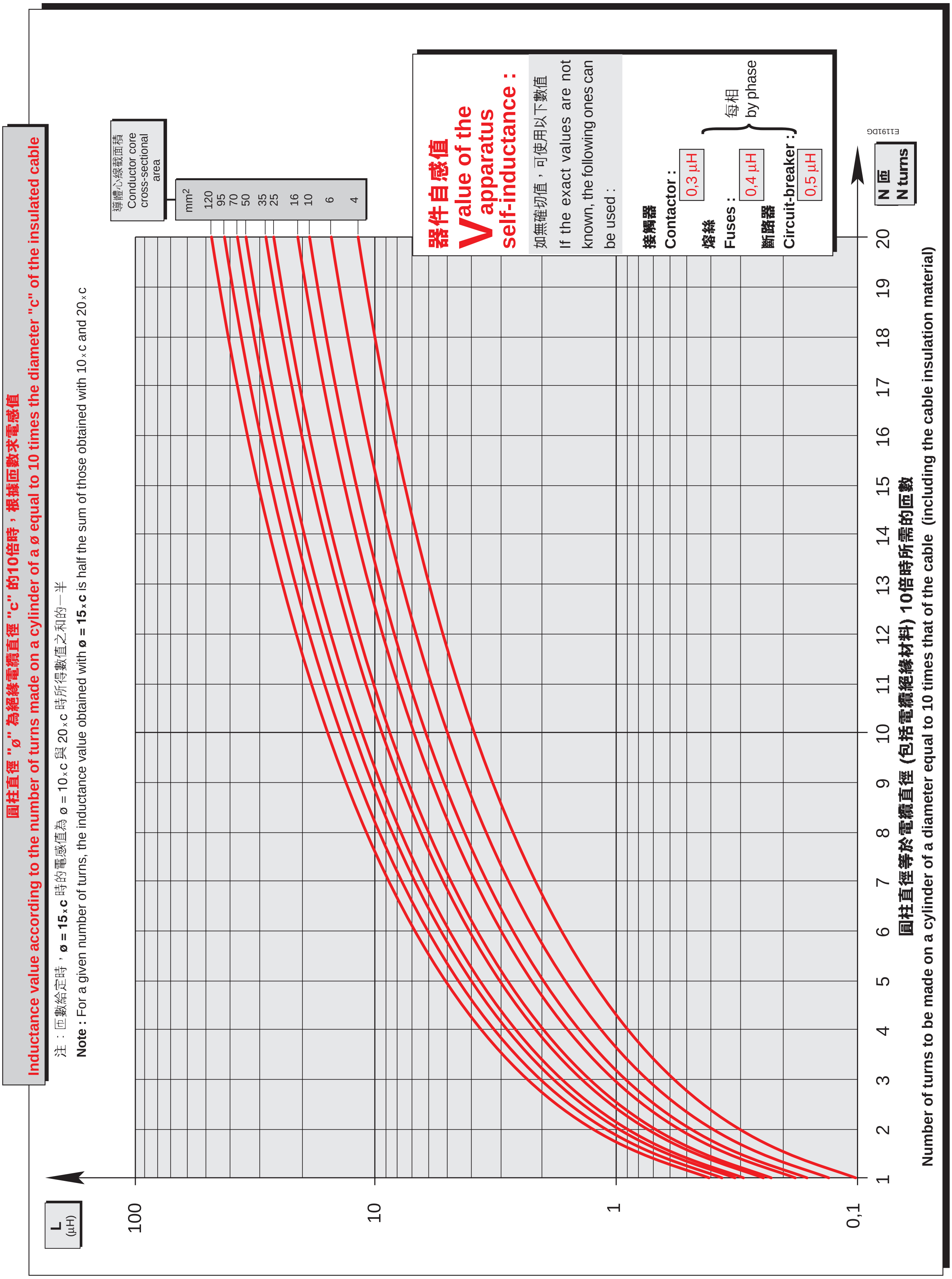
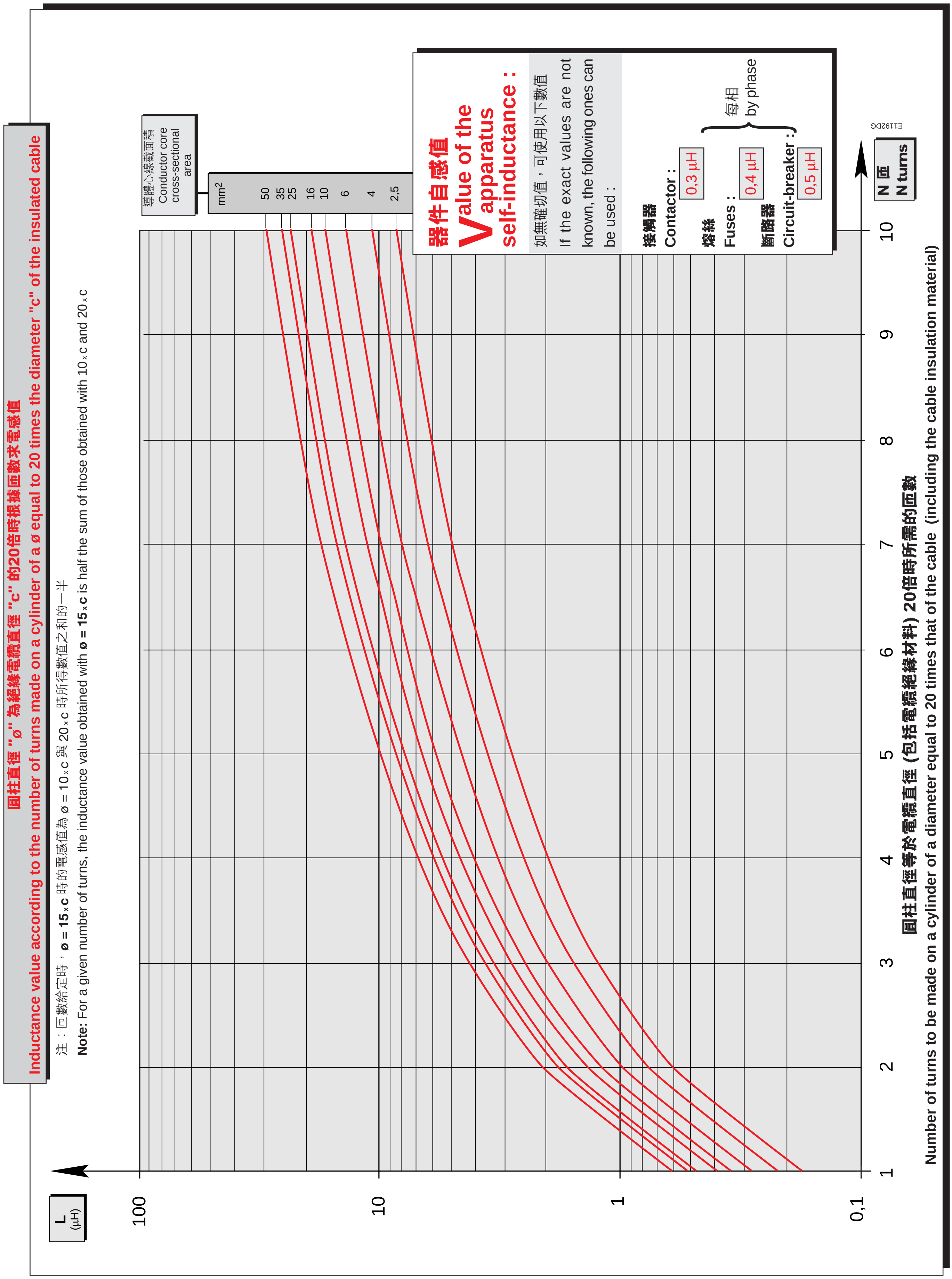
浪湧峰值的衰減 - 附加電感 (Ø = 10 x 電纜直徑)
Attenuation of the Inrush Peak - Additional inductances (Ø = 10 x cable diameter)



浪湧峰值的衰減 - 附加電感 (Ø = 20 x 電纜直徑)
Attenuation of the Inrush Peak - Additional inductances (Ø = 20 x cable diameter)



三相電容器組相同功率幾步到位。
Three-phase capacitor bank with several steps of identical power.

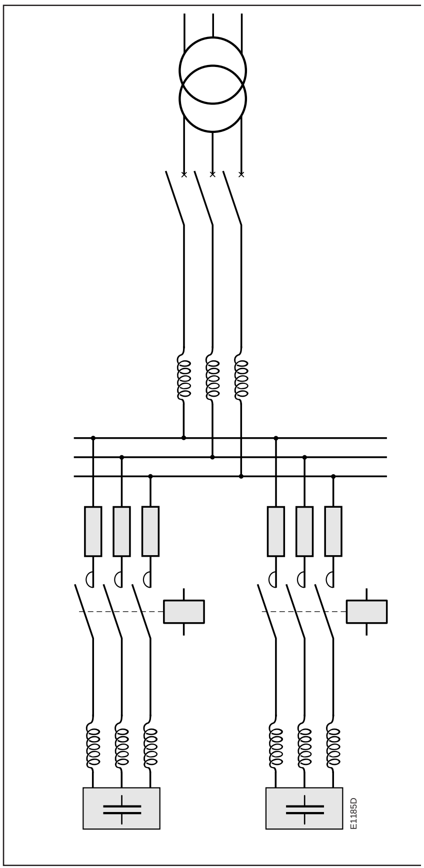
例 Example:

變壓器 ：630KVA 400V 50Hz 短路電壓 χ = 4%
電容器 ：一組 6 步，各 20kvar
連接 ：變壓器 / 電容器 ：10 米相鄰電纜 a_m = 4 d
電容器 / 母線 ：0.50 米，三角形連接 10mm² a_m = 4 d
溫度 ：θ = 40 °C

Transformer : 630 kVA 400 V 50 Hz
Short-circuit voltage χ = 4 %
Capaciors : bank with 6 steps of 20 kvar
Connections : transformer/ capacitors : 10 m of adjacent cables a_m = 4 d
capacitors/ busbars : 0.50 m in delta 10 mm² a_m = 4 d
Temperature : θ = 40 °C

$$\hat{I} = k_1 \frac{n-1}{n}\sqrt{\frac{Q_n}{L_n}}$$

(見第 6頁) (see page 6)



L_t : 每相變壓器電感 (見第 8 頁圖)
Transformer inductance per phase (chart on page 8) — L_t = 30 µH

L_1 : 斷路器電感 (見第 12 和 13 頁)
Circuit-breaker inductance (pages 12 and 13) — L_1 = 0.5 µH

L_2 : 接線電感：變壓器 / 電容器組每相 (見第 9 頁圖) L_2 = 0.47 µH x 10 ⇒ L_2 = 4.7 µH
Connection inductance : transformer/capacitor bank by phase (chart on page 9)

L_x : 每相的附加電感，如有必要 (此例中值為0)。如L_x不為0，將下面的附加電感L_y減去相同值。
Additional inductance, if necessary, per phase (value 0 for this example). If L_x other than 0, reduce by the same amount the value of the additional inductance L_y below.

L_3 : 接線電感：母線 / 電容器，每相 (見第 9 頁圖) L_3 = 0.47 µH x 0.5 ⇒ L_3 = 0.24 µH
Connection inductance : busbar/capacitor, per phase (chart on page 9)

L_4 : 熔絲電感 (見第 12 和 13 頁圖)
Fuse inductance (pages 12 and 13) — L_4 = 0.4 µH

L_5 : 接觸器電感 (見第 12 和 13 頁圖)
Contactor inductance (pages 12 and 13) — L_5 = 0.3 µH

$L_n = L_3 + L_4 + L_5$ = 0.94 µH

L_y : 附加電感，如大必要時，每相每步 (見第 10 頁圖)
Additional inductance, if necessary, per phase and per step (page 10)

Q : 電容器功率 (kvar) (n 個相同步)
Capacitor power (kvar) (n identical steps)

選擇接觸器 (第2-3-4頁) Selecting the contactor (pages 2-3-4)	型號 (見第3頁的表) Type (table page 3)	**UA 26**
尋找 L_m (見第11頁的圖) Look for L_m (chart on page 11)	網絡所需最小電感 Network minimum inductance	L_m = 3.2 µH

如 If $L_m \le L_3 + L_4 + L_5 + \ldots$ ⇒ 無需附加電感 No additional inductance L_y
如 If $L_m > L_3 + L_4 + L_5 + \ldots$ ⇒ 加入附加電感 Add an additional inductance L_y L_y = 3.2 µH – 0.94 µH = 2.26 µH

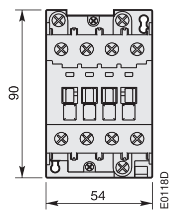
L_y 由3匝 10 mm² 銅電纜 (見 13頁的圖) 製成 Ø = 20 c
L_y made up of 3 turns per phase of 10 mm² copper cable (as per chart on page 13) Ø = 20 c

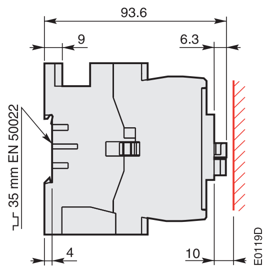
如要取消或減少L_y，可選用接通容量更大的接觸器
If you want to eliminate or reduce L_y you can choose a contactor with a higher making capacity

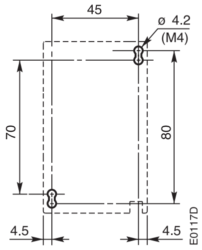
如選用 **UA75** 接觸器，從第11頁的圖可得 L_m = 0.85 µH **0.85 < 0.94 因此無需附加電感**
If you choose an **UA75** contactor, the chart (page 11) gives L_m = 0.85 µH **Thus no additional inductances as 0.85 < 0.94 µH**

上游電感值 $L_t + L_1 + L_2$ = 35.2 µH 使得加入附加電感 L_x 失去意義。
The upstream inductance value $L_t + L_1 + L_2$ = 35.2 µH makes the addition of additional inductances L_x pointless.

UA 26

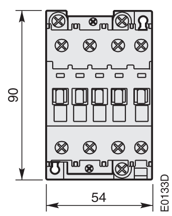


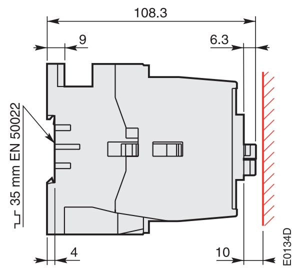


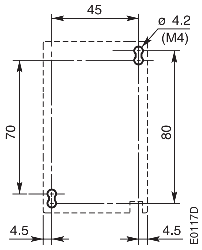


開孔圖
Drilling plan

UA 30

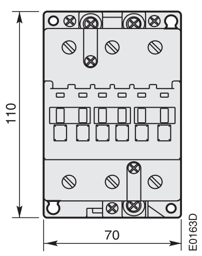




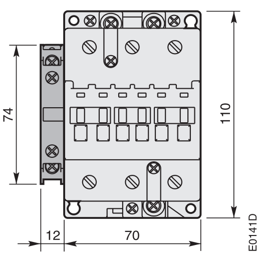


開孔圖
Drilling plan

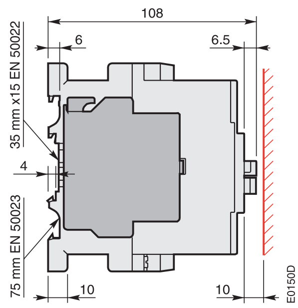
UA 50, UA 63, UA 75

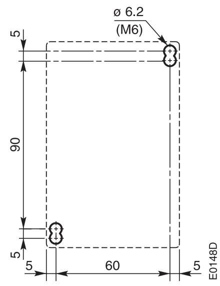


UA 50, UA 63, UA 75-30-00 11



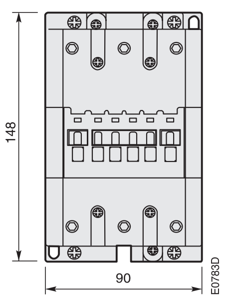
UA 50, UA 63, UA 75-30-



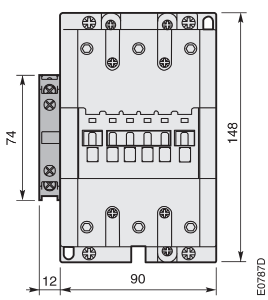


開孔圖
Drilling plan

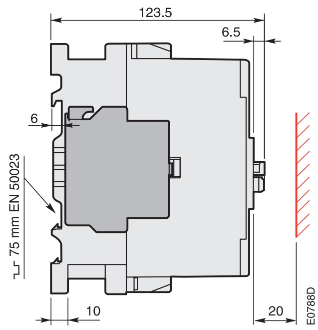
UA 95, UA 110

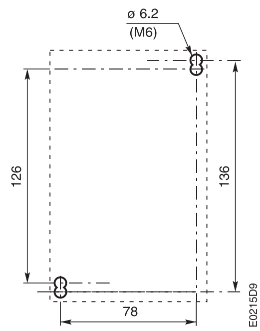


UA 95, UA 110-30-00 11



UA 95, UA 110-30-



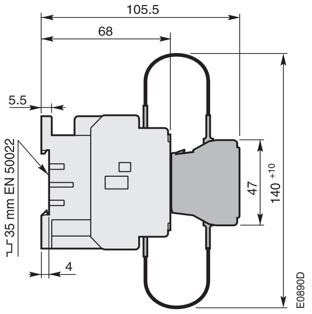


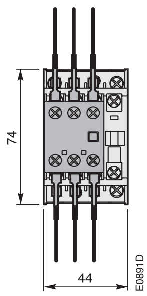
開孔圖
Drilling plan

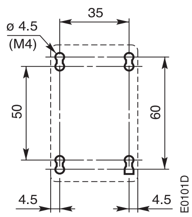
UA 3-pole Contactors for 3-phase Capacitor Switching

尺寸圖 Dimensions (mm)

UA 16 .. -

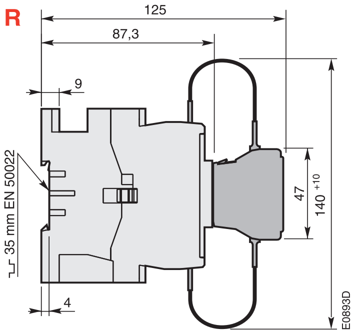


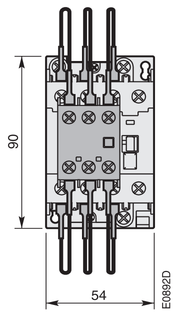


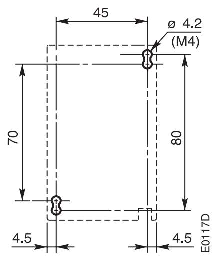


開孔圖
Drilling
plan

UA 26 .. -
R

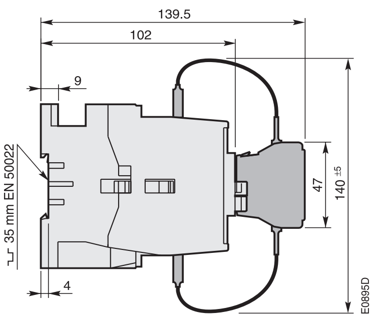


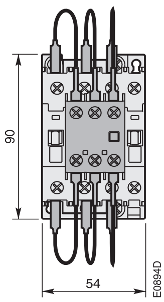


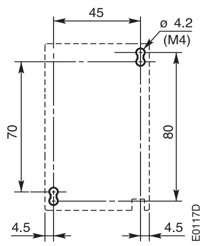


開孔圖
Drilling
plan

UA 30 .. -

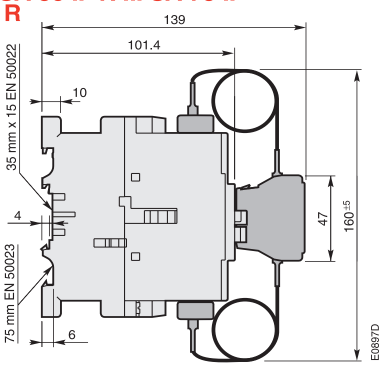


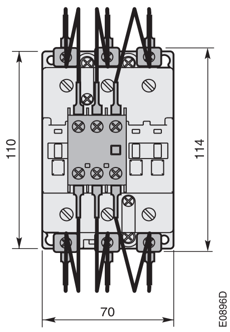


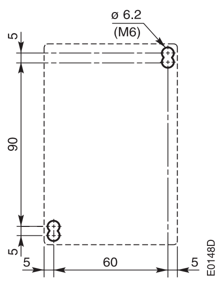


開孔圖
Drilling
plan

UA 50 .. -R ... UA 75 .. -
R







開孔圖
Drilling
plan

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可索取詳細尺寸圖內 Autocad DWG / DXF 格式。
Detailed dimension drawings on Autocad DWG / DXF formats available on request.

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