KURSUS REKABENTUK

SISTEM PAM

"REKABENTUK SISTEM ELEKTRIK"

Institut Pembangunan Kompetensi JPS
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Kursus Rekabentuk Sistem Pam

Rekabentuk Sistem Elektrik

Oleh Ir.LOH BAK KIM

Tindakan Awalan

1. Suaikena tapak projek
2. Semak senarai peralatan mesin/pam yang memerlukan kuasa elektrik!
3. Dapatkan pelan kunci, lokasi, tapak projek!
4. Dapatkan pelan bangunan serta pelan lokasi peralatan mesin yang dicadangkan.

Tindakan dengan pihak yang berkuasa untuk memberi perkhidmatan sokongan

- (A) Bekalan Elektrik.
- (B) Perkhidmatan telepon jika rumah
- kawalan memerlukan perkhidmatan
- telefon.

Siasatan Tapak

- (1) Uruskan lawatan tapak berdasarkan pelan
- kunci, lokasi, dan tapak yang diperolehi.
- (2) Siasat keadaan ditapak dan tentukan jarak
- kedudukan tiang elektrik yang sediada.
- (3) Dapatkan malumat tentang jenis
- pencawang elektrik yang terdekat dari
- tapak projek.

Tentukan jumlah beban elektrik project

- (1) Kumpulkan data permulaan beban
- elektrik dengan butiran terprinci
- mekanikal.
- (2) Semak dan tentukan keperluan beban
- elektrik dari segi percahayaan lampu
- dan kuasa kecil yang diperlukan
- diseluruh tapak yang berkenaan.

Kemukakan Permohonan Bekalan Elektrik

- Kemukakan permohonan bekalan elektrik dengan mengikut buku panduan TNB
- Isi kandungan mustahak!
- (A) Kehendak Maksima
- (B) Tarikh Bekalan diperlukan.

Rekabentuk Sistem Elektrik untuk Papan Kawalan Pam

- (1) Semak dengan rakan Mekanikal
- tentang size atau jenis peralatan
- jentera yang digunakan.
- (2) Jalankan rekabentuk asas mengikut
- panduan teknik pembekal peralatan.

Jenis motor yang terpileh untok sistem pam:-

- 'A.C . Induction motors 'pada dasar nya digunasebagai penggerak utama.
- Jenis:-
- (a) 'Squirrel-cage 'motok
- (b) 'Slip ring' (wound rotor) motok

- Saiz motok adalah direkabentukkan oleh
- Jurutera Mekanikal kerana muatannya mesti sanggup bergerak beban mekanikal yang tersambung.

Faktar pertimbangan rekabentuk berkenaan dengan data elektrik yang perlu diambil perhatian:-

- (A) Bersangkutan Dengan Daya
- Pengeluaran (Performance)
- (B) Perhubungan antara Kuasa
- sebenar dan kuasa 'Apparent'.

(A) Faktar data elektrik yang bersangkut dengan Daya Pengeluaran

- (1) Votan punca sistem bekalan:-
- Kadar votan motok terpileh mesti
- dalam lingkungan + or – 5% daripada
- kadar votan sistem bekalan.
- (2) ‘Speed’
- (3) ‘Torque’
- (4) ‘motor output power’
- (5) ‘Efficiency’
- (6) ‘Power factor’

(B) Perhubungan antara kuasa sebenar dan kuasa 'Apparent'

- Kuasa sebenar=Apparent kuasa x Cos Q
- Or kW=kVA (Apparent power) x power
- factor

Apparent in kVA= power in kW / p.f.

$$\text{Apparent in kVA} = \frac{\text{power in kW}}{\text{p.f.}}$$

.f. must be above 0.85

Power Distribution systems

- **Main Switch Board/Motor Control Centre**
- In distribution systems, circuit-breakers with overload and earth fault protection relays are used for the overload and earth fault protection for the feeder circuits.
- Motor protection circuit-breakers, or in combinations with contactors as starter are used for the load switching

Power Distribution systems

- **Motor Control Centre**
- (1) The circuit breaker with adjustable
- short circuit n-release is responsible
- for short circuit protection.
- (2) The over-load protection is provided
- by the over-load relay in conjunction with
- the contactor which also performs the
- switching function.

Electrical Motor Starters

- Type of conventional Starters and motor rating:-
- Rating | type of motor | Type of Starter
- Up to | Squirrel-cage | Direct on line
- 3h.p. | | (DOL)
- 3-10h.p. | Squirrel-cage | Star Delta/
- | | Auto Transformer
- Above 10 | slip ring | Resistance
- h.p. | Rotor | (secandary)

COMMON methods of Starting Squirrel –cage motor

- (a) Direct on line starting
- (b) Star Delta Starting
- (c) Auto-transformer starting for
- submersible motor
- (d) Rotor resistance starter usually used
- for slip ring motor

(a) Direct On Line Starting(DOL)

(

- Characteristic:-
- 1. Directly switch on to full line
- 2. Full voltage is applied to the motor
- winding
- 3. Full values of starting current
- 4. high torque

(a) Direct On Line Starting (DOL)

- Advantages:-
- 1. simple control gear and wiring
- 2. high starting torque
- 3. less maintenance
- 4. less initial cost

(a) Direct On Line Starting (DOL)

- Disadvantages:-
- 1. High voltage drop, can trigger-off the
- no-volt device of other motors near by.
- 2. Other nearby motors may stall because
- of excessive voltage drop in the line.

(b) Star Delta Starting

(1) During Starting, stator winding will be connected in star, so that each phase receives 1/3 of the supply voltage.

(2) However, the starting current and will be reduced in proportion to the square of the voltage ratio.(30% and 25% respectively, of the DOL values)

(C) Auto-transformer starting

- (1) The starter comprises of a three phase auto-transformer on which tapping points are provided on the secondary side. Taps on the transformer allow adjustments of the starting torque and in-rush current.

(C) Auto-transformer starting

- Characteristics produced by voltage Taps

Tap %	Starting Torque % locked Torque	locked current
50	25	28
65	42	48
80	64	67

Normally the starting current is limited to 150% of the full-load motor current.

(d) Rotor resistance starter

- If direct start is not permissible and starting torque is too low with star-delta or auto-transformer starts, a slip ring motor may be selected!
- Disadvantages is the power loss in the starting resistance.

(E) A.C. Semiconductor motor controller and starter

- Due to the high initial value of starting torque and current for three phase squirrel-case induction motor, solid-state reduced voltage starters are becoming more popular for "SOFT " starting!

(E) A.C. Semiconductor motor controller and starter

- Special Features and Characteristic:-
- (1) Offer optimized soft starting,
- (2) Controlled soft stopping,
- (3) Allow energy saving at partial load and
- d. c. braking,
- (4) Provide greater reduction in current
- surge,

(E) A.C. Semiconductor motor controller and starter

- Special Features and Characteristic:-
- (5) Reduces mechanical stresses on drive
- coupling, belts, gears, pumps, valves,
- etc.
- (6) Reduces electrical loading on the
- supply network and switchgears,
- (7) Reduces mechanical wear and tear
- (8) increase the service life of the motor itself.

(E) A.C. Semiconductor motor controller and starter

- Types-:
- (A) SOFT STARTER-Which regulate the
- value of the motor voltage and
- current at constant frequency during
- the starting and stopping period.
- (B) VARIABLE SPEED DRIVES-Which can
- alter both the voltage and frequency of the
- motor supply for the purposes of controlling
- torque and/or speed during various stages of
- operation.

(E) A.C. Semiconductor motor controller and starter

- Operating modes and features:-
- *Soft Starting*
- (1) Achieved by means of a simple linear
- voltage ramp, using microprocessor control unit to cause the motor terminal voltage to increase linearly from a preset initial value (adjustable from 20% supply voltage) to 100% of the supply voltage within the pre-selected ramp time.

(E) A.C. Semiconductor motor controller and starter

- the Operating modes and features:-
- *Soft Starting*
- (2) Achieved by a *start impulse* (also known as
- "kick start" feature) to overcome initial static
- friction in the drive and/or terminal voltage
- may be controlled in such a way as to limit
- the starting current to a specific value before full
- supply voltage is applied to the motor.

(E) A.C. Semiconductor motor controller and starter

- the Operating modes and features:-
- *Soft Starting*
- (3) Achieved by means of *voltage limiting*
- *method,* the terminal voltage may be held constant
- for a period of time during the run-up to reach the
- desired load acceleration characteristic.
- (4) Allow for emergency start feature, if a single
- thyristor or a thyristor pair has become
- permanently conductive (failed).

(E) A.C. Semiconductor motor controller and starter

the Operating modes and features:-

- *Soft Stopping*
- When motor is switched off instantaneously (i.e. terminal voltage to zero), the motor will coast down as determined by the moment of inertia of the total drive system and the friction. By means of soft stop feature, the motor terminal voltage is reduced gradually after the switch-off signal.
- Thereby, the initial value of the stop ramp is set to 90% of the supply voltage and the final value to 85% of the initial start voltage.
- The micro-processed feature incorporate intelligent software which can recognize the behaviour of the run-down characteristic and adjust the terminal voltage accordingly during preset run-down time.

(E) A.C. Semiconductor motor controller and starter

- the Operating modes and features:-
- *D.C. Braking*
- (1) In the case of a drive with a high moment of
- inertia, the D.C. braking feature may be
- activated to reduce the run-down time. A
- d. c. current is injected into the stator
  winding, creating a stationary magnetic
- field, and circulating currents are induced in the
- rotating short-circuited (squirrel cage) rotor. The resultant
- braking torque slow the motor down.
-

(E) A.C. Semiconductor motor controller and starter

- the Operating modes and features:-
- *Energy saving at partial load*
- It can reduce the terminal voltage to such an extent, that the motor is supplied with just enough energy for it to maintain the minimum required torque and to ensure that possible load pulse do not lead to excessive speed reduction.

(E) A.C. Semiconductor motor controller and starter

- the Operating modes and features:-
- *Operation with a bypass contactor*
- Unless rapid star/stop operation is required, it is recommended that the
- *Solid-state soft starter* be by-passed by a contactor once motor has reached full load speed.

(E) A.C. Semiconductor motor controller and starter

- the Operating modes and features:-
- *Protection and control function*
  - A number of protection and control functions are available to be preprogrammed into the control unit:-

(1) Over load and short circuit protection,

(2) Time monitoring,

(3) Temperature monitoring,

(4) Self testing in the full-on mode.

A. C. Motor Protection

:-

- (A) Overload protection-By thermal or
- magnetic overload relays
- (B) Short-Circuit Protection-By moulded
- case circuit breaker (mccb) sized to
- take the starting current of the motor
- (C) Single Phasing protection in 3-phase
- motor- Single Phasing protection relay
- is incorporated in the overload protection

A. C. Motor Protection

- (D) Overheating Protection-By
- temperature sensors built into the motor.

Cara menentu atau memilih saiz kabel

- 1. Rujuk kepada Peraturan IEE semasa:-
- Perkara pertimbangan:
- CARA kabel di pasang.
- Jarak kabel diperlukan.
- Fakta lain:- fakta jumlah litar dipasang
- bersama.
- faktar suhu persekitar
-
-

Contoh memilihki kabel berpandu kepada peraturan IEE

- 1. Saiz minima untuk litar kuasa =2.5 sq.mm
- 2. Pilih saiz kabel 2.5 sq.mm
- Dari table IEE:-
- Berkadar=22A
- Volt drop(mV)/A/metre:8.8

Cara memilih kabel............

- Full load A bagi motok terpilih =10A
- Jarak motok dari papan kawalan=12m
- Jumlah per litar=1
- Keturunan votan dialami:-
- 8.8/1000x10x12=1.056V(4% 415V=16.6V)
- Fakta kadar menurun:-
- Bilangan litar cara I =1 (untuk 1=100%)
- Suhu persekitaran pada 35 degree C
- =0.97
- Kadar sebenar keupayaan membawa arus=
- 22Ax1x0.97=21.34A
- Kesimpulan: saiz kabel terpilih ialah 2.5sq.mm dipasang dalam
- G.I. conduit.

Rekabentuk Papan Kawalan

- Jumlah pam dipasang=3
- Anggap 2 masih beroperasi bilangan Ke-3 terpaksa dimulatugas:-
- Arus mengalih=2x10A
- Arus Bermula =42A
- Jumlah =62A
- Saiz papan kawalan di tentukan=60A

Rekabentuk Papan Kawalan

- **Contoh Ke-2**
- Jumlah pam dipasang=4
- Anggap 3 masih beroperasi bilangan Ke-4 terpaksa dimulatugas:-
- Arus kadar =50A @ rated voltage:415V
- Arus mengalih=3x50A
- Arus Bermula =150A(soft starter)
- Jumlah =300A
- Saiz papan kawalan di tentukan=300A

Papan Suis Utama

- Beban lain,misalan lampu dan kuasa kecil yang di kehendaki=20A
- Saiz Papan Suis Utama=300A+20A=320A
- Spare =20% =64A
- Keseluruhan=384A
- Saiz Pemutus Litar Utama=400A

Jika Janakuasa tunggusedia diperlukan

- Cara kiraan terpaksa rujuk kepada 'NEMA code ' untuk anggaran starting kVA.
- Fakta tambahan:-
- 1.kecekapan janakuasa
- 2.keupayaan normal diberi

Cara Menentukan Saiz Janakuasa

	Starting		Running	
	kVA	kW	kVA	kW
(1) Lighting and				
small power				15.5
p.f.=0.95			16.3	
(2)Start 1st pump				
25hpx5.3 kVA				
/hp	132.5			
132.5x0.4pf		53.0		
Add L&P	16.3	15.5	16.3	15.5
Total	148.8	68.5	16.8	15.5

Cara Menentukan Saiz Janakuasa

	Starting		Running	
	kVA	kW	kVA	kW
(3) Run 1st pump at21.2hp at 0.88 Efficiency (21.2hpx0.746kW X1/0.88)				18.0
18@0.95pf			18.9	
Add L&P			16.3	15.5
Total load			35.2	33.5

Cara Menentukan Saiz Janakuasa

	Starting		Running	
•	kVA	kW	kVA	kW
(4)Start 2nd pump				
25hpx5.3 kVA				
/hp	132.5			
132.5x0.4pf		53.0		
run 1st pump				
& L&P	35.2	33.5	35.2	33.5
Total	167.7	86.5	35.2	33.5

Cara Menentukan Saiz Janakuasa

1	Starting		Running	
	kVA	kW	kVA	kW
(5)Run 2 pumps at20hp at 0.88 Efficiency (20hpx0.746kW X2x1/0.88)				33.9
33.9kW@0.95pf			35.7	
Add L&P			16.3	15.5
Total load			52.0	49.4

Cara Menentukan Saiz Janakuasa

	Starting		Running	
•	kVA	kW	kVA	kW
(6)Start 3rd pump				
25hpx5.3 kVA /hp	132.5			
132.5x0.4pf		53.0		
run 2 pump & L&P	52.0	49.4	52.0	49.4
Total	184.5	102.4	52.0	49.4

Cara Menentukan Saiz Janakuasa

	Starting		Running	
	kVA	kW	kVA	kW
(7)Run 3 pumps at18.4hp at 0.88 efficiency				
(18.4hpx0.746kW X3x1/0.88)				46.8
46.8kW@0.95pf			49.3	
Add L&P			16.3	15.5
Total load			65.6	62.3

Cara Menentukan Saiz Janakuasa

- The critical generator loads are the kVA and kW for starting the 3rd pump.
- Therefore the size of the proposed generator shall be at least capable of delivering 184.5 kVA for 6 to 10 sec. So a 200 kVA generator on standby is specified.

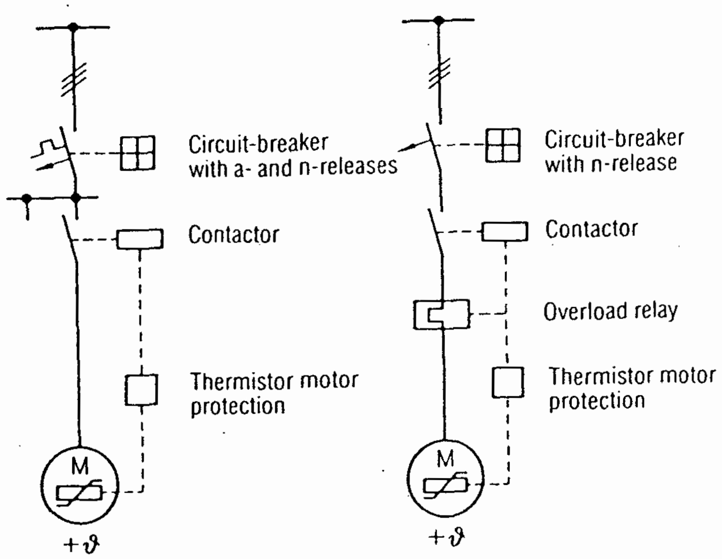
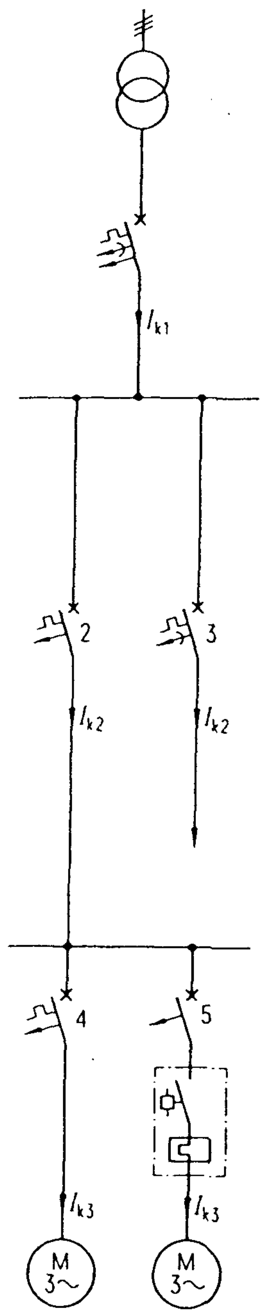


Fig. 1

Switchgear combinations with a thermistor motor protection device, and *with* additional overload protection (single-line diagrams)

Fig. 2.

Power distribution system with circuit-breakers but *without* fuses



No.	Type of circuit-breaker	Order No.	Rated short-circuit breaking capacity (I_{cn})	Type of overload release: a Ad-just-able	a Fixed	z Ad-just-able	z Fixed	n Ad-just-able
Incomer circuit-breaker								
1	Circuit-breaker for discriminative protection	3WN	$> I_{k1}$	×	–	×	–	×
Distribution circuit-breaker								
2	Circuit-breaker for distribution protection	3VF	$> I_{k2}$	–	×	–	–	×
3	Circuit-breaker for discriminative protection	3WN	$> I_{k2}$	×	–	×	–	–
Load (consumer) circuit-breaker								
4	Circuit-breaker for motor protection	3VU	$> I_{k3}$	×	–	–	×	–
5	Circuit-breaker and d.o.l. starter	3VU 3TW	$> I_{k3}$ –	× ×	– –	– –	× –	– –

Fig. 3

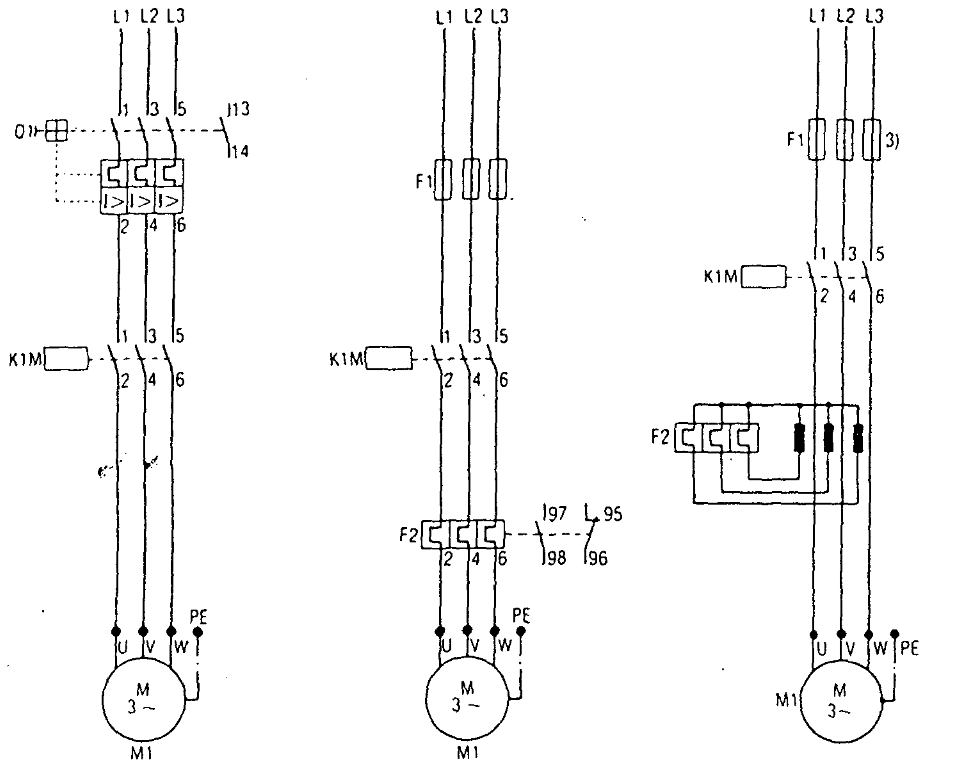
Fuseless
without overload relay

Short-circuit protection [1]) and overload protection through PKZM manual motor starter or NZM(H) circuit-breaker

Fuses
with overload relay

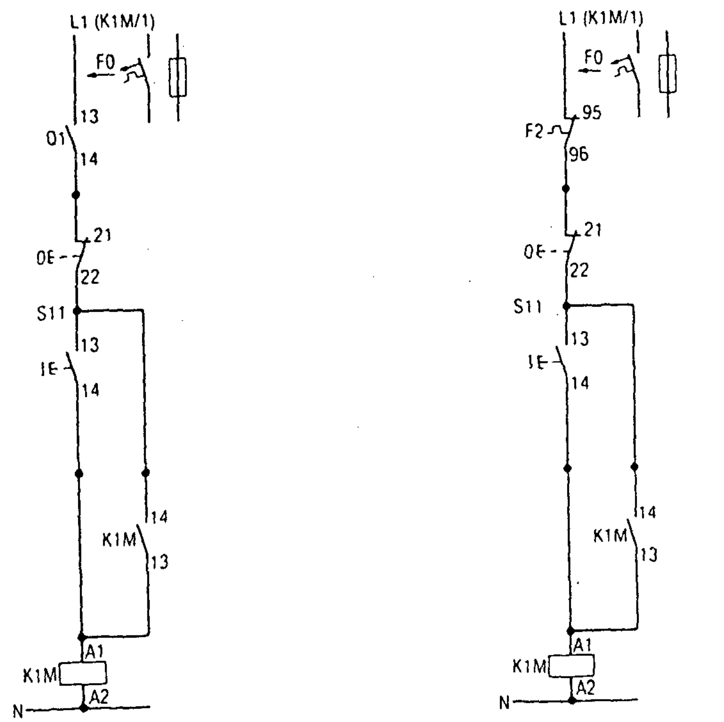
Short-circuit protection [2]) for contactor and overload relay through fuses F1

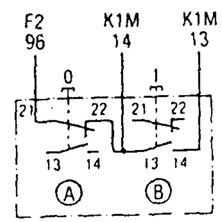
Short-circuit protection [3]) for contactor through fuses F1



Without overload relay

With overload relay





The short-circuit capacity of the contacts in the circuit has to be considered when selecting F0.

Two-way push-button station

Control circuit device

I = On
0 = Off

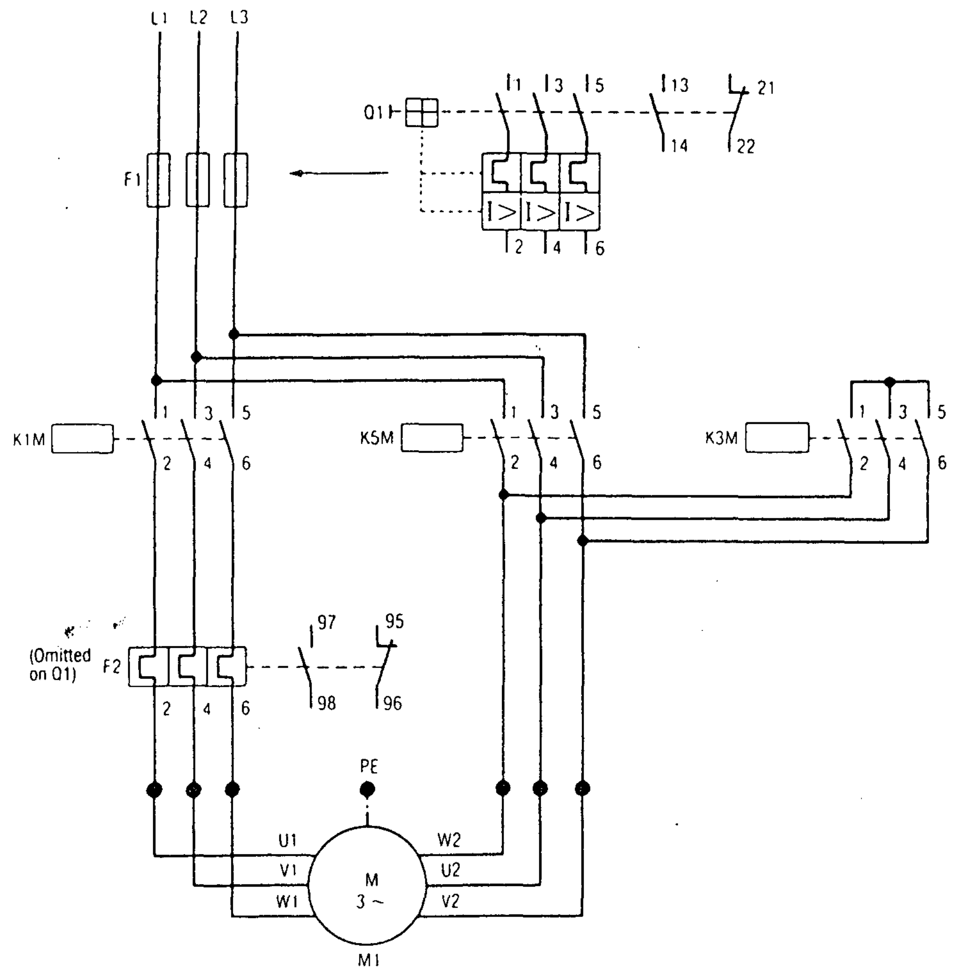
CAD 22: MOTORAC 1111121, 1111221
For connection of further control circuit devices, see Page 9/16.

Mode of operation: contactor coil K1M is energized by pressing push-button I. The contactor closes, switches the motor on and maintains itself via its own auxiliary contact K1M/14-13 and push-button 0, after push-button I has been released (pulsed contact). Contactor K1M is de-energized, in the normal course of events, by pressing push-button 0, or in the event of an overload through the break contact 95-96 on the overload relay F2. The coil current is interrupted, and contactor K1M switches the motor off.

[1]) Protective device in the supply line in accordance with Main Catalogue or AWA installation instructions
[2]) Fuse size in accordance with data on the rating plate of the overload relay
[3]) Fuse size in accordance with Main Catalogue (Technical data for contactors)

VWS 211-401/CAD 22: MOTORAC 1111111, 1111211

SDAINL automatic star-delta starters



Fuseless without overload relay:

- Relay current = rated motor current
- Protective device in the supply line in accordance with Main Catalogue or AWA installation instructions

With **fuses** and overload relay:

- Fuse size in accordance with data on the rating plate of the overload relay F2
- Standard version: relay current = rated motor current x 0.58

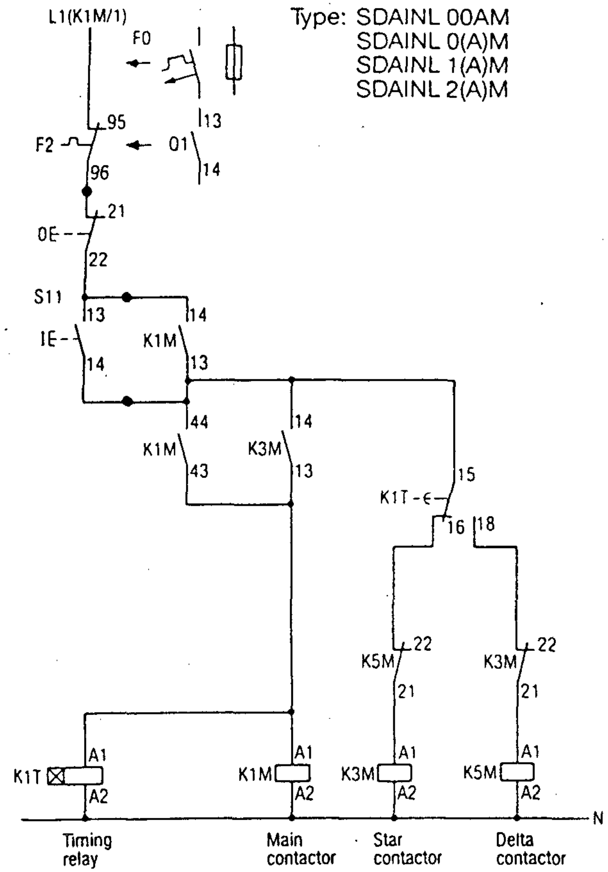
For other arrangements of the overload relay F2, see Page 9/17.

Star-Delta Starting of Three-Phase Motors

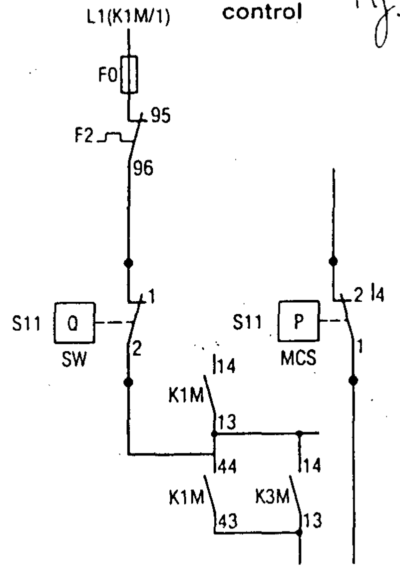
Automatic star-delta starters

Fig. 4

Type: SDAINL 00AM
SDAINL 0(A)M
SDAINL 1(A)M
SDAINL 2(A)M



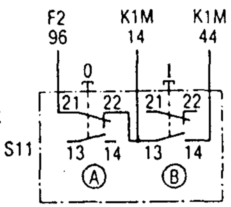
Two-wire control



Two-way push-button station

Control circuit device

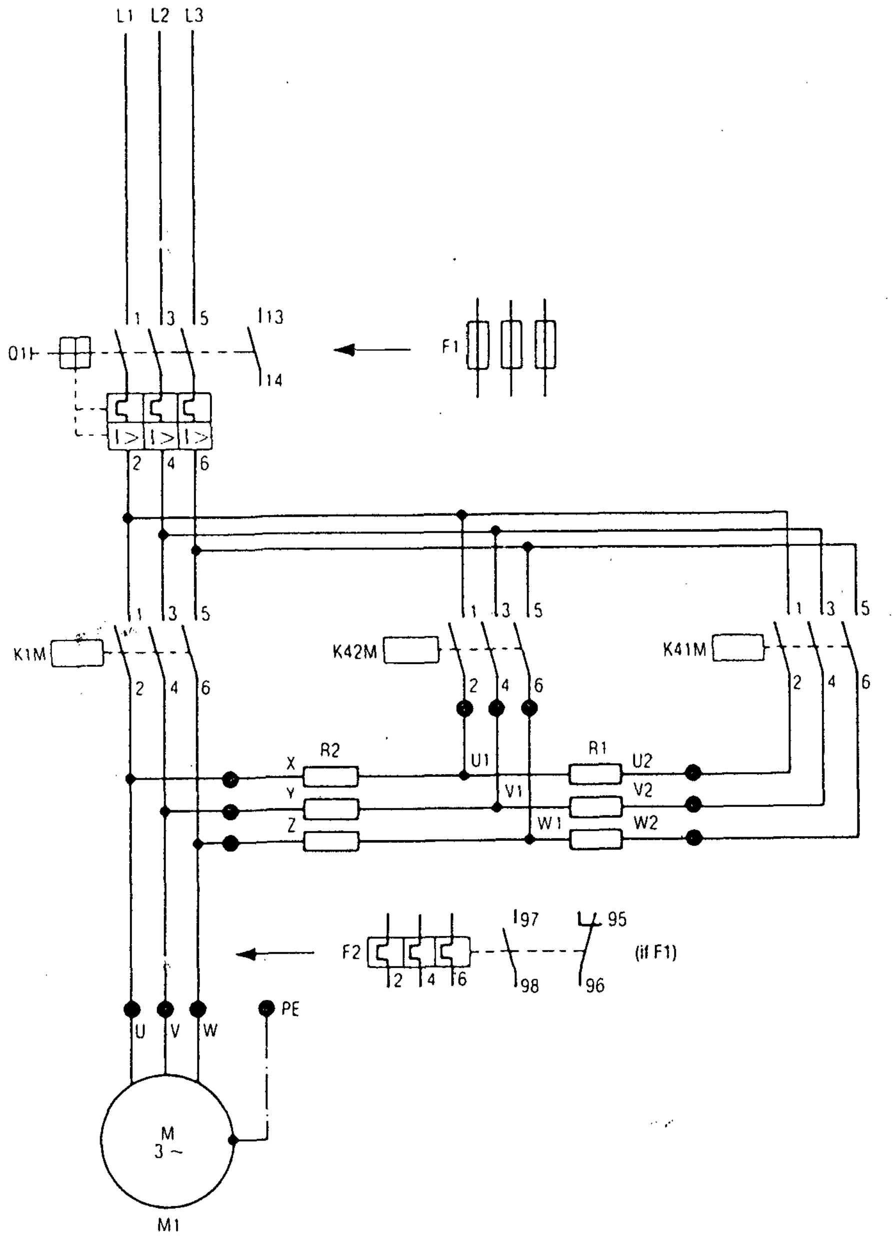
I = On
0 = Off



For connection of further control circuit devices, see Page 9/24.

Mode of operation: push-button I energizes star contactor K3M, the make contact K3M/14-13 of which applies voltage to main contactor K1M: this closes and applies voltage to motor M1 in the star connection. K1M and K3M maintain themselves via make contact K1M/14-13 and K1M additionally via K1M/44-43 and push-button 0. Timing relay K1T is energized at the same time as main contactor K1M. When the pre-set changeover time has elapsed, K1T opens the circuit of K3M via the changeover contact 15-16 and closes the circuit of K5M via 15-18. Star contactor K3M drops out. Delta contactor K5M closes and switches motor M1 to full mains voltage. At the same time, break contact K5M/22-21 interrupts the circuit of K3M, thus interlocking against renewed switching on while the motor is running.
The motor cannot be started up again unless it has previously been disconnected by push-button 0, or in the event of an overload, by the break contact 95-96 of the overload relay F2, or via the make contact 13-14 of the manual motor starter or circuit-breaker.

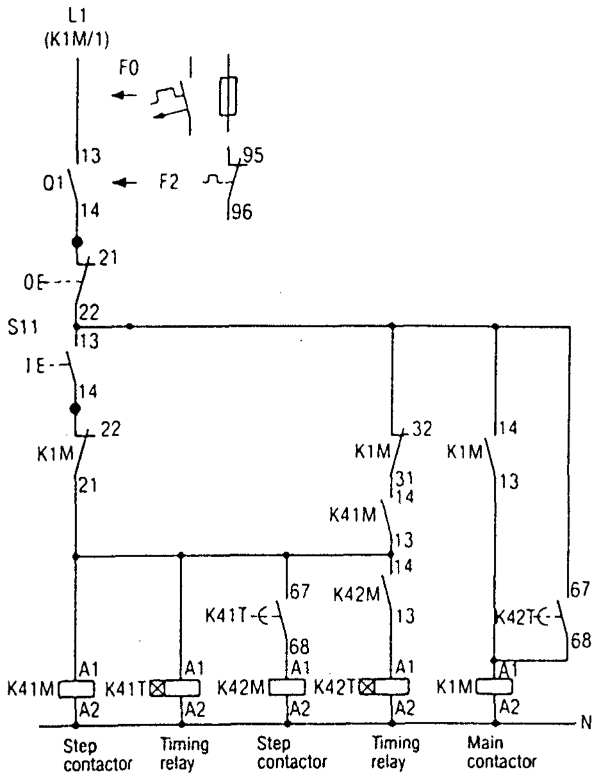
DDAINL three-phase automatic stator resistance starters

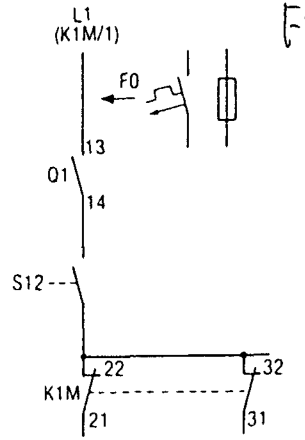


VWS 222-401, -402/CAD 22: MOTORAC 1412111

Three-Phase Automatic Stator Resistance Starters
with Main Contactor and Resistors, Style Two-Stage Three-Phase

Fig 5





Two-wire control

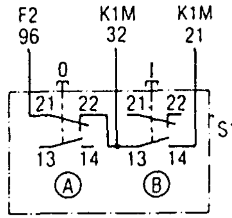
Overload relay should always be set to manual reset.

CAD 22:
MOTORAC 1412121

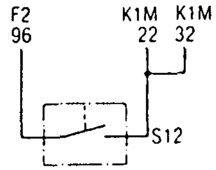
Three-wire control

Two-way push-button station

I = On
0 = Off



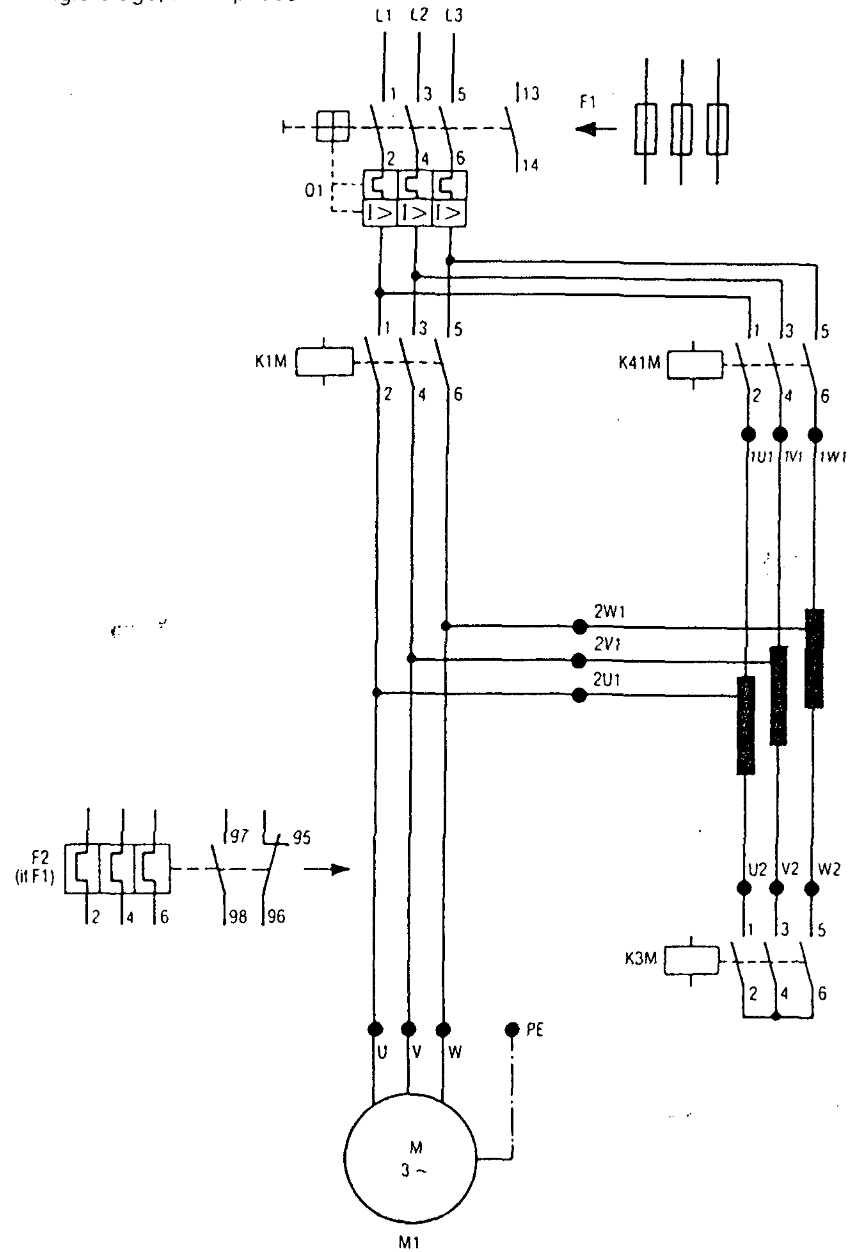
Two-wire control

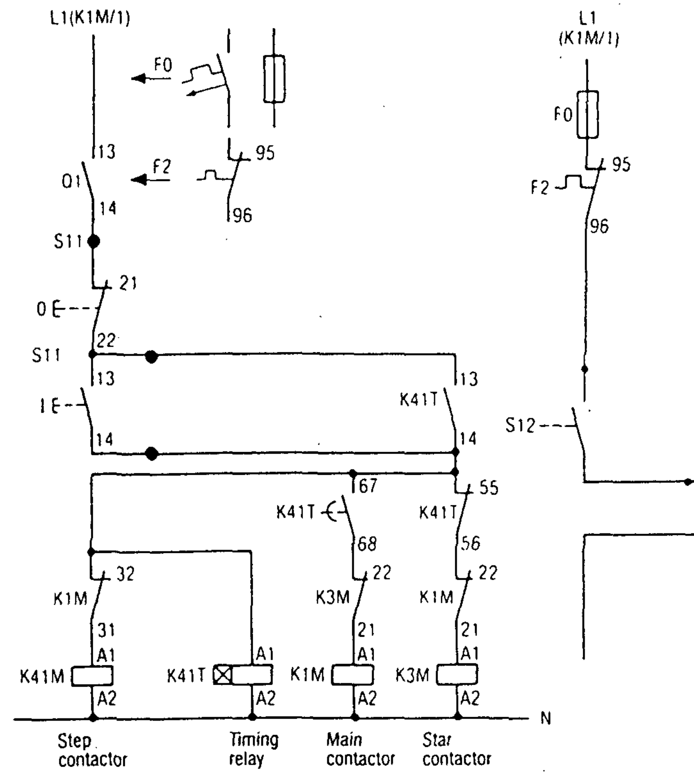


Mode of operation: push-button I energizes step contactor K41M and timing relay K41T. The circuit is maintained by make contact K41M/14-13 via K1M/32-31 and push-button 0. The motor is connected to the supply with resistor R1 + R2 in series. When the pre-set starting time has elapsed, make contact K41T/67-68 energizes step contactor K42M, which shorts out the resistor R1. At the same time, make contact K42M/14-13 energizes timing relay K42T. When the pre-set starting time has elapsed, K42T/67-68 energizes main contactor K1M, which shorts out the resistor R2, and the motor runs at rated speed. K1M is maintained via K1M/14-13. K41M, K42M, K41T and K42T are de-energized by the break contacts K1M/22-21 and K1M/32-31. The motor is switched off after pressing push-button 0, or in the event of an overload, by break contact 95-96 of the overload relay F2 or make contact 13-14 of the manual motor starter or circuit-breaker. Step contactor K42M, resistor R2 and timing relay K41T are omitted in single-stage starting circuits. Timing relay K42T is connected directly to K41M/13 and resistor R2 is connected via its terminals U1, V1 and W1 to K1M/2, 4, 6.

Three-Phase Autotransformer Starters

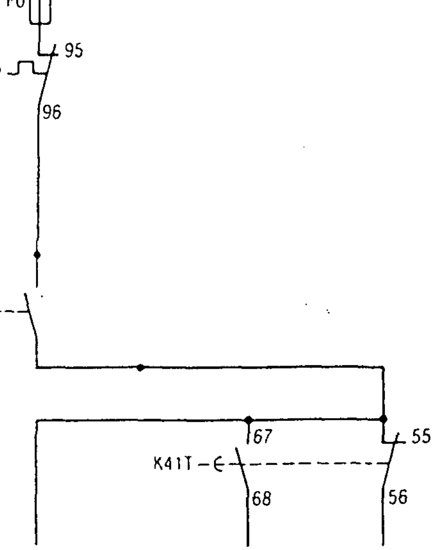
ATAINL three-phase autotransformer starter
with main contactor and starting transformer, single-stage, three-phase





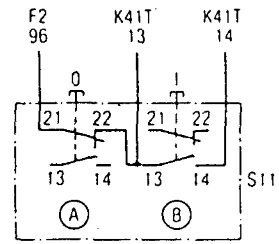
Two-wire control
Overload relay should always be set to *manual reset*.

Fig. 6

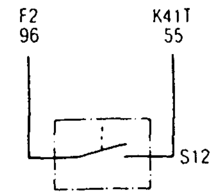


Three-wire control

I = On
0 = Off



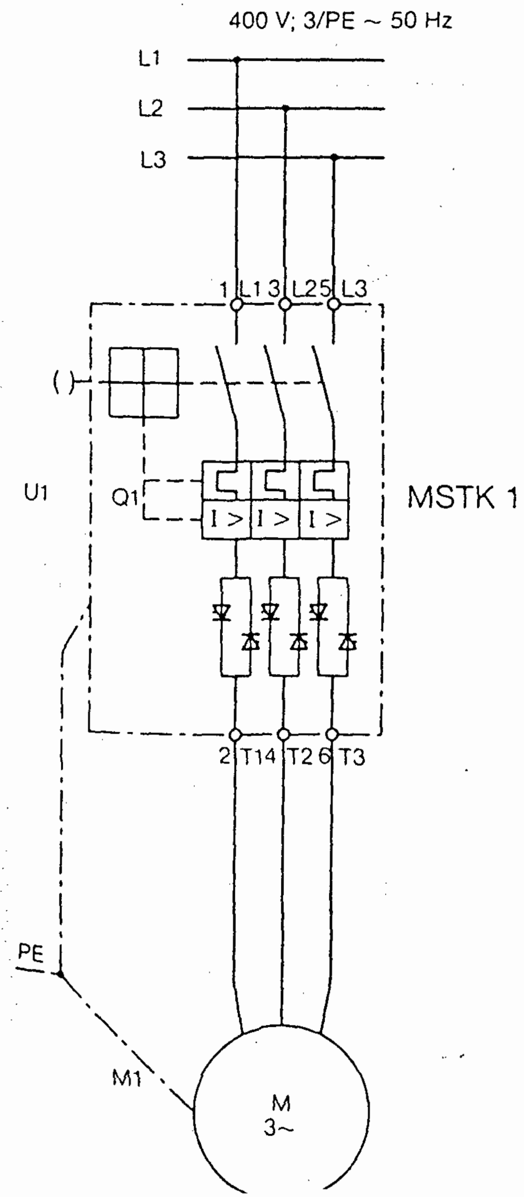
Two-wire control

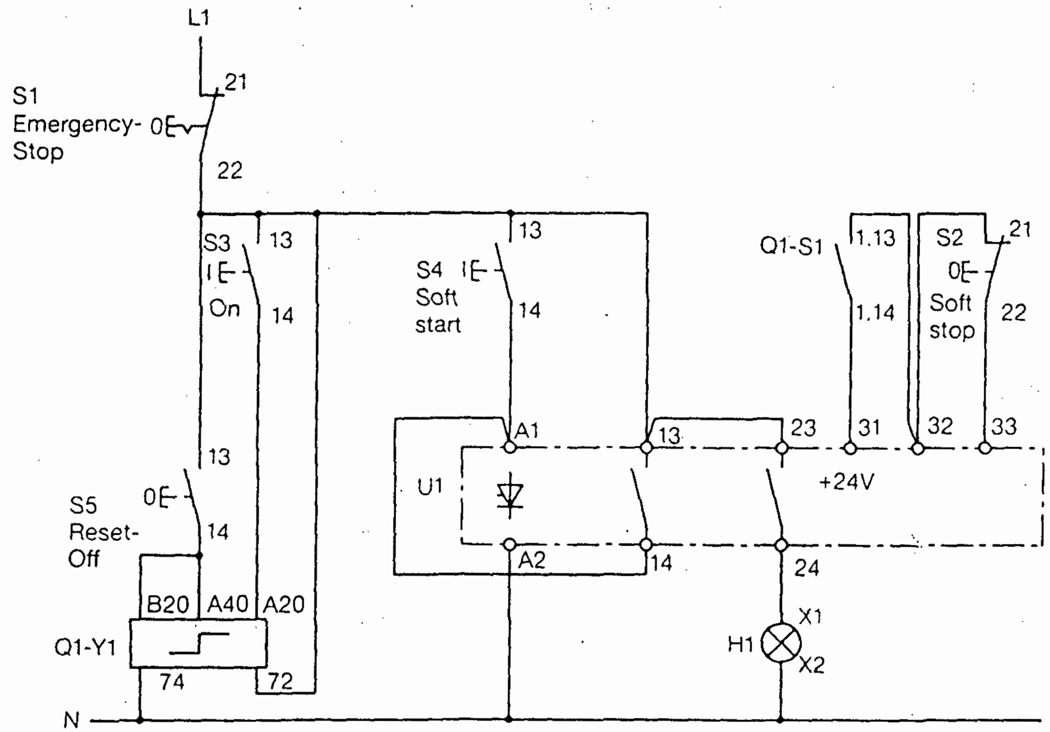


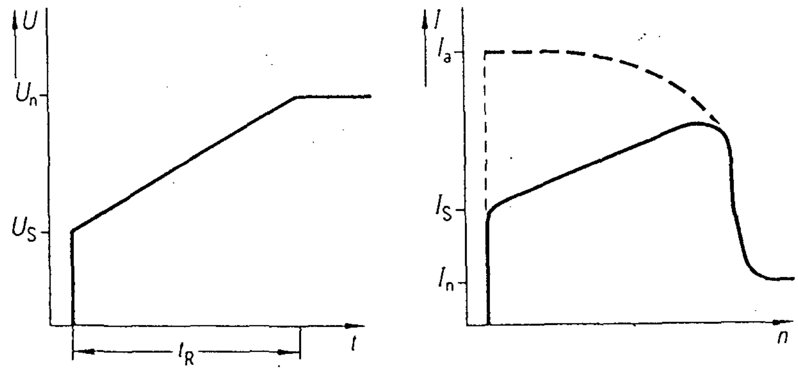
Mode of operation: push-button I energizes star contactor K3M, step contactor K41M and timing relay K41T simultaneously. The circuit is maintained via K41T/13-14. When K41T has elapsed, break contact K41T/55-56 de-energizes star contactor K3M and make contact K41T/67-68 energizes main contactor K1M. Break contact K1M/32-31 de-energizes K41M, thus disconnecting the starting transformer and the motor runs at rated speed.
Restarting is only possible if push-button 0 has been pressed, or in the event of an overload, if the motor has been switched off by break contact 95-96 of overload relay F2. With a two-wire control, overload relay F2 should always be set to manual reset, which will prevent any automatic restarting of the motor following disconnection via overload relay F2.

Softpact MSTK 1
Mains connection with remote operator and auxiliary contact module

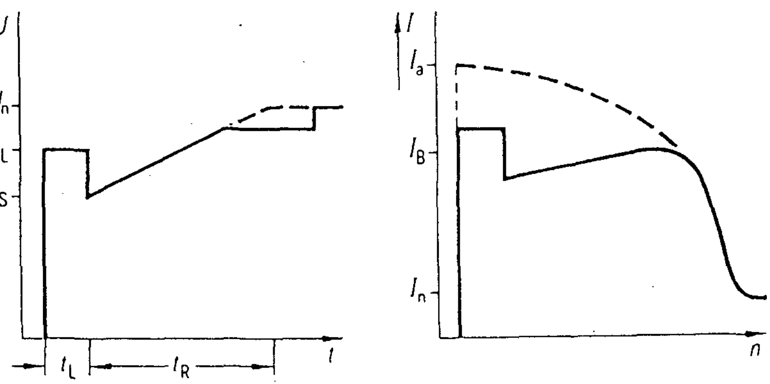
Fig. 7.



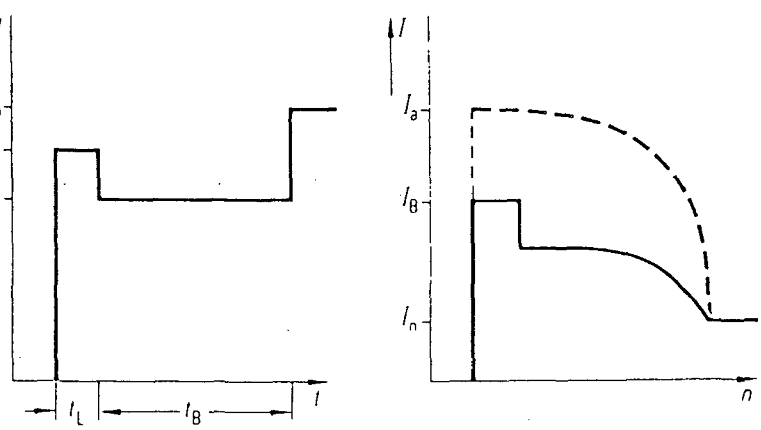




a) Soft start with a linear voltage ramp



b) Soft start by means of a start impulse followed by current limiting



c) Soft start by means of a start impulse followed by voltage limiting

Figure 8
Illustration of some of the starting parameters which may be used to obtain optimum load acceleration throughout the starting time

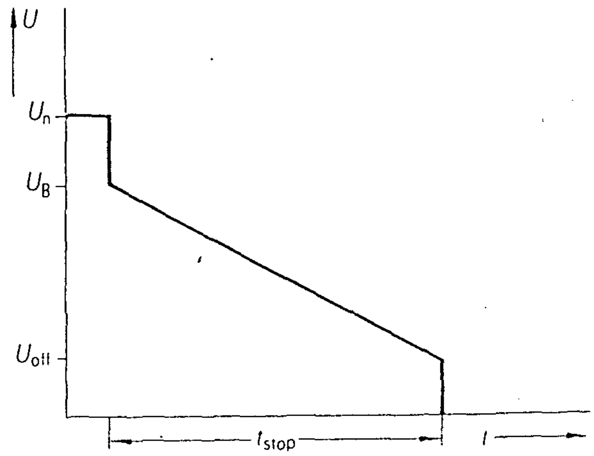


Figure 9.
Voltage behaviour during run-down with the soft-stop feature