Bosch Rexroth Frequency Converter

Multi-Pump Water Supply System

Application Instruction

R912006858
Edition 01

Application Background

Constant pressure water supply system (also called multi-pump application) offers huge potential for energy saving. Normally the user only needs 3 (or 4) small-size pumps running simultaneously to achieve full-load operation (In case of light load application, 1 or 2 pumps are sufficient). The multi-pump configuration, i.e. one large-size pump in combination with a multiple of small-size pumps works effectively to save the energy.

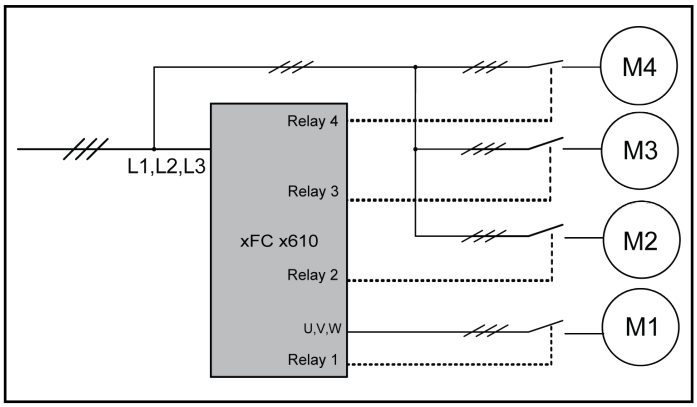
Multi-pump application is realized through 4 relays installed on the relay card of frequency converter.

Multi-pump application features the following functionalities,

- Direct start without shift
- Direct start with shift
- Soft start without shift
- Motor bypass protection

Function Introduction

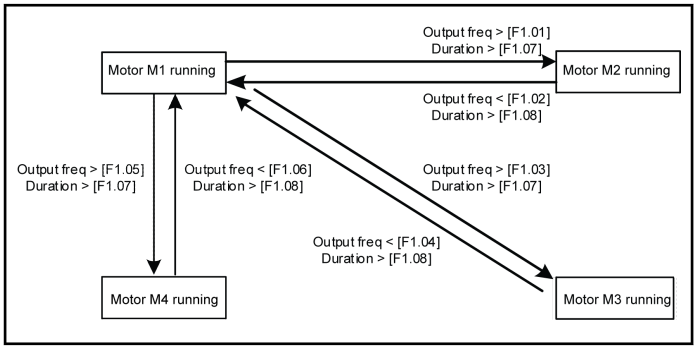
Direct Start without Shift



System wiring 1

As shown in the diagram above, the system consists of 4 motors, i.e. M1...M4. M1 is the main motor to be connected with the converter output. The other 3 motors, , M2, M3, M4 are auxiliary motors to be connected to the grid via a switch. The diagram below illustrates the operatiing process of the system.

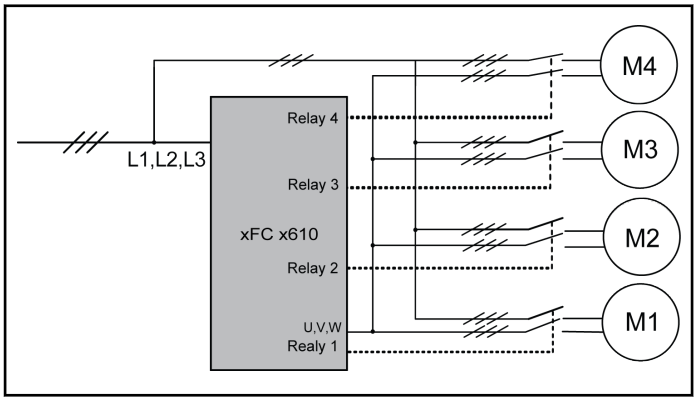
1. In the state of initialization, the main motor will operate under ‘PID sleep / wake’ mode according to the water pressure variation.
2. The auxiliary motors, M2, M3, M4 will start / stop according to their own threshold and time delay.



Running status

Direct Start with Shift

Set F1.00 to ‘2’: When ‘direct start with shift’ mode is activated, any one motor from M1 to M4 will be driven by frequency converter and the rest of the motors will run in the mode of ‘Direct start without shift’.



System wiring 2

In the state of initialization, when M1 starts running after being driven by frequency converter with the output fre-

quency lower than [F1.12] and with the time exceeding [F1.13], the following procedures will be followed:

1. M1 will freewheel to stop.
2. Disconnect M1 from frequency converter.
3. Determine the next ready-on motor according to motor bypass protection feedback. (The selected motor must be in idle state.)
4. Close the switch that connects between the frequency converter and ready-on motor.
5. Wait for [F1.09], and start the ready-on motor.
6. The shift function will stop working, when no more motors are available to be used as next running motor (due to bypass).

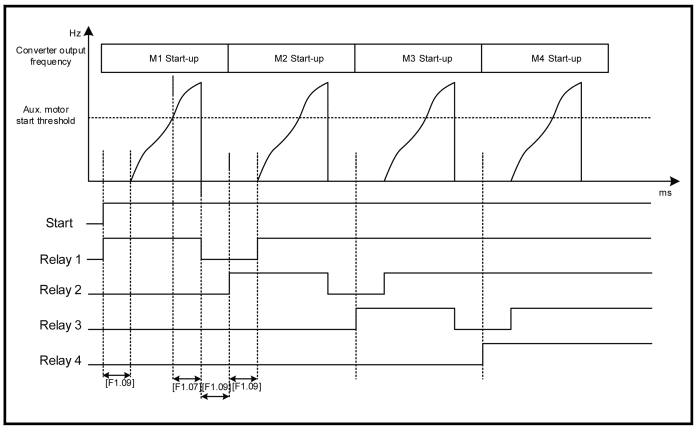
The current shift status will be recorded in the frequency converter which will perform the shift function as per last saved status at next power-on.

Soft Start without Shift

The wiring of the soft start without shift will be arranged in the same manner as that of direct start with shift.
The operation of soft start without shift will encounter the following three scenarios in terms of motor soft start, motor stop and soft start restore.

	Soft start order	Motor stop order	Soft start recovery order
Scenario 1	M1 -> M2	M1	M1 -> M3 -> M4
Scenario 2	M1 -> M2 -> M3	M1 -> M2	M1 -> M2 -> M4
Scenario 3	M1 -> M2 -> M3 -> M4	M1 -> M2 -> M3	M1 -> M2 -> M3

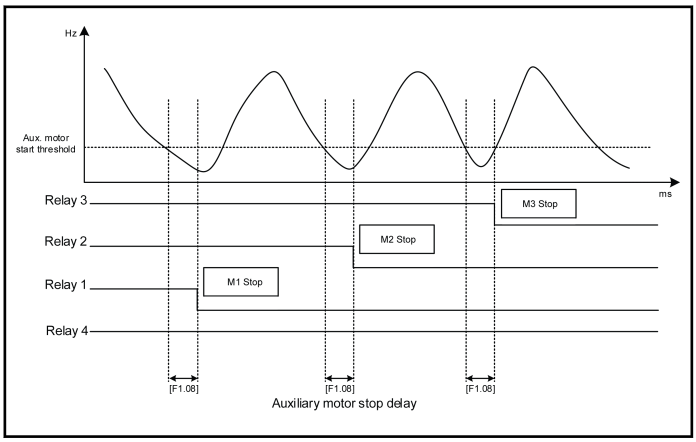
Take scenario 1 for example, M1 will start to work first, and when the water pressure runs low, M2 will get started to retrieve the pressure back to a constant level. However, if the pressure runs up too high, M1 will stop working. If after a period of running to have insufficient pressure again, soft start will re-activate with motors to be started in a sequence of M1 -> M3 -> M4. Similar working procedures will apply for Scenario 2 and 3.



Start-up logic

Notes about the startup of M1 and M2:

1. Close Relay 1 first and then the switch that connects between M1 and converter output will close off.
2. The converter first waits for [F1.09] and then starts to run.
3. If the output frequency of the converter exceeds [F1.01] with the time running beyond [F1.07], M1 will freewheel to stop and Relay 1 will disconnect, so will M1 disconnect from the converter.
4. First wait for [F1.09] and then Relay 2 will close off. The converter output will connect to M2 through external control circuit.
5. Again wait for [F1.09] and the converter will start M2. In parallel, Relay 1 will close and M1 will be driven directly by grid voltage.



Stop logic

The graph above illustrates the stop process. (M4 will be driven by converter and the rest of the motors will be connected to the grid):
If the output frequency of the converter is lower than [F1.02], M1 will stop.

If the output frequency of the converter is lower than [F1.04], M2 will stop.
If the output frequency of the converter is lower than [F1.06], M3 will stop.

Motor Bypass Protection

When the motor bypass protection is active, the motor status can be read by converter via digital input X1...X5 and EX1...EX4.
When the auxiliary motor is bypassed, the control logic will automatically bypass this motor with warning message: “APFx” (motor bypass).
When the main motor is bypassed, the converter will stop the output and the motor will stop running with error code “APEx” (Main motor bypass error).

Hardware Requirement

1. The extension module shall be provided with 4 relays with NO and NC.
2. The converter must be fitted with extension module.
3. The extension card does not support hot plug.
4. Extension module can be identified by the converter automatically.
5. The function of the relays on optional module shall be configurable via the parameters.

Parameter and Code

Parameter List

Code	Name	Setting range	Default	Attri.
F1.00	Auxiliary motor control mode	0: Inactive 1: Direct start without shift 2: Direct start with shift 3: Soft start without shift	0	Stop
F1.01	Auxiliary motor 1 start threshold	0.00...[E0.09] Hz	40.00	Run
F1.02	Auxiliary motor 1 stop threshold	0.00...[F1.01] Hz	20.00	Run
F1.03	Auxiliary motor 2 start threshold	0.00...[E0.09] Hz	45.00	Run
F1.04	Auxiliary motor 2 stop threshold	0.00...[F1.03] Hz	15.00	Run
F1.05	Auxiliary motor 3 start threshold	0.00...[E0.09] Hz	50.00	Run
F1.06	Auxiliary motor 3 stop threshold	0.00...[F1.05] Hz	10.00	Run
F1.07	Auxiliary motor start delay	0.0...3,600.0 s	2.0	Run
F1.08	Auxiliary motor stop delay	0.0...3,600.0 s	2.0	Run
F1.09	Main motor start delay	0.1...10.0 s	0.5	Run
F1.12	Automatic motor shift threshold	0.0...100.0%	50.0	Run
F1.13	Automatic motor shift interval	0.5...100 h	5.0	Stop
F1.23	Shift status	0: Inactive 1: Motor 1 2: Motor 1 3: Motor 3 4: Motor 4	0	Read
F1.24	Application activation	0: Inactive 1: Active	1	Stop

Basic parameters

Code	Name	Setting range	Default	Attri.
F2.00	X1 application function	0: Inactive 1: Motor 1 bypass 2: Motor 2 bypass 3: Motor 3 bypass 4: Motor 4 bypass	0	Stop
F2.01	X2 application function		0	Stop
F2.02	X3 application function		0	Stop
F2.03	X4 application function		0	Stop
F2.04	X5 application function		0	Stop
F2.05	EX1 application function		0	Stop
F2.06	EX2 application function		0	Stop
F2.07	EX3 application function		0	Stop
F2.08	EX4 application function		0	Stop

Input terminal parameters

Code	Name	Setting range	Default	Attri.
F3.00	Relay 1 output selection	0: Inactive 1: Motor control 1 2: Motor control 2 3: Motor control 3 4: Motor control 4	0	Stop
F3.01	Relay 2 output selection		0	Stop
F3.02	Relay 3 output selection		0	Stop
F3.03	Relay 4 output selection		0	Stop

Output terminal parameters

- If motor bypass functions are used, it's recommended to deactivate the terminal functions correspondingly on the standard converter, i.e. E1.00...E1.04, H8.00...H8.03 are set to '0', while the corresponding terminals F2.00...F2.08 are set to anything than '0'.
- It's suggested the following rules shall be obeyed for setting the start / stop threshold of auxiliary motor.
  F1.01 <= F1.03 <= F1.05
  F1.02 >= F1.04 >= F1.06
- The error type will be defined by parameter E9.05...E9.07.
- When F1.24 is set to '1' by default, the multi-pump application function will be active. Whereas when F1.24 is set to '0', the multi-pump application function will be inactive. The converter can be applied only with standard firmware functions.
- When F1.00 = 1, M1 will be the main motor while the other motors, M2, M3, M4 will be auxiliary motor 1...3 sequentially.
- When F1.00 = 2 and when M1 is the main motor, M2, M3 and M4 will be auxiliary motor 1...3 sequentially;
  When M2 is the main motor, M3, M4 and M1 will be auxiliary motor 1...3 sequentially;
  When M3 is the main motor, M4, M1 and M2 will be auxiliary motor 1...3 sequentially;
  When M4 is the main motor, M1, M2 and M3 will be auxiliary motor 1...3 sequentially.
- When F1.00 = 3 and when M1 is the main motor, M2, M3 and M4 will be auxiliary motor 1...3 sequentially;
  When M2 is the main motor, M1, M3 and M4 will be auxiliary motor 1...3 sequentially;
  When M3 is the main motor, M1, M2 and M4 will be auxiliary motor 1...3 sequentially;
  When M4 is the main motor, M1, M2 and M3 will be auxiliary motor 1...3 sequentially.

Error Code

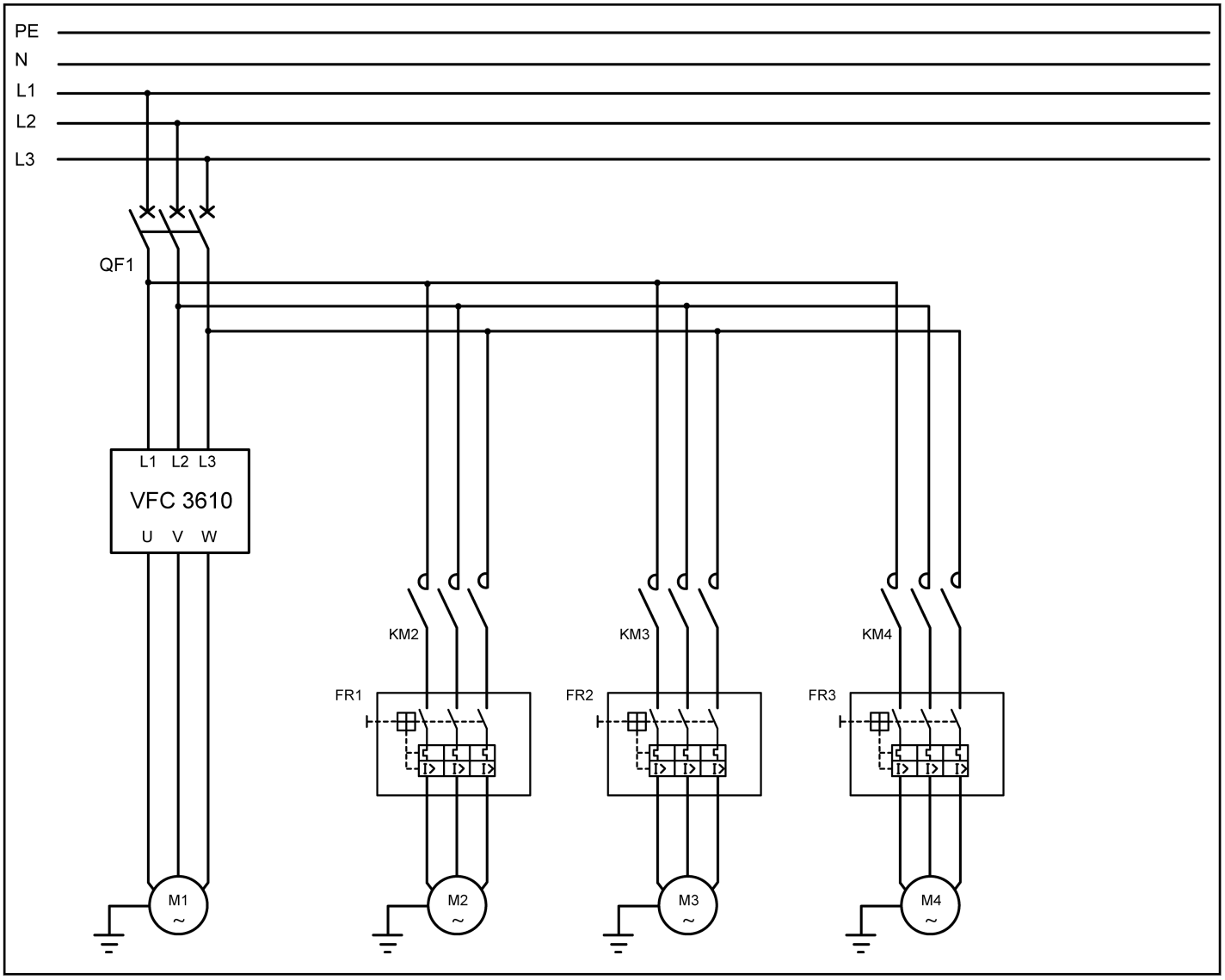
Nr.	Code	Name	Description
60	ASF-	Application firmware error	Firmware version mismatch, etc
61	APE1	Application error 1	Motor 1 error
62	APE2	Application error 2	Motor 2 error
63	APE3	Application error 3	Motor 3 error
64	APE4	Application error 4	Motor 4 error

Warning Code

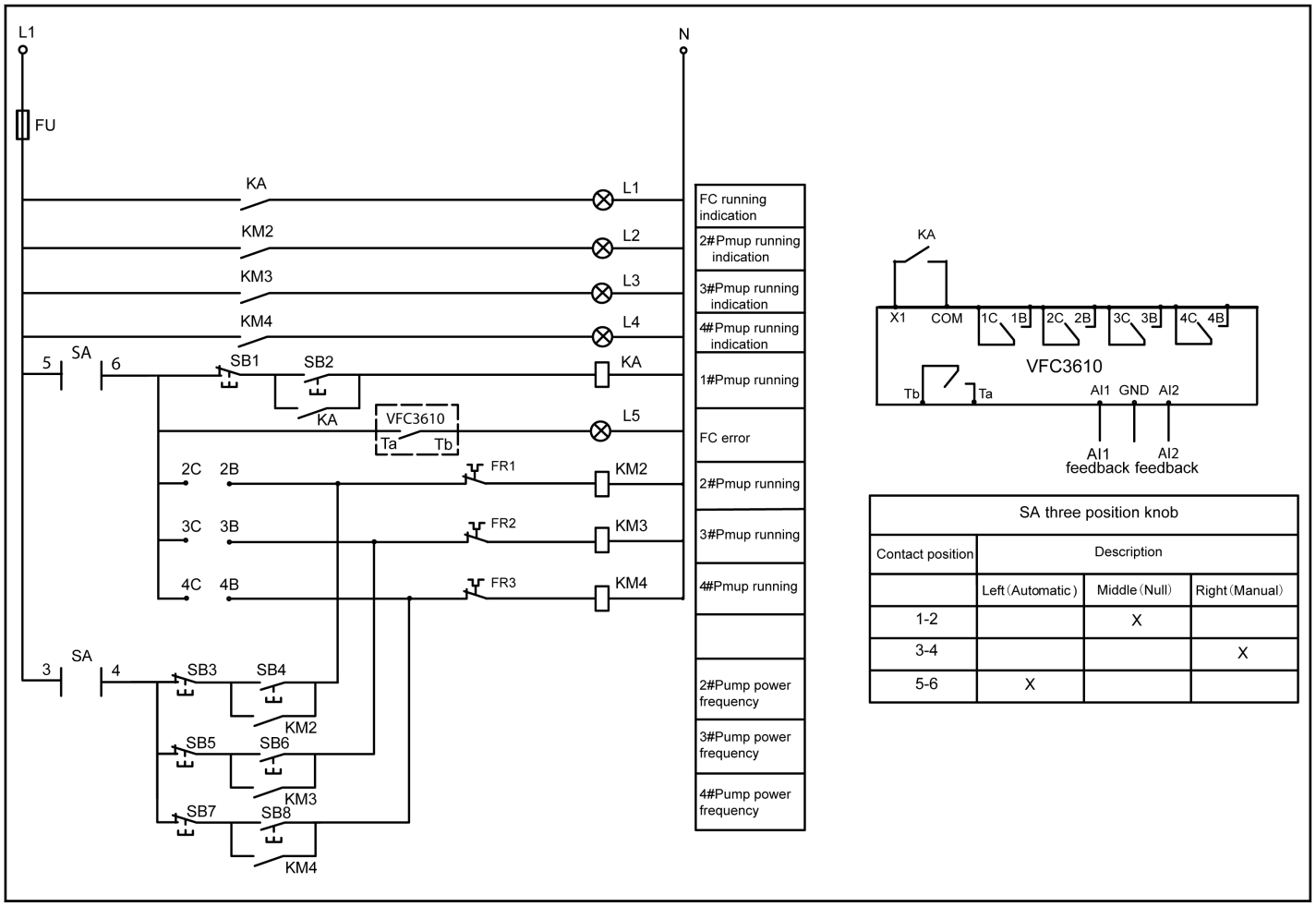
Code	Description
APF1	Motor 1 bypass warning
APF2	Motor 2 bypass warning
APF3	Motor 3 bypass warning
APF4	Motor 4 bypass warning

Application Example

Example 1: Direct Start without Shift (F1.00 = 1)



Main circuit



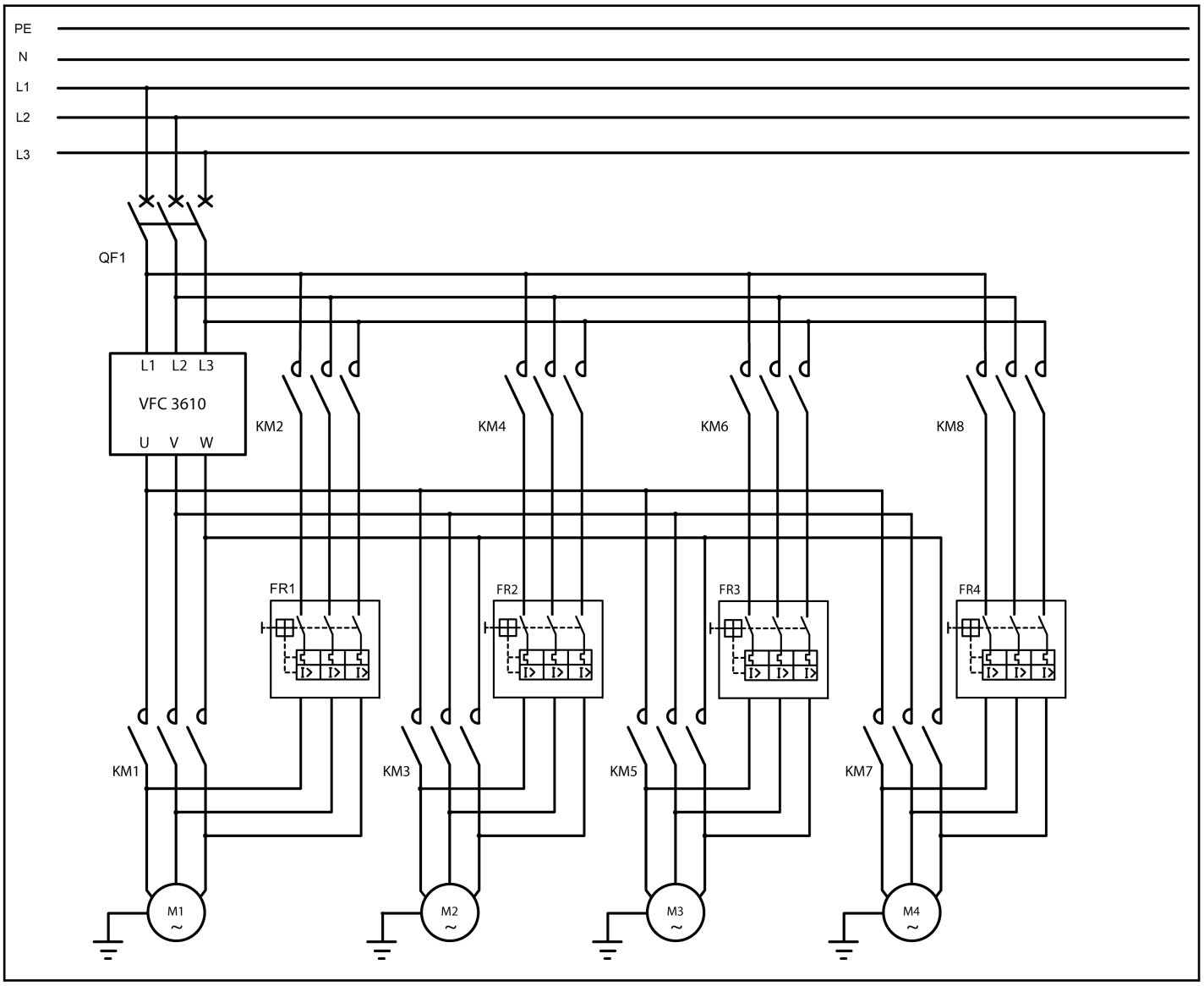
SA three position knob			
Contact position	Description		
	Left (Automatic)	Middle (Null)	Right (Manual)
1-2		X	
3-4			X
5-6	X		

Control circuit

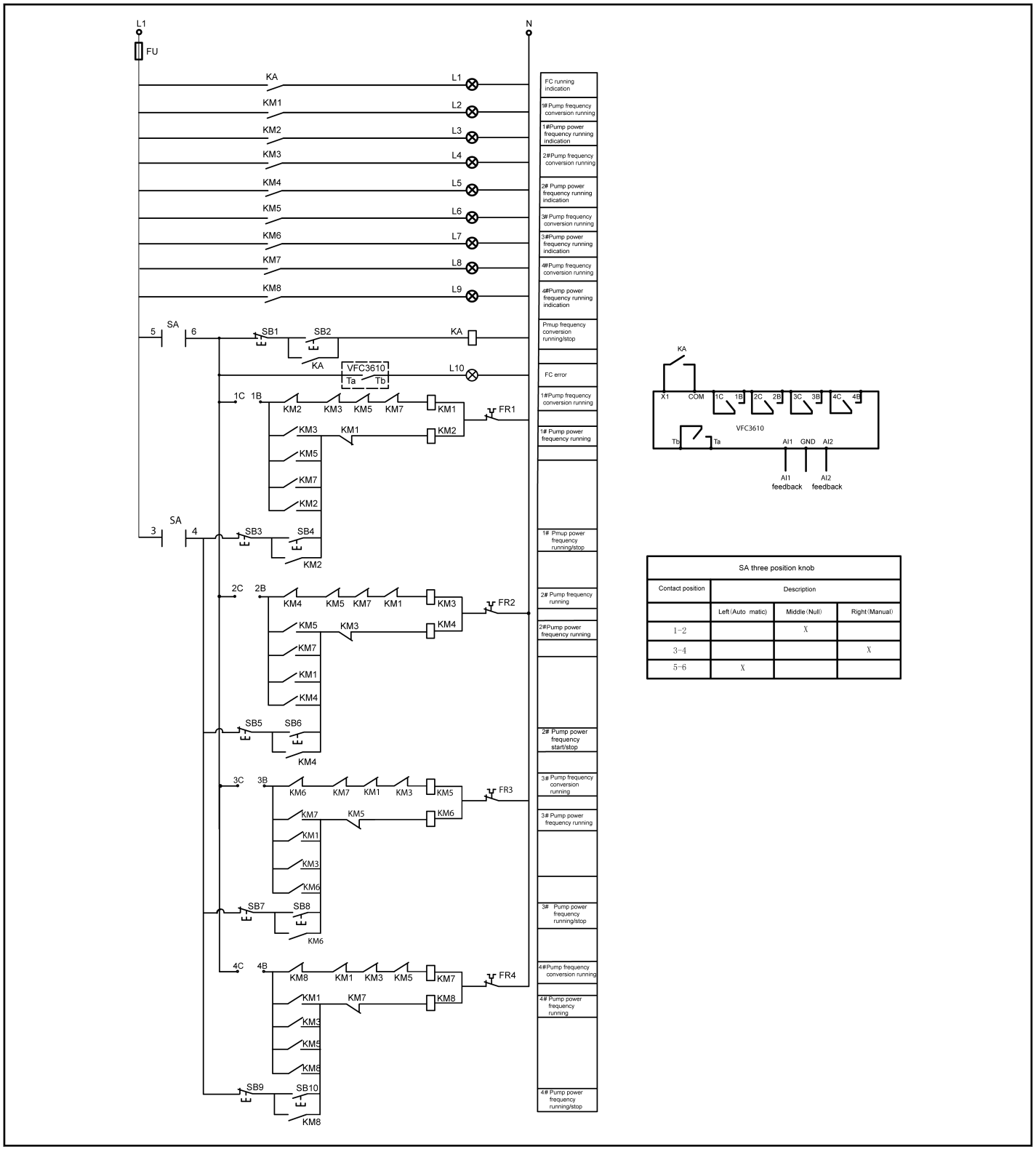
E0.07 = 25	E5.07 = 30	F1.00 = 1
E4.00 = 2	E5.08 = 50	F1.01 = 45
E4.01 = 0	E5.09 = 0.0	F1.02 = 35
E4.05 = 0	E5.10 = 60	F1.03 = 48
E4.15 = 1.5	E5.15 = 25	F1.04 = 30
E4.16 = 1.5	E5.16 = 60	F1.05 = 50
E4.17 = 0	E5.17 = 2	F1.06 = 25
E4.18 = 0.5	E5.18 = 5	F1.07 = 2.0
E5.05 = 30	E5.19 = 90	F1.08 = 2.0
E5.06 = 0.0	E5.20 = 0.5	F1.09 = 0.5

Recommended parameter setting

Example 2: Direct Start with Shift (F1.00 = 2)



Main circuit



SA three position knob			
Contact position	Description		
	Left (Auto matic)	Middle (Null)	Right (Manual)
1–2		X	
3–4			X
5–6	X		

Control circuit

E0.07 = 25	E5.08 = 50	F1.02 = 35
E4.00 = 2	E5.09 = 0.0	F1.03 = 48
E4.01 = 0	E5.10 = 60	F1.04 = 30
E4.05 = 0	E5.15 = 25	F1.05 = 50
E4.15 = 1.5	E5.16 = 60	F1.06 = 25
E4.16 = 1.5	E5.17 = 2	F1.07 = 2.0
E4.17 = 0	E5.18 = 5	F1.08 = 2.0
E4.18 = 0.5	E5.19 = 90	F1.09 = 0.5
E5.05 = 30	E5.20 = 0.5	F1.12 = 60
E5.06 = 0.0	F1.00 = 1	F1.13 = 5.0
E5.07 = 30	F1.01 = 45	

Recommended parameter setting

Example 3: Soft Start without Shift (F1.00 = 3)
The wiring arrangement of main and control circuit resembles that for example 2.

The parameters setting resemble that for example 1.

Note: The power frequency startup have been applied in the control methods recommended above. Therefore please carefully check on grid capacity and component selection in actual application.

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