MEC 108

Coursework 2

Student ID: 1931254
Full name: Zhongnan Li
Email address: Zhongnan.li19@student.xjtlu.edu.cn

Solution:

Problem A

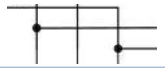
1. Working principle:

① For the power circuit, the 3-phase power supply with $V_L = 575V$ and basic frequency = 60Hz is the input power. The input power goes through AC contactor and AC reactor, into the Variable Voltage Variable Frequency Drive (VVVF). After some operations in VVVF, the output goes out from VVVF with another frequency level and supplies the motor.

② For the control circuit, when QS closes, the main power supply is connected. Then press SB2, KM is energized with all its contacts closed, the system is ready to start.

Speed control: Press SB3, SB4, SB5, energizing KA1, KA2, KA3, to obtain 3 variable speeds.

Stop: Press ST, KA1, KA2, KA3 are deenergized, motor stop, SB1 unlock. Then press SB1 to cut off power supply

Fault control: (There is a small mistake in the circuit. We move the  to the place between QS and KM)

When a fault is detected, KM open, TB open, TC close, the power supply is cut off and fault indicator light is on. When the fault is fixed, press SB6 to reset the system.

2. Aspects considered:

(1) Power supply and power line voltage: 3-phase input power with 100 kW rated power and 575 V rated voltage

(2) Control circuit: The proposed voltage level is 110 V, Since the voltage on control circuit is related to the rated voltage of the coil of the electrol magnetic control components such as control relays.

(3) Load of the electrical control system:

Number of phases: 3 ; Rated voltage: 575 V

Rated power: 100 kW ; Number of poles: 4 ;

Connection type: Y.

(4) Protection mechanisms:

① Overload relay FR, shuts down the system when the circuit is overload.

② Circuit breaker QS, shuts down the power supply when errors occur.

③ Fuses FU1, stops the electricity when there is too much power, surving as a shot circuit protection.

④ Under voltage protection, prevents the situation where the power supply is not enough for the control circuit, as a result of the current being not enough to pull the magnetic plunger.

3. Components in the circuit :

No.	Code	Name	Function	Quantity
1	QS	Circuit Breaker	control power supply	1
2	KM	AC Contactor	power on contactor	1
3	KA, KA1, KA2, KA3,	Control Relay	speed control	4
4	AL	AC Reactor	limit high harmonic	1
5	T1	Transformer	transform voltage	1
6	L21, L22, L23	Zero-phase Reactor	Suppress external interference	3
7	FU1	Fuse	protect circuit	3
8	SB1, SB2, SB3, SB4	Switch	switch power and speed	4
9	ST	Stop Switch	switch power off	1
10	M1	Induction Motor	make fan move	1
11	FR	Overload Relay	protect circuit	1
12	HL1, HL2, HL3	Indicator Light	indicate the state of speed	3
13	HA	Fault Alarm	ensure the circuit work properly	1
14	SB5	Reset Switch	reset the circuit	1

Problem B

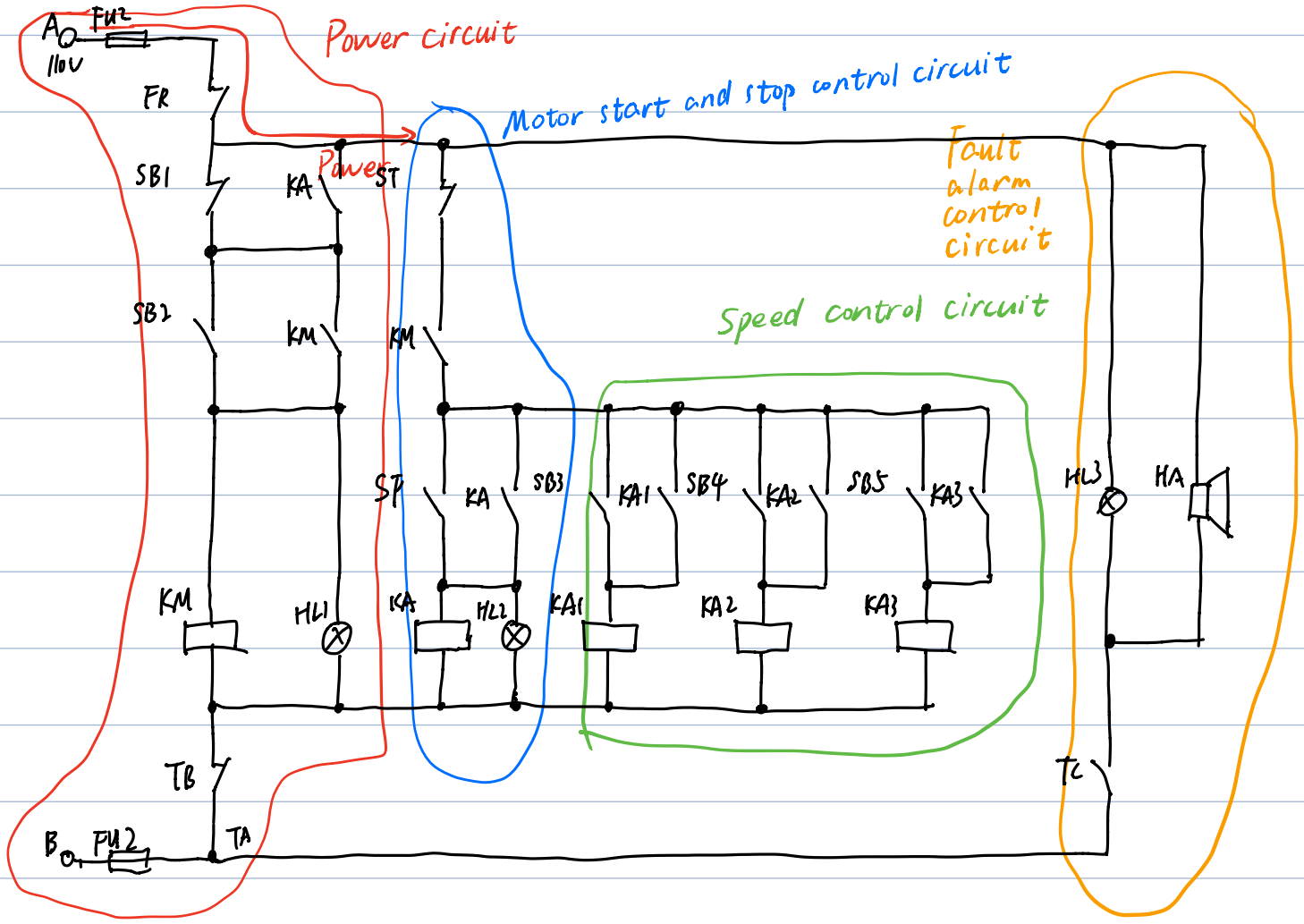
1. The purpose of using a PLC based control:

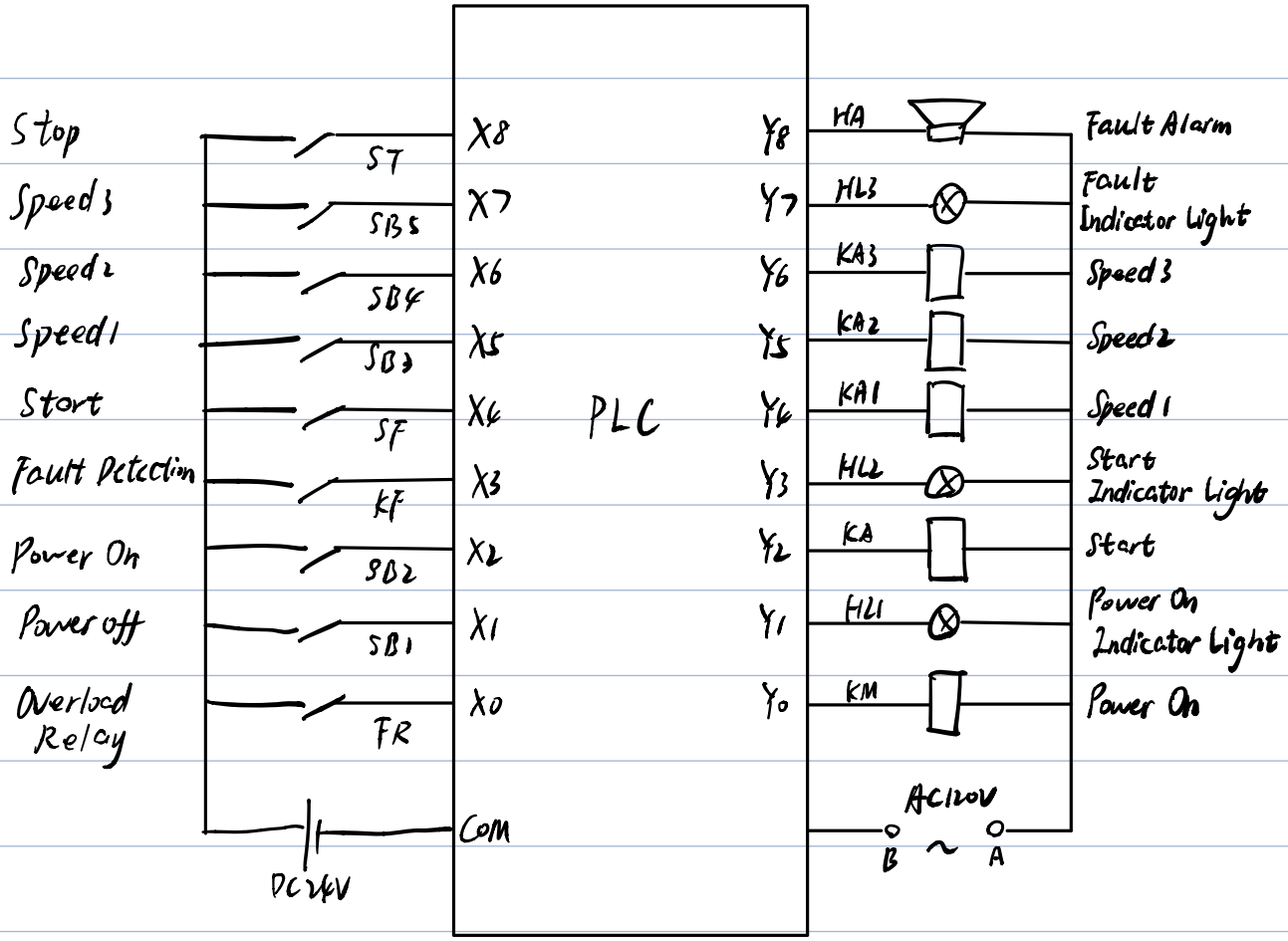
   ① To eliminate a lot of physical contact

   ② To reduce failure rate caused by physical components

   ③ To make the circuit easy to modify

2. PLC based Electrial Control Circuit Schematic Diagram

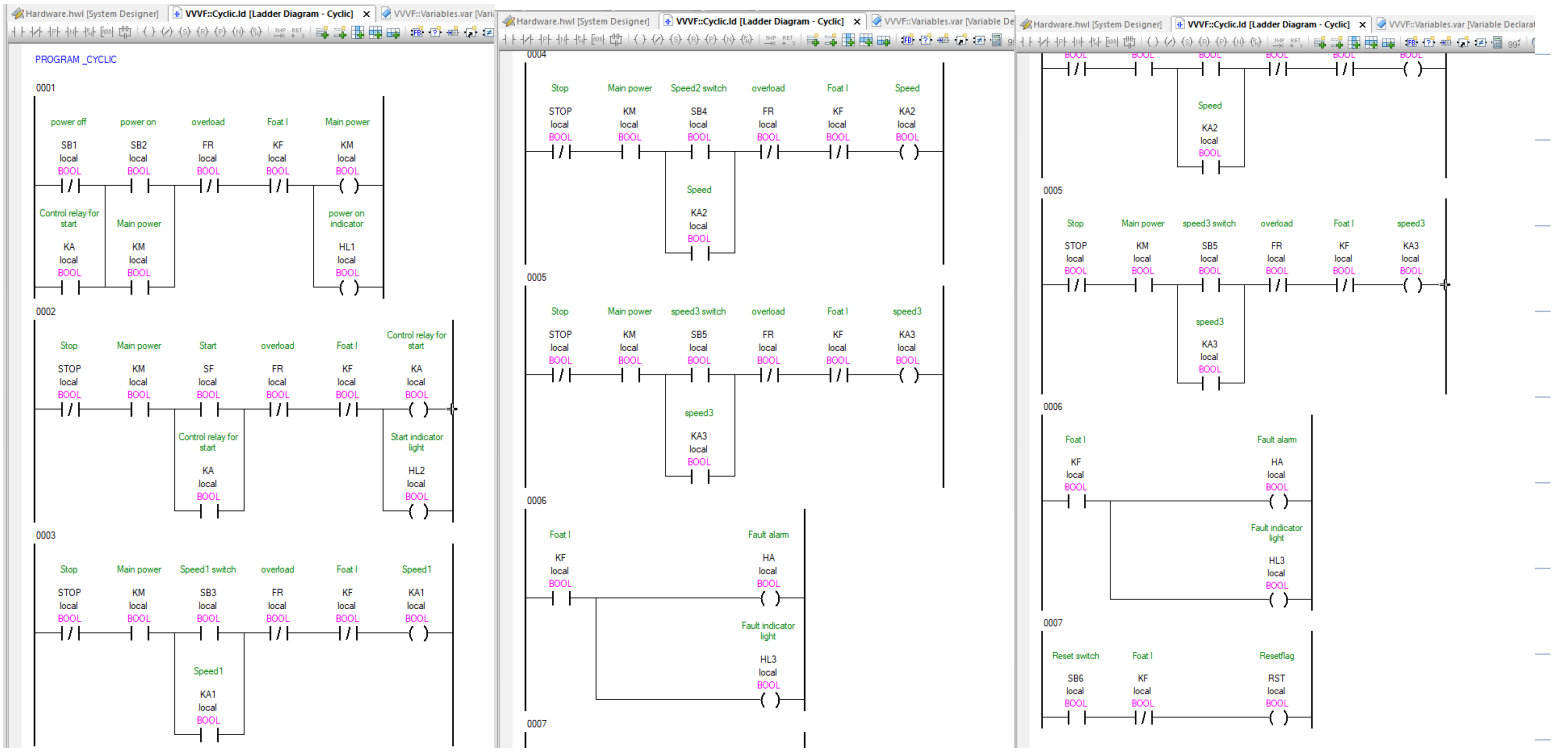



Stop
Speed 3
Speed 2
Speed 1
Start
Fault Detection
Power On
Power off
Overload Relay
ST
SB5
SB4
SB3
SF
KF
SB2
SB1
FR
DC24V
X8
X7
X6
X5
X4
X3
X2
X1
X0
COM
PLC
Y8
Y7
Y6
Y5
Y4
Y3
Y2
Y1
Y0
HA
HL3
KA3
KA2
KA1
HL2
KA
HL1
KM
AC120V
B
A
Fault Alarm
Fault Indicator Light
Speed 3
Speed 2
Speed 1
Start Indicator Light
Start
Power On Indicator Light
Power On

3. I/O allocation for the PLC:

I/O Type	Component	I/O Index	Comments
Inputs	FR	X0	Overload relay contact
	SB1	X1	Power off
	SB2	X2	Power on
	KF	X3	Fault detection
	SF	X4	Start
	SB3	X5	Acceleration
	SB4	X6	Deceleration
	ST	X7	Stop
	SB5	X8	Reset
Outouts	FWD	Y0	Start the motor to operate in forward
	X1	Y1	Signal acceleration
	X2	Y2	Signal deceleration
	RST	Y3	Reset the VVVF after fault clear
	KM	Y4	Power on the VVVF
	HL1	Y5	Power on indicator light
	HL2	Y6	Start indicator light
	HL3	Y7	Fault indicator light
	HA	Y8	Fault alarm
	KA	Y9	Control relay, soft

4. The LAD program



5. The working procedure of the LAD programme.

First, the LAD programme of the control circuit is shown as figure 1. All the switches are open, the system is not powered.

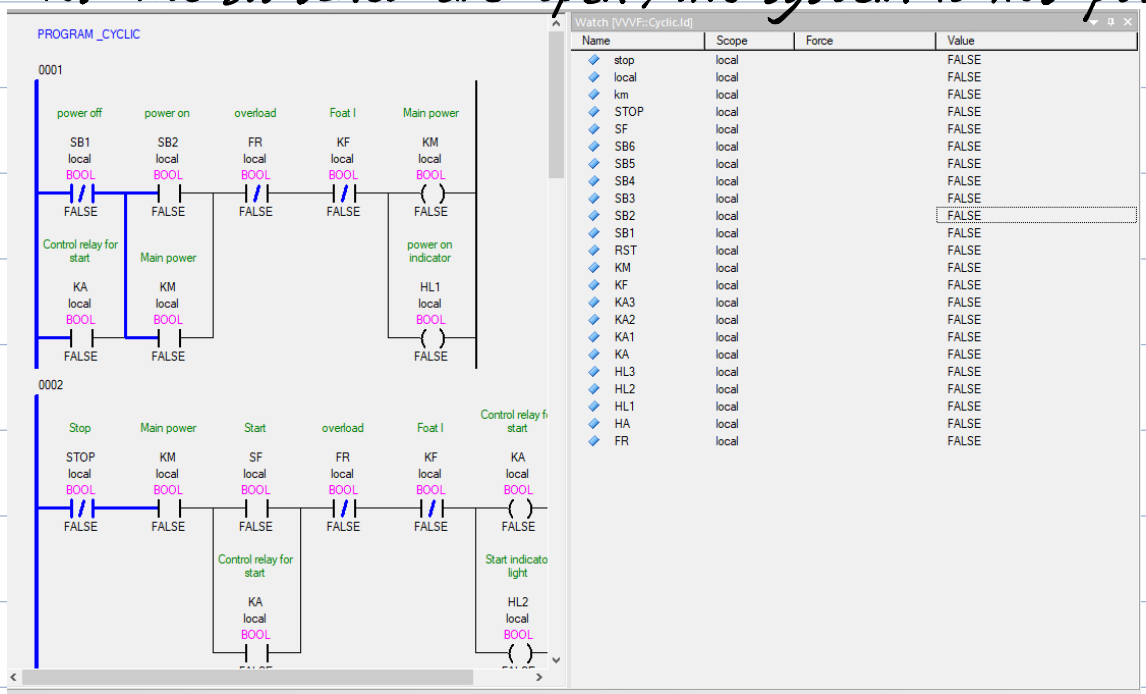


Fig. 1

① To connect the main power supply, set SB2 (power on switch) as TRUE as shown in figure 2. Main power KM is self-locked.

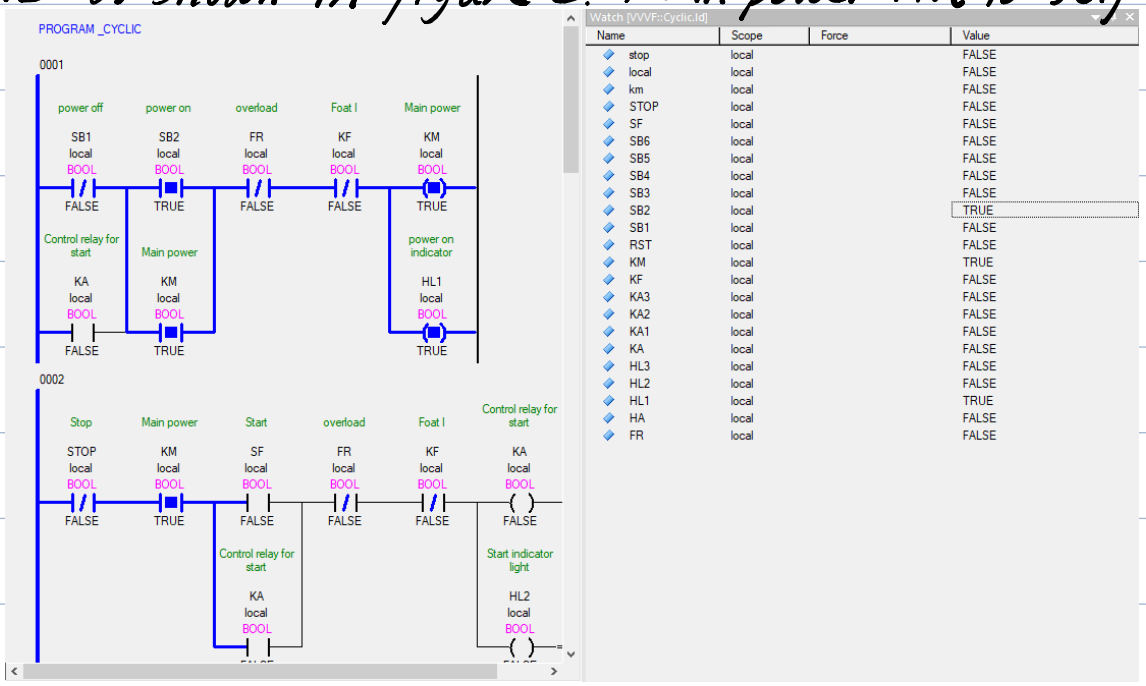


Fig. 2

② Set SF (start switch) as TRUE to start the system as shown in figure 3 and figure 4. The system is ready to start.

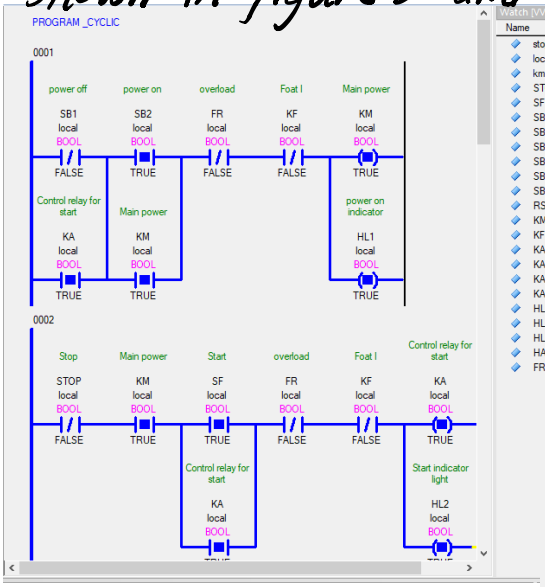


Fig. 3

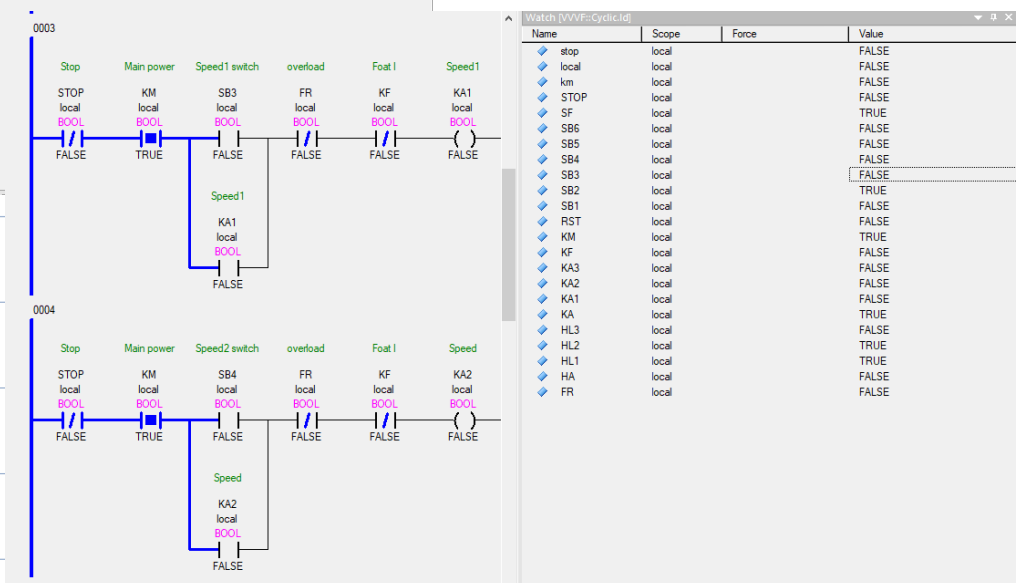


Fig. 4

③ Set SB3 (Speed1 switch) as TRUE to obtain speed1;

Set SB4 (Speed switch) as TRUE to obtain speed2;

Set SB5 (Speed switch) as TRUE to obtain speed3;

All these three variable speed are shown in figures 5, 6, 7.

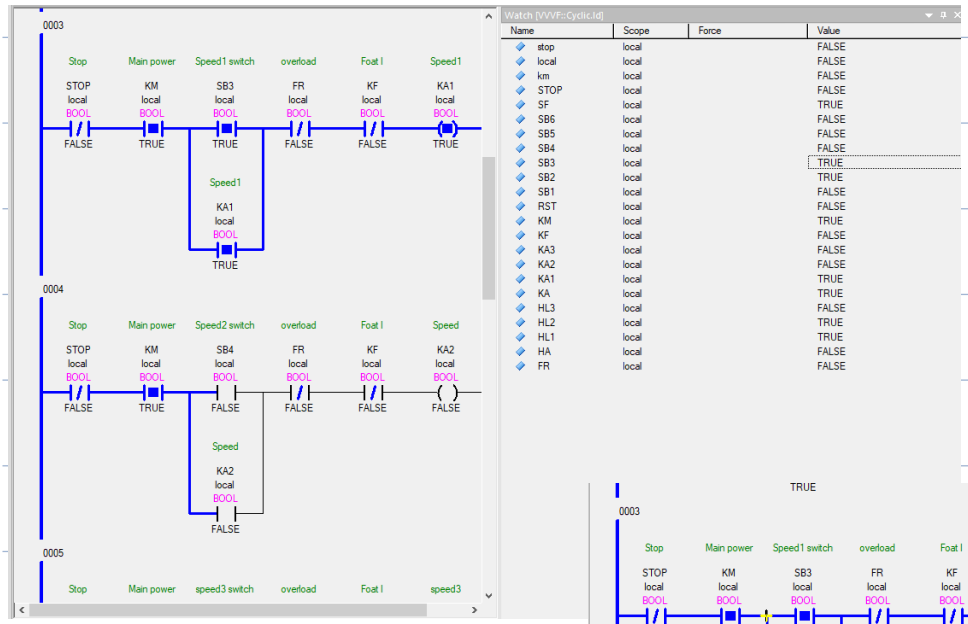


Fig. 5

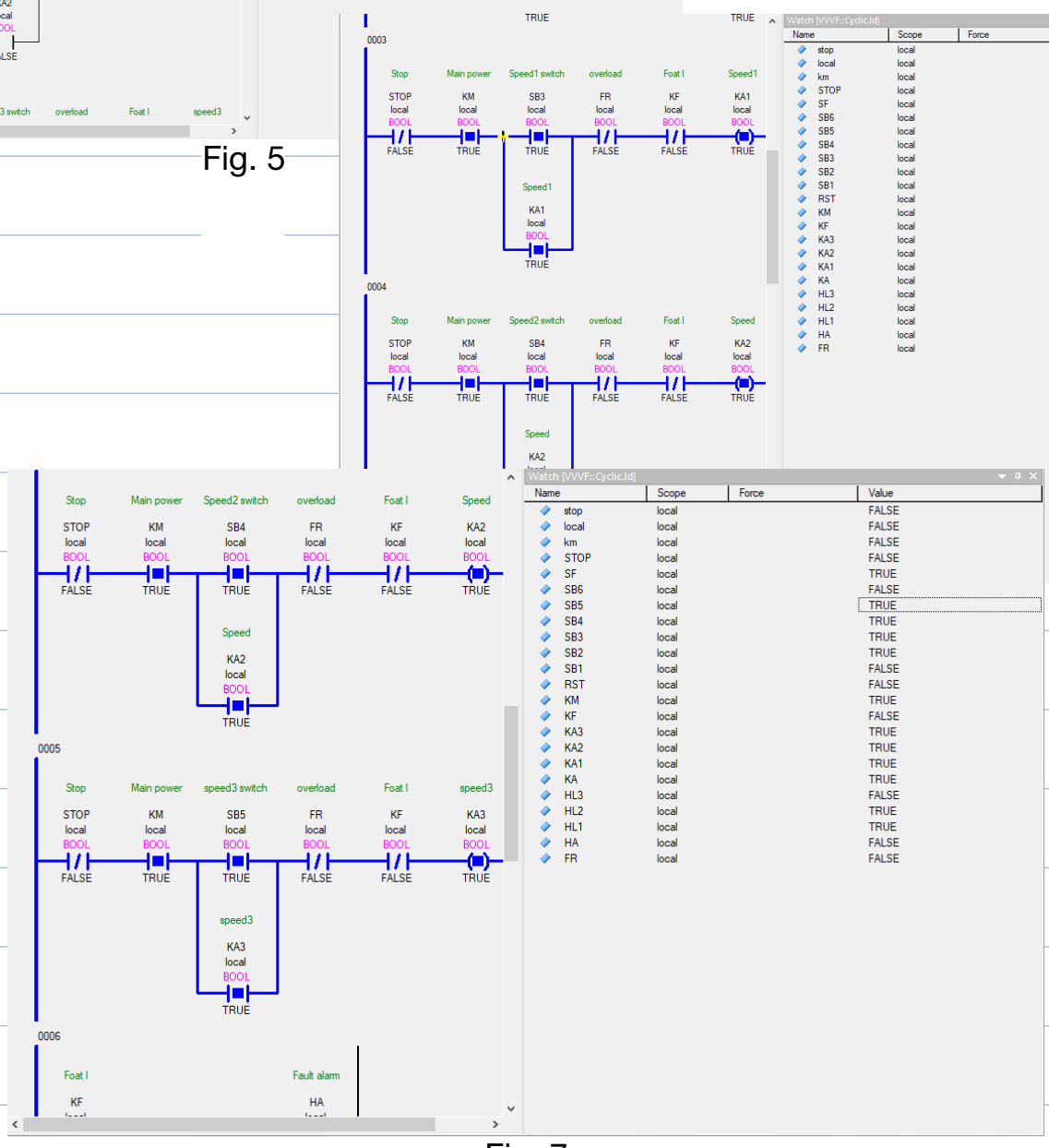


Fig. 7

④ To stop the system, first set STOP as TRUE, and the set SB1 (power off switch) as TRUE as shown in figure 8. The motor stops first and power supply is cut off.

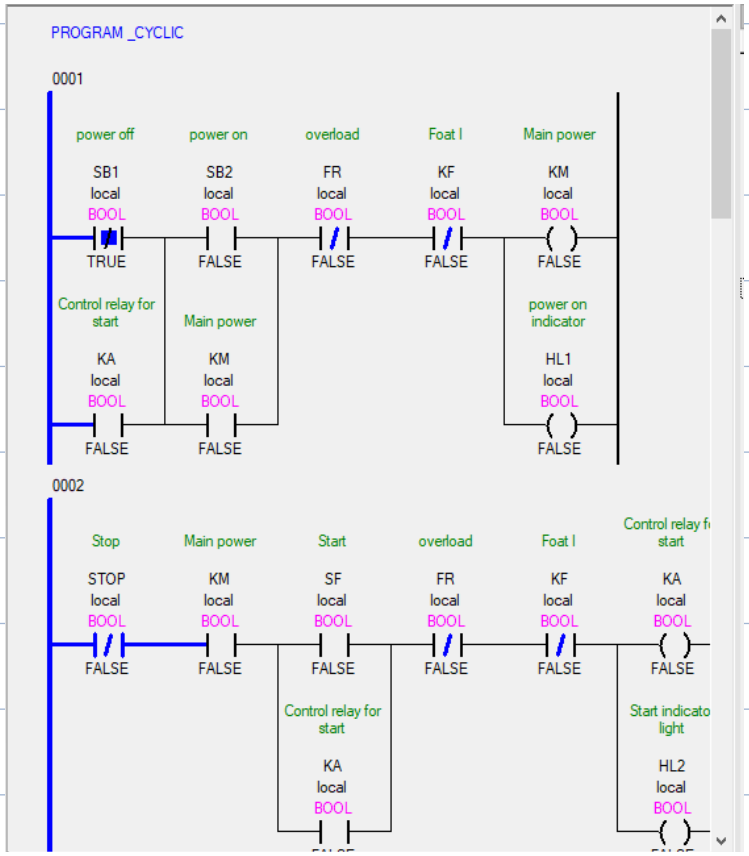


Fig. 8

⑤ When a fault is detected, KF (fault switch) is TRUE, KM (main power) is FALSE, the power supply is cut off, and HL3 (fault indicator light) is TRUE, light on as in Fig 9.10.11.

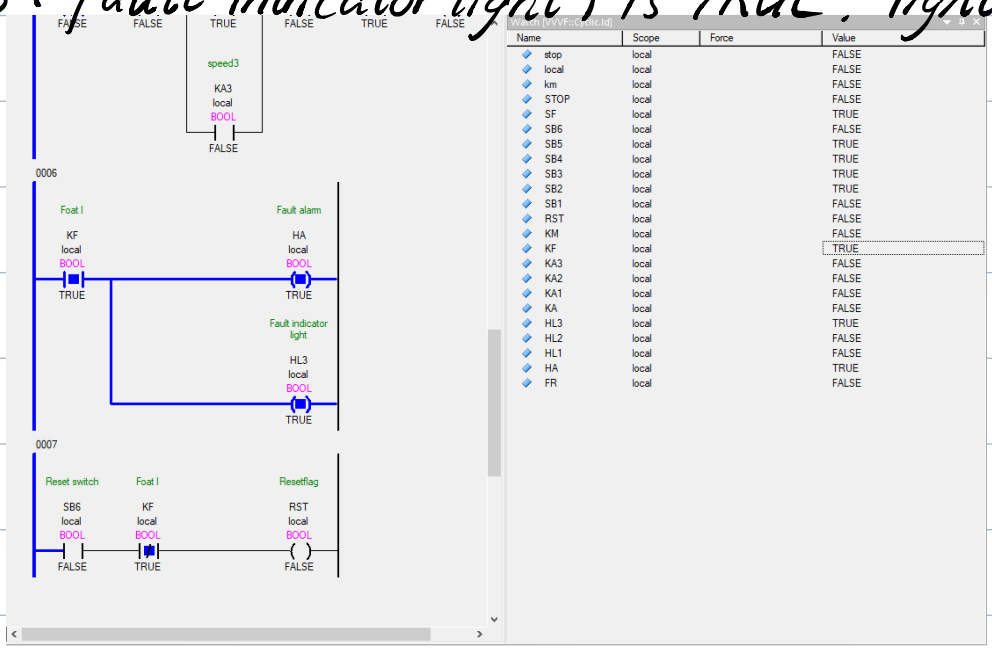


Fig. 9

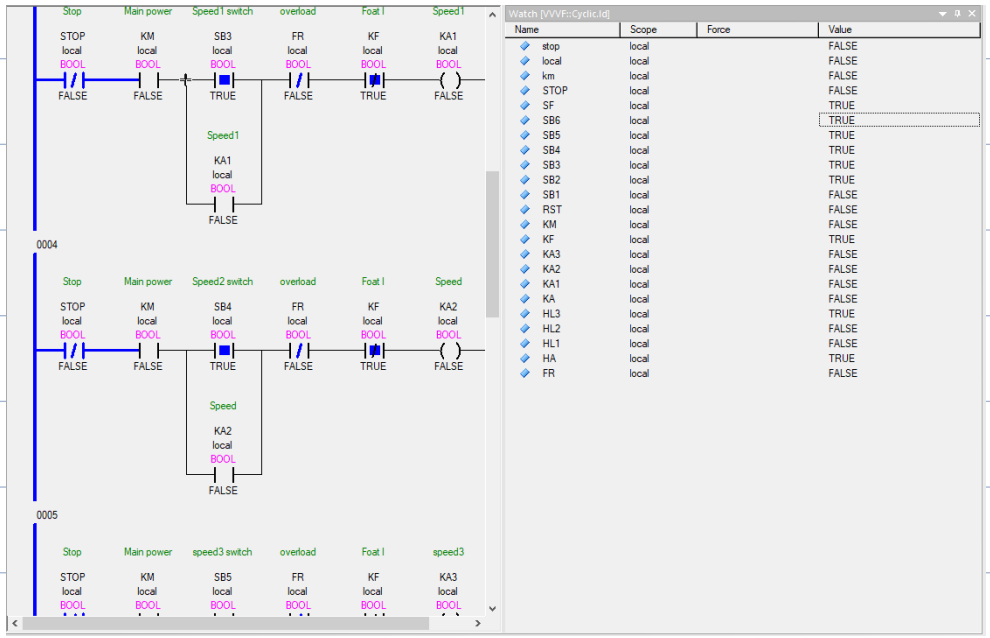


Fig. 10

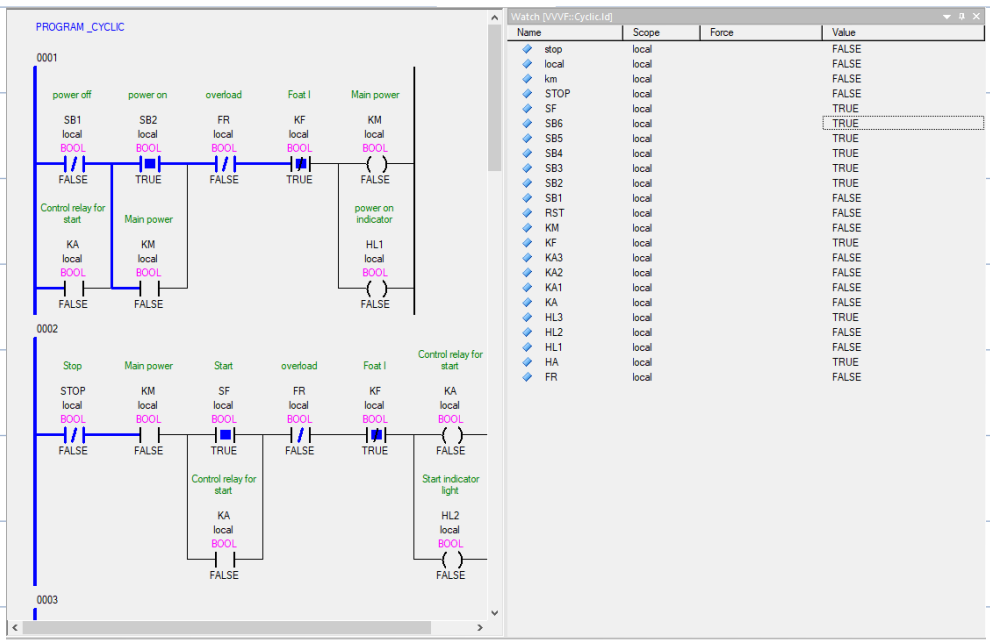


Fig. 11

⑥ When the fault is fixed, set SB6 (Reset switch) as TRUE to reset the system as shown in figure 12.

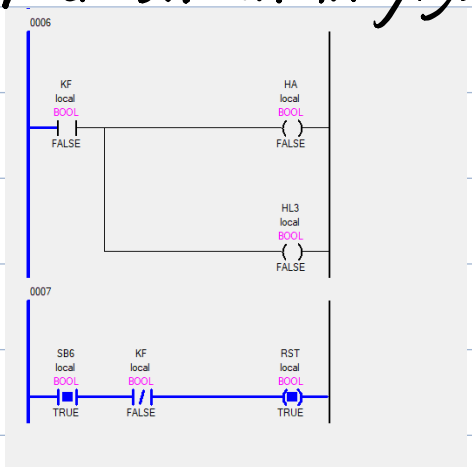


Fig. 12

(1) Only the power circuit is the same as the traditional control circuit.

(2) By using PLC programme, KA and KM which are control relay and auxiliary contact originally in traditional control circuit have been replaced with soft components. And most of the switches such as TB, TC are replaced with soft components.