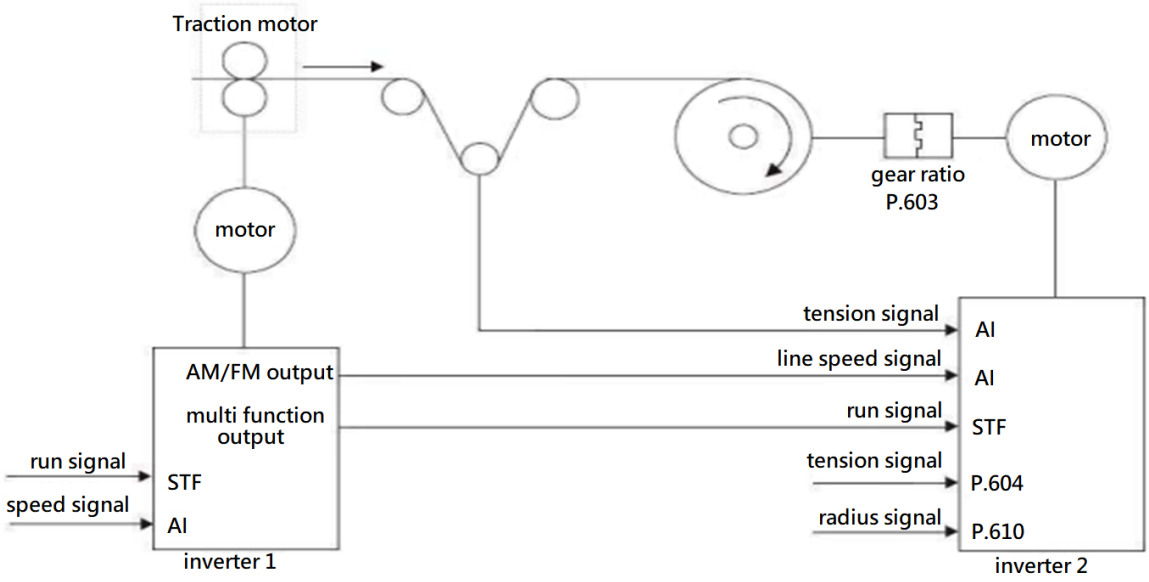
FA successful application

Case name	Shihlin inverter on cable production line---this case is about Shanghai“xx 龙”equipment				
Department	FA engineer group	Date	2014-05-6	page	14
Product	SF-GT、SF-G、SS2 series	Code	ANI00010	ver	B

Shihlin SF-GT features on tension control

SF-GT series products built-in tension control software is widely used in wire drawing machines, winding equipment, etc. (refer to the following figure), the model specifications are currently listed 380V series 1.5KW~110KW, the highest frequency can output 650HZ, with SVPWM control software operation response ability.



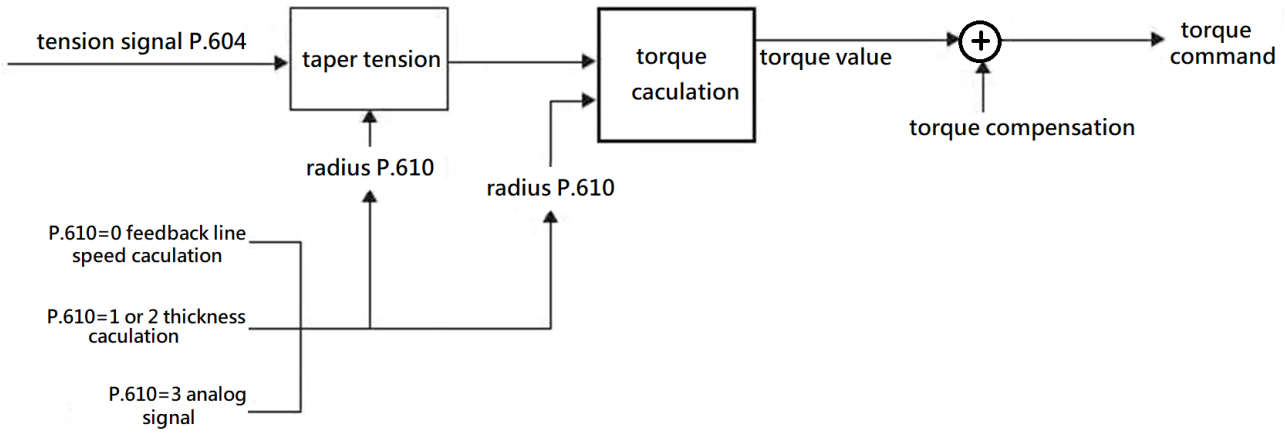
2、with PG03 expansion card can do V/F, vector, open loop and close loop torque

Inverter appearance PG03 appearance

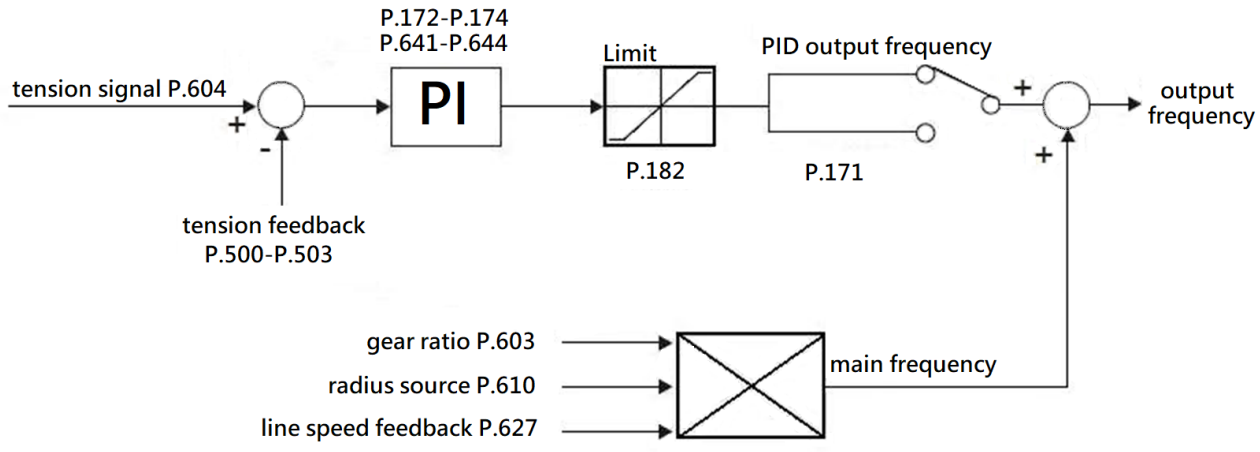
3、SF-GT series inverters have perfect self-tuning function, quick response to load inertia and external feedback signals, effective control of production process and transmission operating stability. Inverter tension control is a complex control technology, SF -GT series are built with special control arithmetic module, which greatly reduced user calculations if the relevant parameters are set properly , the following

briefly describes how SF-GT achieves its tension control.

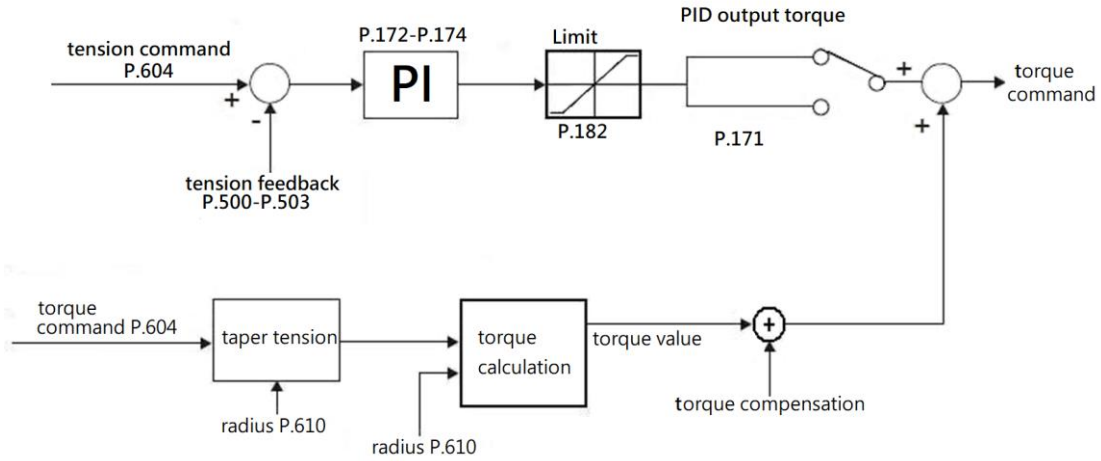
3.1 SF-GT open-loop torque control: The inverter can accurately control the motor output torque under the closed-loop vector (with speed sensor vector control). To use this control mode, an encoder must be installed (the inverter must be equipped with a PG card). . According to the formula F=T/R (where F is the material tension, T is the torque of the reel, and R is the radius of the winding), the tension of the reel can be adjusted according to the change of the winding diameter, and the tension on the material can be controlled. It is the basis of the open-loop torque mode to control the tension. Another reason for the feasibility is that the tension on the material is only from the torque of the reel, and the torque of the reel is mainly applied to the material.



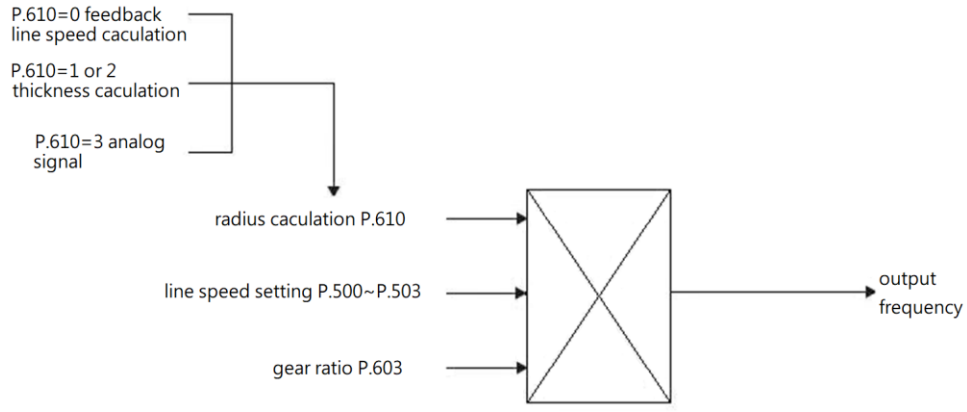
3.2 SF-GT closed-loop speed control: Closed loop means that the tension (position) detection feedback signal is required to form a closed-loop system. The speed control mode means that the inverter adjusts the output frequency according to the feedback signal to achieve the control purpose. The principle of the control mode is to calculate a matching frequency set value f1 by the material line speed and the actual coil diameter, and then perform a PID adjustment value f2 by the tension (position) feedback signal, and the final frequency output is f=f1+f2. F1 can basically match the line speed of the take-up roll with the material line speed, then the f2 part can be adjusted slightly to meet the control requirements, which solves the contradiction between the rapid response and the control stability in the closed-loop control.



3.3 SF-GT closed-loop torque control: The tension feedback closed-loop regulation is added based on the open-loop tension control. By using the tension sensor to feedback tension value along with the setting value a PID closed loop is formed, which adjusts the inverter output torque. The principle of the control mode is to calculate a matching torque set value T1 by setting the tension and the actual coil diameter, and then performing a PID adjustment by the tension (position) feedback signal to generate a torque adjustment value T2, and the final torque output is T= T1+T2. In this mode, the target value of the system is set in from P.170 to P.183, the goal of the control is to stabilize the feedback signal of the tension (position) at the setting value of the PID. In particular, when using position signals (such as tension pendulum, floating roller) for feedback, changing the set value (PID reference) does not necessarily change the actual tension. Changing the tension requires changing the mechanism such as the weight of the pendulum or floating roller.



3.4 SF-GT constant line speed control: The principle of this control mode is to control the output frequency of the inverter through the line speed setting and the current coil diameter, ie ω=V/R, calculate the coil diameter R in real time, adjusting the angular velocity ω(output frequency f = ω /2π) according to the change of R so that the linear velocity V is constant. There are two methods for calculating the diameter of the coil, one is calculated by linear velocity, and the other is calculated by the increasing of thickness. Among them, when calculating the line speed, it is necessary to distinguish between the set line speed and the actual line speed. The coil diameter calculation requires the actual line speed instead of the set line speed. At the same time, the line speed setting source (P656) cannot be the same as the actual line speed detection feedback source (P627).



4、SF-GT includes pulse control frequency and output 0~100KHz pulse, two -10V~+10V voltage input, one way 0~10V/4~20mA analog input control frequency, two way 0~10V/0~20mA analog output.

2. Introduction to the automatic system of cable making

The production equipment is roughly divided into six parts, the pay-off machine (Fig. 1), the extruder (Fig. 2), the tension wire storage machine (Fig. 3), the traction machine (Fig. 4), and the take-up reel machine (Fig. 5), and the cable arranging machine (Figure 6).

The original wire is formed into a finished product through a fixed speed wheel set and a drawing mold, and is conveyed to the take-up reel through a wire guide wheel at a certain speed through a last fixed speed wheel. The wire drawing machine is to ensure that the wire between the fixed speed wheel and the take-up reel has a constant tension to complete the drawing process. The fixed speed wheel set is driven by the main motor, the speed is determined by the product specifications, and the line speed is also constant. The wire speed of the take-up reel increases as the diameter of the take-up reel increases. In order to ensure a certain tension, that is, to maintain the line speed of wire feeding and wire feeding, it is necessary to continuously reduce the rotation speed of the take-up reel to ensure that the wire take-up speed is constant, and the pay-off machine has perfect PID control operation to achieve better tracking capability.

Fig.1

Fig.2

Fig.3

Fig.4

Fig.5

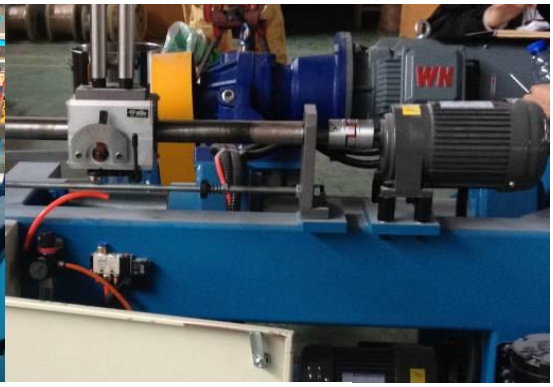


Fig.6

Requirements and control method

This is a case about Shihlin inverters on Shanghai “xx 龙” equipment, we used Shihlin SF-GT（Ver0.122 and over）,SF-G, SS2 series. The list below is for this case only, usually by choosing the same ratings on motor is enough.

Inverter used list：

No	Machine	Motor stats.	Inverter model	Accessories
1	pay-off machine	380V/3.7K 4P	SF-040-3.7K-GT	---
2	extruder	380V/37K 4P	SF-040-45K/37K-G	---
3	traction machine	380V/3.7K 4P	SF-040-3.7K-GT	---
4	tension wire storage machine	380V/7.5K 4P	SF-040-7.5K-GT	PG03
5	take-up reel machine	380V/11K 4P	SF-040-11K-GT	PG03
6	cable arranging machine	380V/0.75K 4P	SS2-043-0.75K	---

3.1 Pay-off machine

3.1.1 Function

The operation of the customer's pay-off machine requires the inverter to have PID function, and it needs to work in both forward and reverse. The PID target is set from the parameter given (P.225=50%), and the feedback comes from the position of the “movable wheel” in Figure 7. When the "movable wheel" is between 0-5V, the pay-off machine needs to reverse the take-up line. When the "movable wheel" is between 5V-10V, the pay-off machine needs to be forwarded to release; when later the equipment is not working, the pay-off machine should be stable enough, the performance of the "movable wheel" is basically maintained at 5V position without fluctuating up and down, and when the equipment moves, the pay-off machine can respond quickly according to the position of the "movable wheel"; The customer requested that if the feedback is suddenly lost, the inverter has signal loss detection and stopped immediately.

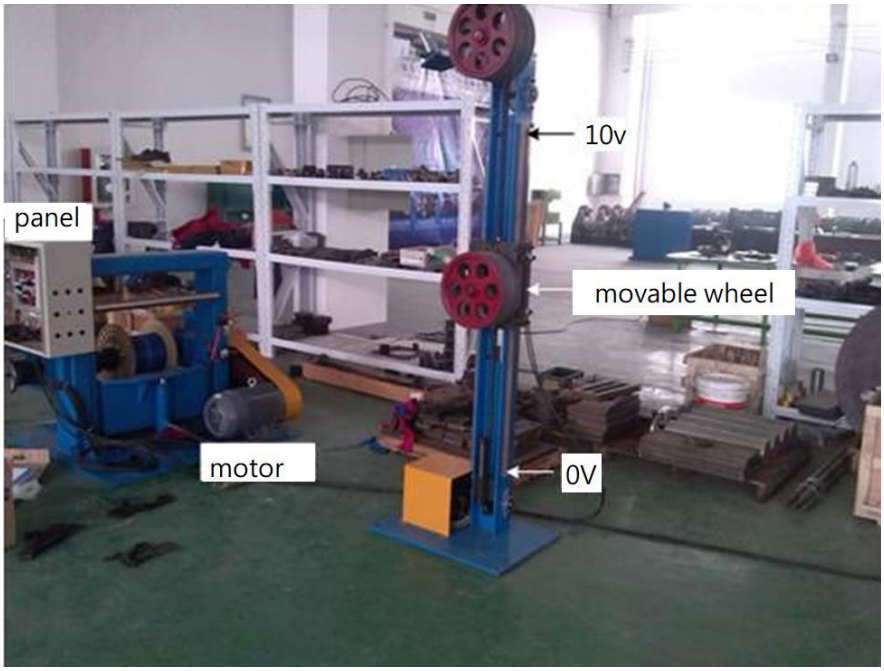
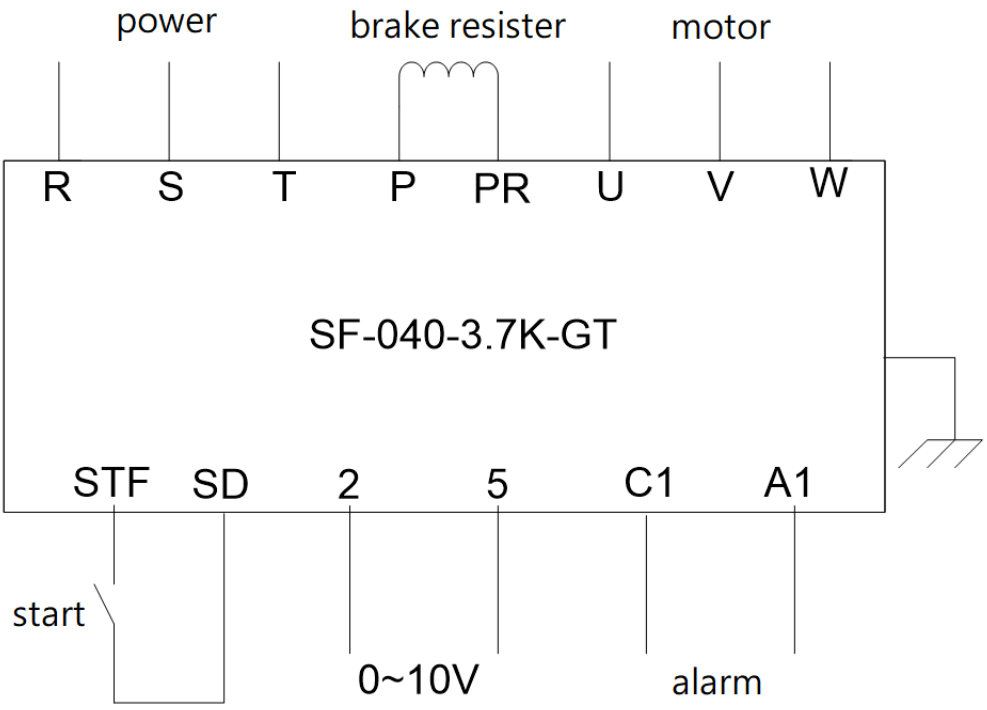


Fig.7

3.1.2 Wiring diagram



3.1.3 Parameter

Num	Parameter	Default	Setting value	Description
1	P.0	3	2	Torque boost
2	P.7	20	0.5	Acceleration time
3	P.8	10	0.5	Deceleration time
4	P.13	0.5	0	Starting frequency
5	P.60	31	1000	2-5 input signal filter constant
6	P.73	0	1	2-5 terminal voltage select
7	P.129	0	5	Relay A2-B2-C2 output function
8	P.130	2	5	Terminal SO2-SE function
9	P.500	1	4	Terminal 2-5 analog input function
10	P.223	0	1	Analog feedback bias
11	P.224	100%	50	Analog feedback gain
12	P.225	20	50	PID target value
13	P.427	-	1	PID reverse enable
14	P.420	-	1	Two PID control enable
15	P.421	-	5	PID value switch bias lower limit
16	P.422	-	10	PID value switch bias upper limit
17	P.172	20	100	Proportional gain
18	P.173	1	2	Integration time
19	P.641	20	1200	Proportional gain P2
20	P.642	1	1.5	Integration time
21	P.175	0	30	Error bias
22	P.176	0	0.1	Error time
23	P.177	30	1	Error disposal method
24	P.170	0	1	PID function(set last)

3.2 Extruder

3.2.1 Function

The extruder makes a plastic skin layer for cable processing. It is necessary to melt the plastic particles and then extrude the insulation layer of the cable according to different mold (Fig. 8). This part requires stable operation of the inverter in open-loop vector control.

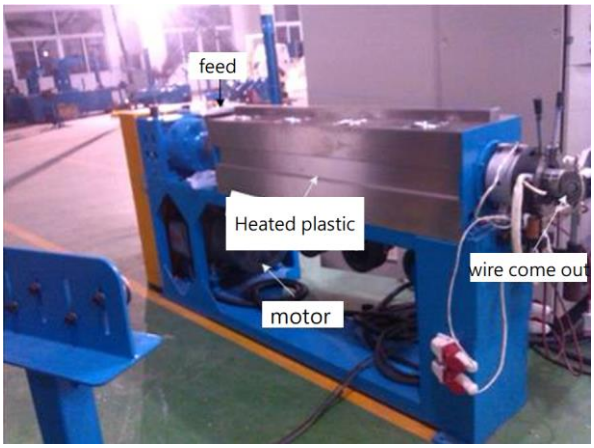
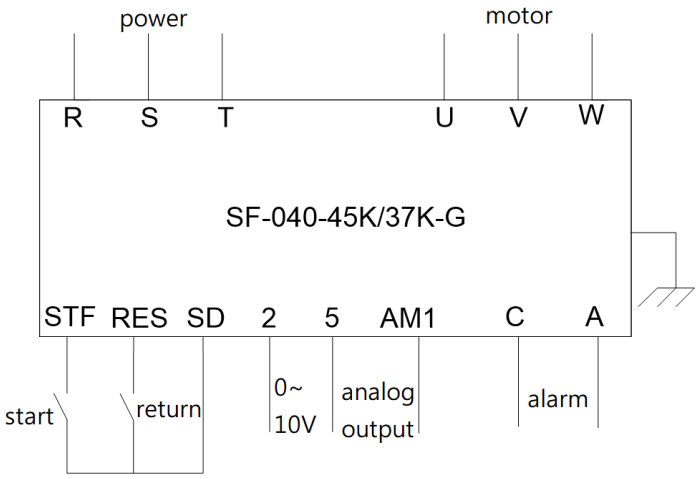


Fig 8

3.2.2 Wiring diagram



3.2.3 Parameter

num	Parameter	Default	Setting value	Description
1	P.7	20	50	Acceleration time
2	P.8	30	10	Deceleration time
3	P.60	31	1000	2-5 input signal filter constant
4	P.72	5	2	Carrier frequency
5	P.73	0	1	2-5 terminal voltage select
6	P.300	0	3	Motor control mode（Sensorless vector control SVC）
7	P.302	0	37	Motor auto tuning parameters, set by motor specs.
8	P.303	4	4	
9	P.304	440	380	
10	P.305	50	50	
11	P.306	0	69.9	
12	P.307	1410	1475	

3.3 Traction machine

3.3.1 Function

The application of the customer's tractor is relatively simple, the external mode is started, the frequency command is derived from the analog quantity, and the operation is performed in the VF mode, but the running speed of the motor is required to be stable in the full frequency band (from 0.5 Hz to 50 Hz) (Fig. 9).

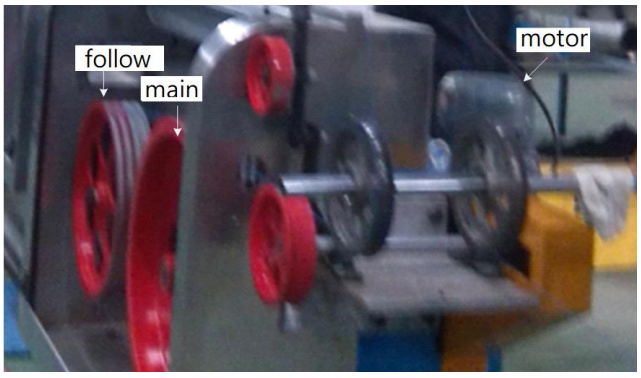
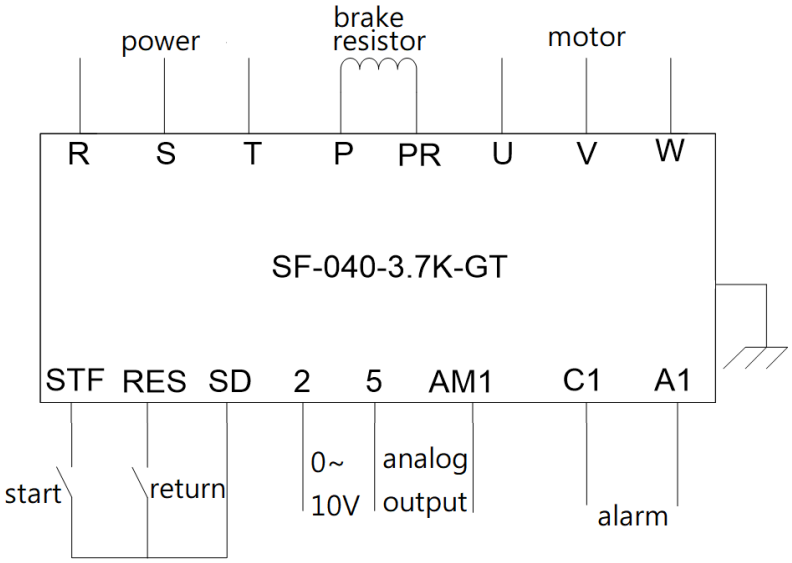


Fig.9

3.3.2 Wiring diagram



3.3.3 Parameter

num	Parameter	Default	Setting value	Description
1	P.7	5	50	Acceleration time
2	P.8	5	10	Deceleration time
3	P.54	0	1	Terminal AM1/HDO function
4	P.60	31	1000	2-5 input signal filter constant
5	P.73	0	1	2-5 terminal voltage select
6	P.300	0	0	Motor control mode
7	P.302	0	4	Motor auto tuning parameters, set by motor specs.
8	P.303	4	4	
9	P.304	220/440	380	
10	P.305	50/60	50	
11	P.306	By volume	8.8	
12	P.307	1410/1710	1440	

3.4 Tension wire storage machine

3.4.1 Function

The tension wire storage inverter has a torque control mode, so that the "moving wheel" has enough forward force to tighten the "tension line"; when the "tension start" button is pressed, the inverter rotates in the torque mode. The torque command can be adjusted by turning the "tension adjustment" knob. When the "tension stop" button is pressed, the inverter stops. When the "tension reverse" button is pressed, the inverter drives the motor to reverse operation (Figure 10), the inverter is using PG03 expansion card.

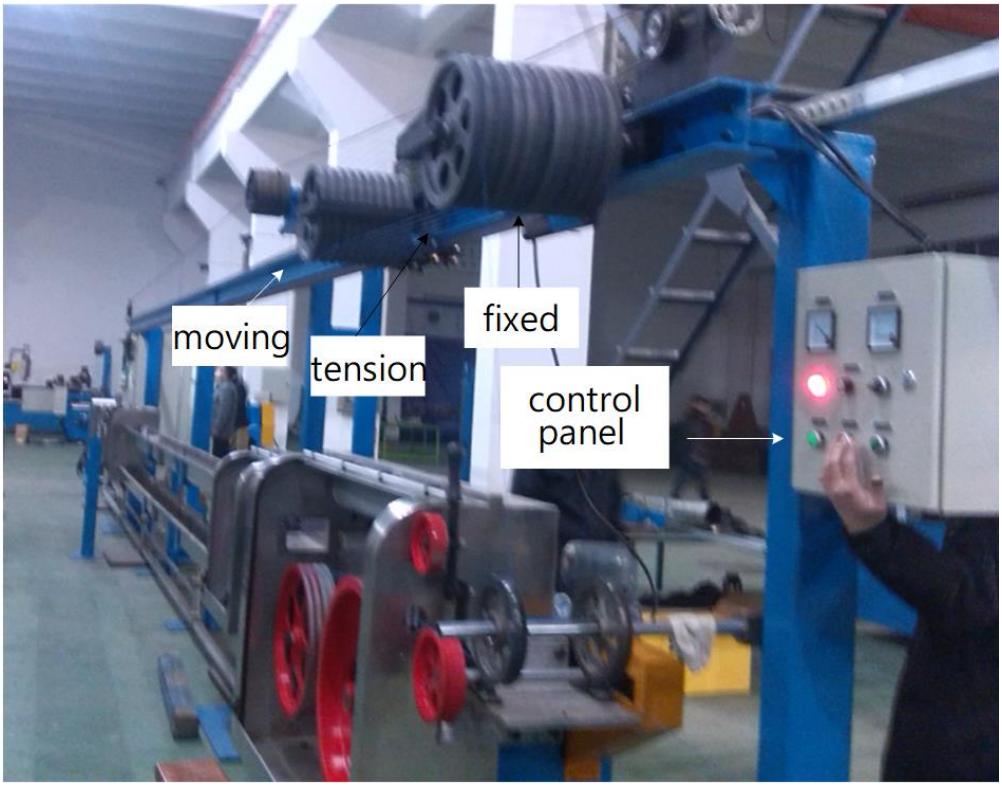
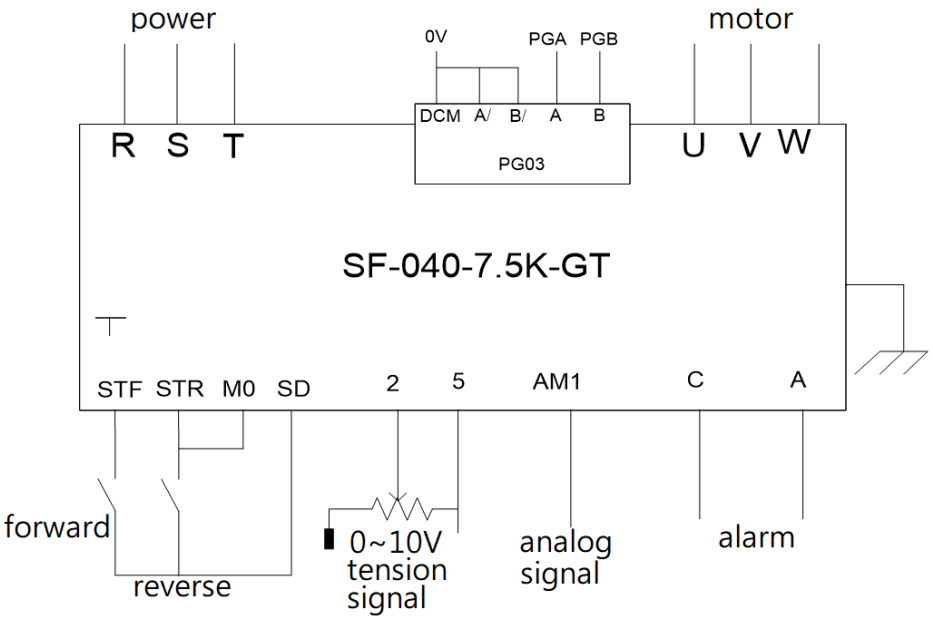


Fig.10

3.4.2 Wiring diagram



3.4.3 Parameter

num	Parameter	Default	Setting value	Description
1	P.13	0.5	0	Starting frequency
2	P.54	0	1	Terminal AM1/HDO function
3	P.79	0	4	Hybrid 1
4	P.80	2	55	Set terminal M0 to switch between speed/torque
5	P.300	0	4	Motor control mode（Closed loop vector）
6	P.301	0	2	Motor auto tuning parameters, set by motor specs.
7	P.302	0	7.5	
8	P.303	4	4	
9	P.304	440	380	
10	P.305	50	50	
11	P.306	0	15.6	
12	P.307	1410	1450	
13	P.350	1024	1024	Encoder pulse per round
14	P.351	0	1	Encoder AB phase（set by wiring）
15	P.352	1	0	Disable zero speed detect alarm
16	P.354	1	0	Disable over speed detect alarm
17	P.402	30	40	Torque mode limit is set to 40% of P.305
18	P.405	0	1	Torque limit is set by analog input
19	P.407	-	1	Torque limit bias only used in reverse
20	P.500	1	2	Input analog signal to terminal 2-5 for torque command

3.4.4 Note

If there is tension fluctuating problem, lower the value of P.312(for 7.5Kw motor the value is about 100), then use P.997 to reset.

3.5 Take-up reel machine

3.5.1 Function

The inverter is switched by the panel “receive/jog” button to switch between tension and speed control mode (Fig. 11). When switching to the line-receiving mode, the inverter turns on the torque mode. In torque mode, the tension signal is send from the panel by the potentiometer, and speed signal is set from the parameter P.402. When switching to the jog mode, the inverter turns on the speed mode. The upper speed limit is determined by terminals 2 and 10 and the value of P.38. The speed signal is send from the motion sensor signal plus the tension controller both calculated through PLC (Figure 12).

Fig.11

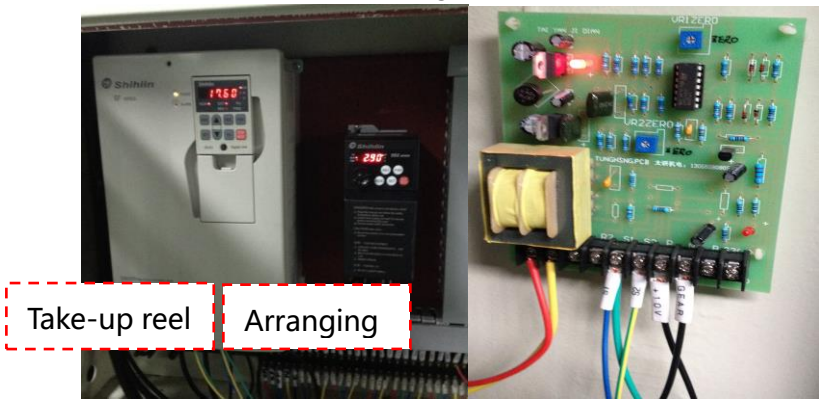
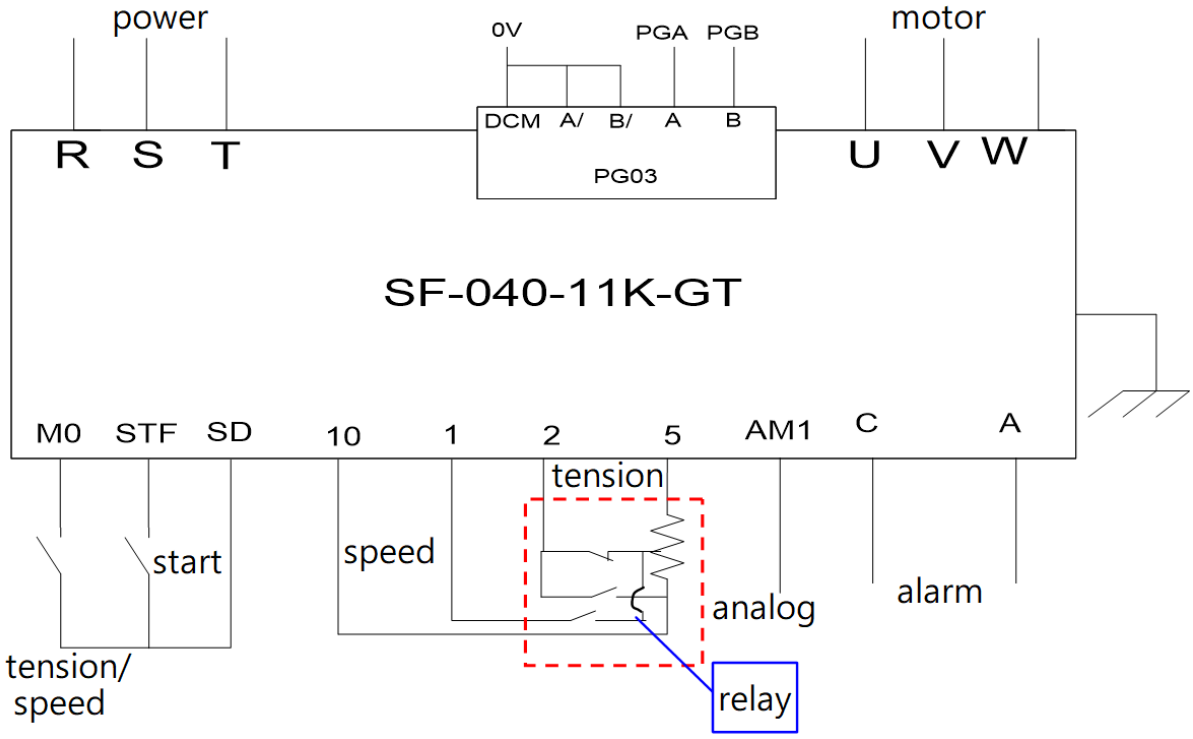


Fig.12

3.5.2 Wiring diagram



3.5.3 Parameter

num	Parameter	Default	Setting value	Description
1	P.60	31	2000	2-5 input signal filter constant（2000ms）
2	P.79	0	0	PU mode
3	P.80	2	55	Set terminal M0 to switch between speed/torque
4	P.192	0	0	Terminal 2-5 minimum input voltage
5	P.193	10	10	Terminal 2-5 maximum input voltage
6	P.194	0	0.1	Terminal 2-5 minimum input voltage to percentage（after setting P.194 ,set P.192=0，otherwise alarm）
7	P.195	100	10	Terminal 2-5 maximum input voltage to percentage（after setting P.195,set P.193=10，otherwise alarm）
8	P.300	0	4	Motor control mode（Closed loop vector）
9	P.301	0	2	Motor auto tuning parameters, set by motor specs.
10	P.302	0	11	
11	P.303	4	4	
12	P.304	440	380	
13	P.305	50	50	
14	P.306	0	22.5	
15	P.307	1410	1450	
16	P.350	1024	1024	Encoder pulse per round
17	P.351	0	2	Encoder AB phase（set by wiring）
18	P.352	1	0	Disable zero speed detect alarm
19	P.354	1	0	Disable over speed detect alarm
20	P.402	30	40	Torque mode limit is set to 40% of P.305
21	P.405	0	1	Torque limit is set by analog input
22	P.407	-	1	Torque limit bias only used in reverse
23	P.500	1	2	Input analog signal to terminal 2-5 for torque command
24	P.501	1	0	Disable terminal 4-5 analog input
25	P.502	0	1	Terminal 1-5 analog input function(frequency)

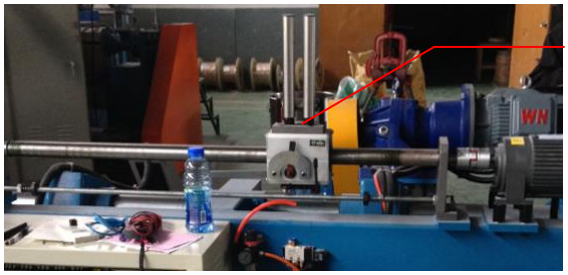
3.5.4 Note

If there is tension fluctuating problem, lower the value of P.312(for 11Kw motor the value is about 80), then use P.997 to reset.

3.6 Cable arranging machine

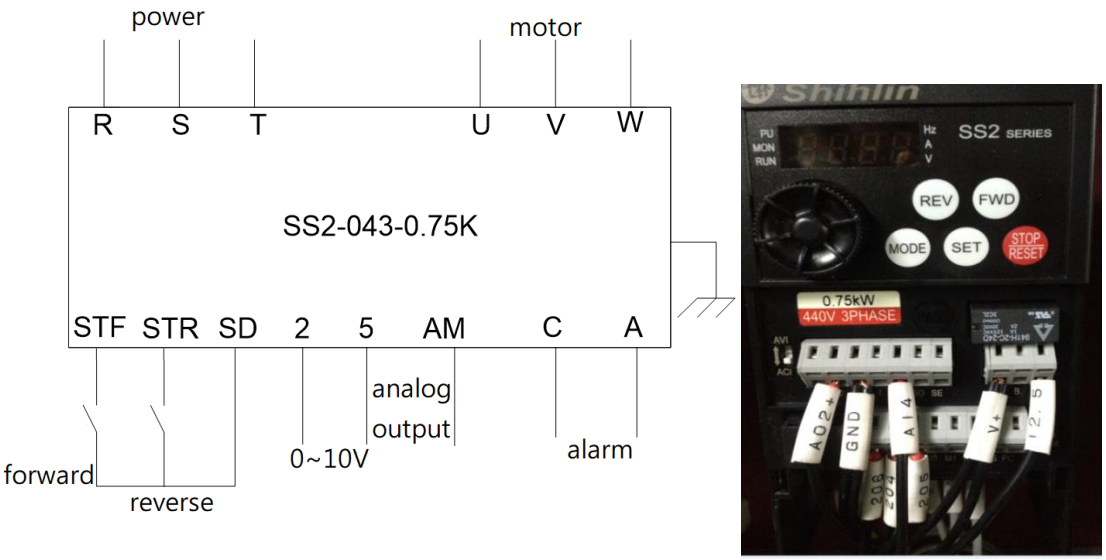
3.6.1 Function

The cable arranging machine is an auxiliary mechanism of the wire take-up machine, and the cable is evenly arranged in the take-up reel, the running speed is provided from analog receiving line signal and the PLC analog signal, the faster the wire take-up, the faster the arranging.



Arranging mechanism

3.6.2 Wiring diagram



3.6.3 Parameter

num	Parameter	Default	Setting value	Description
1	P.7	5	1	Acceleration time
2	P.8	5	1	Deceleration time
3	P.38	50	50	Target frequency
4	P.79	0	2	Operating mode