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Research Article

Troubleshooting of Siemens Drives in Engineering Applications

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ABSTRACT

This article describes some of the main alarms and faults generated by Siemens MASTERDRIVES 6SE70 series drives in engineering project applications and the handling process for these faults and alarms.

Keywords: MASTERDRIVES 6SE70; alarm; fault; troubleshooting

1. Introduction

The following are some frequency converter faults and alarm problems encountered by the author during the project debugging process. After the problems occur, they are inspected, analyzed, and ultimately resolved on site. Of course, the causes of the faults may be diverse, and the same fault alarm can be caused by different reasons. Sometimes complex problems are often caused by small problems. However, in actual handling, if they are treated as very difficult problems, these small problems are often overlooked. The key to handling fault alarms on site is to be bold and careful. This document is only a summary of the specific situations encountered by the author on site.

2. Fault

2.1. F006

The F006 fault indicates overvoltage on the DC bus. The vector comprehensive description of it is shown in **Figure 1**, including possible solutions. However, on-site problems are complex and ever-changing, requiring analysis based on actual situations to find solutions.

F006	**DC link overvoltage** Due to high DC bus voltage, the device shut down. Power supply voltage range | DC voltage range | Shutdown threshold 200V-230V | 270V-310V | appr.410V 380V-480V | 510V-650V | appr.820V 500V-600V | 660V-690V | appr.1020V 660V-690V | 890V-930V | appr.1220V For parallel connected frequency converters (specification L) R949=1: Active device DC bus overvoltage R949=2: DC bus overvoltage of the driven device	Check the power supply voltage or input DC voltage. The frequency converter operates in a feedback mode without the possibility of feedback. If the power supply voltage of the frequency converter reaches the upper limit and operates at full load, F006 will report a fault when there is a phase loss. Perhaps: • Increase P464 descent time • Activate P515 DC bus voltage regulator (pre check P071) • Reduce P526 search speed • P259 maximum power generation (only applicable to P100=3, 4 or 5)

Figure 1. F006 Fault information.

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(1) Basic information of the project. This project uses two sets of 1900kW inverters to drive two 1850kW motors, with a wind turbine gearbox loaded in between. One motor works as the driving end in the electric state, while the other motor works as the loading end in the power generation state.

(2) Description of on-site issues. Due to the power of the intermediate gearbox being 1775kW, during the loading test, the frequency converter stopped and reported F006 fault, which occurred multiple times within a week, causing great trouble for the customer's testing work.

(3) On site problem analysis. Only by understanding the phenomenon when the fault occurs can targeted analysis be carried out and solutions be provided. Therefore, the trace function of DriveMonitor is first used to record some states when the fault occurs, and the fault triggers the trace function. The specific situation is recorded as shown in **Figure 2**.

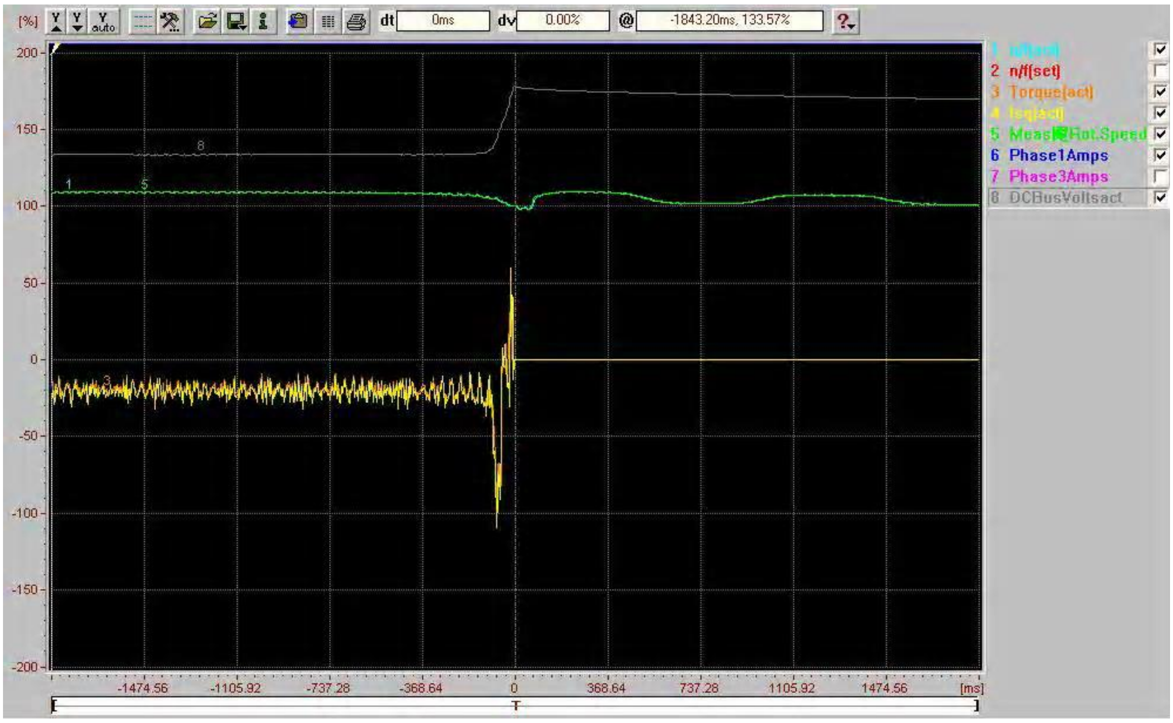


Figure 2. DC bus Yao encoder curve monitoring.

(4) Handling on-site issues. From the results obtained from the on-site trace, it can be seen that there was a sudden increase in the voltage of the DC bus when the fault occurred. What is the reason for this change in the DC bus? Upon careful analysis, it was found that there was a sudden change in the actual value of the motor speed at this time, and it is suspected that the problem lies with the motor encoder. Using the service level permissions of the frequency converter to collect the output curve of the encoder involves the encoder reading parameters r498 and r499 of the frequency converter. Using the collected encoder data for calculation, the specific formula is as follows:

Sqrt（r498^2+r499^2）*21299/500

Activate the curve recording function and use fault signals to trigger recording.

When the frequency converter does not provide an enable signal, the encoder recording curve obtained by manually selecting the motor is shown in **Figure 3**.

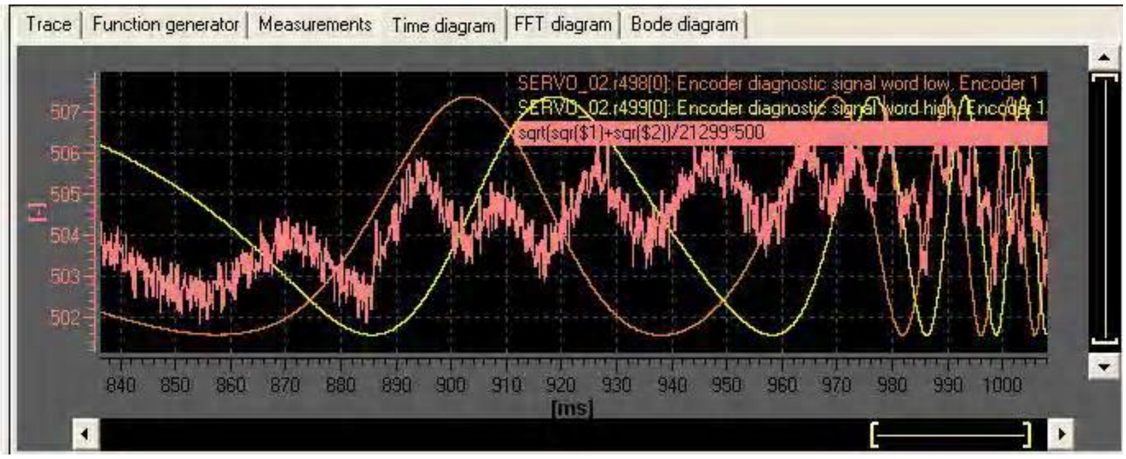


Figure 3. Encoder signal monitoring - frequency converter not enabled.

Provide the enable signal of the frequency converter and record the encoder curve obtained as shown in **Figure 4**.

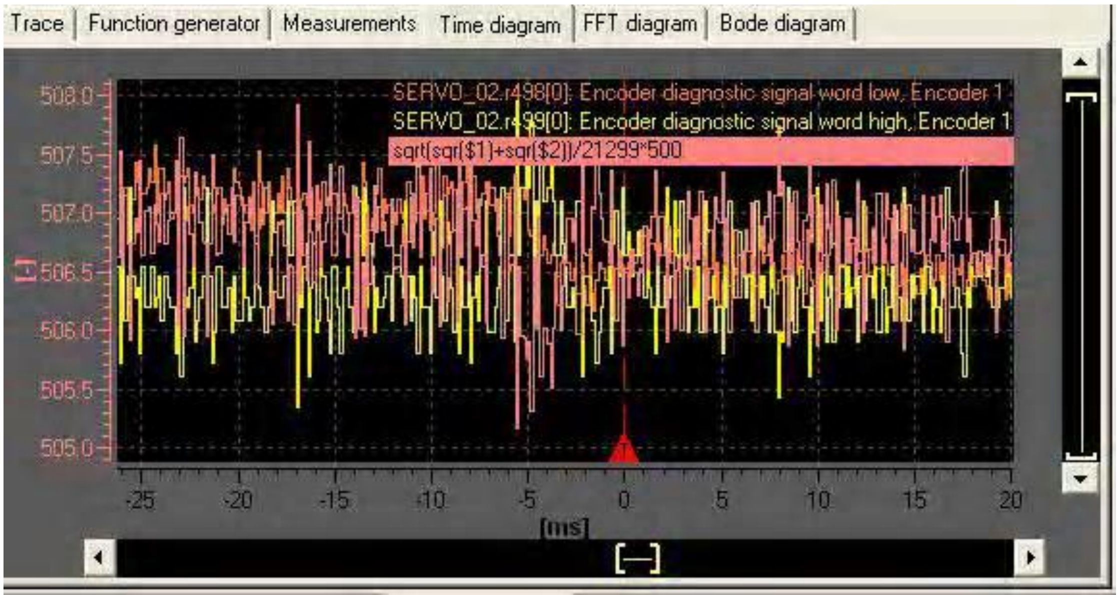


Figure 4. Encoder curve monitoring - under inverter enabling conditions.

Through curve recording, it was confirmed that the fault was caused by an encoder problem. Upon careful inspection of the encoder wiring, there were no issues. Further inspection of the encoder revealed that the encoder fixture had some deformation. After communicating with the operator, it was learned that this week, the on-site assembly personnel accidentally smashed the universal coupling onto the encoder while lifting the universal coupling, causing the fixture to deform and causing the frequency converter to frequently report F006 faults.

(5) Result feedback. After replacing the encoder, the system is running normally and has been running normally for 8 months so far. The built-in trace function of DriveMonitor is like a recorder that accurately records some phenomena when a fault occurs, so it is important to make good use of the trace function to achieve the effect of “knowing the way and using it ingeniously”.

2.2. F011

The F011 malfunction can be said to be a high failure rate of this series of frequency converters, as shown in **Figure 5**. I believe many debugging personnel have had contact with it, but of course, the final effort to overcome it varies, and it can be said that a hundred flowers are competing and a hundred schools are working together. The description in the user manual is very simple. Although the description is very simple, there are countless reasons that triggered the fault. Please share some of the situations encountered by the author on site.

F011	**Overcurrent** The device shut down due to overcurrent. Exceeded shutdown threshold.	**Inspect** • Is there a short circuit or ground fault in the output of the frequency converter • The load is in an overload state • Does the motor match the frequency converter • Is the dynamic requirement too high

Figure 5. F011 fault information.

(1) Basic information of the project. The 7.2MW wind power test bench project has an inverter capacity of 4 * 1000kW and a motor of 3600kW imported from Germany. These four motors are used for single machine or series gearbox testing work.

(2) Description of on-site issues. During motor optimization, the frequency converter reported F011 fault. Despite multiple attempts, the fault persisted. There are a total of 4 sets of frequency converters and motors in this project, of which two sets are normal, and the other two sets have F011 faults.

(3) On site problem analysis. After optimizing the two normal motors, everything ran normally using vector control. So, we downloaded the parameters of the two optimized frequency converters that were used normally to the other two frequency converters that reported F011 faults. When we ran the motors, we found that there was abnormal noise as the speed increased, and the motor itself vibrated significantly. Press the emergency stop button to let the motor OFF2 stop freely. At this time, there is no sound from the motor. The mechanical problem is ruled out, and it is likely that the problem is still on the frequency converter side.

When the frequency converter that has reported a fault is running, use the trace function of Drive Monitor to record the current waveform. The specific situation is recorded as shown in **Figure 6**.

From **Figure 6**, it can be seen that the 1st and 3rd phase current waveforms output by the frequency converter are distorted, and there is also a difference in the amplitude of the two-phase current. It is likely that this distorted waveform has caused motor noise and vibration on-site. Due to the malfunction of individual cabinets, it is not possible to use the trace function of Drive Monitor to monitor each individual cabinet. A clamp ammeter was borrowed on site to detect the output current of each slave cabinet during motor operation. Firstly, a 4-parallel cabinet (P848.1=255) was used to start the motor with current compensation function (P848.4=255). The specific measurement data is shown in **Table 1**.

Table 1. Three phase current recording table Yuan 4 parallel cabinet+current compensation function enable failure.

	P848.4=255 && P848.1=255		
	U	**V**	**W**
M	94	81	13
S1	32	37	45
S2	40	35	56
S3	120	78	130
Sum	286	231	244

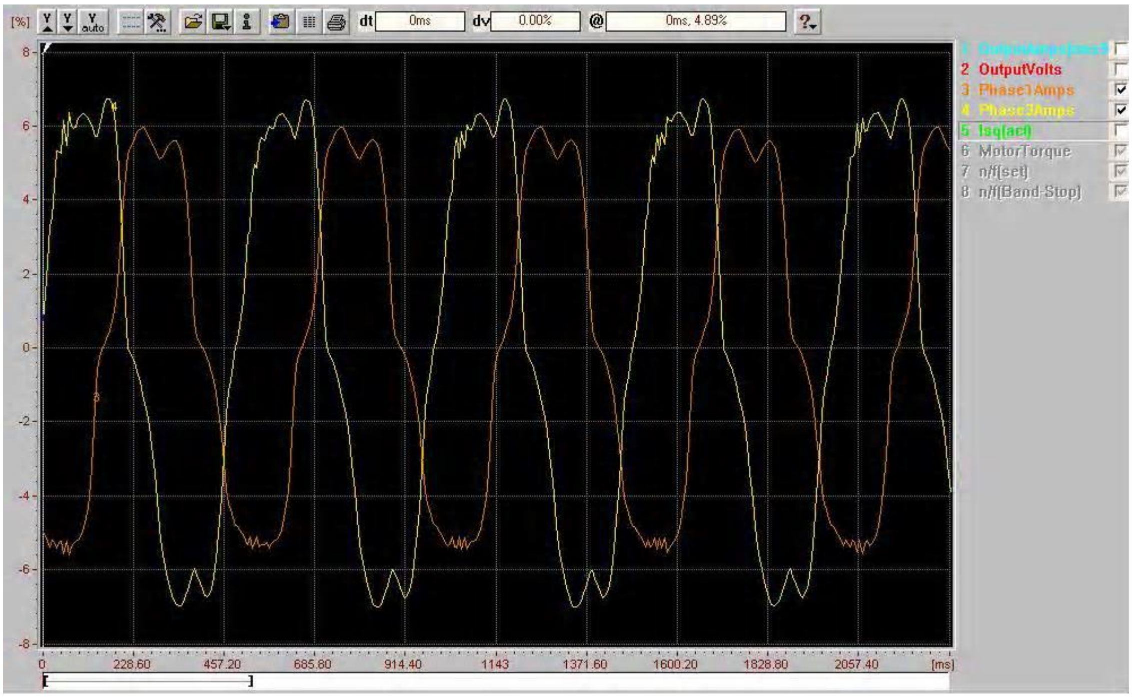


Figure 6. Output current waveform of frequency converter.

The second step is to start the motor with current compensation function using the main cabinet, slave 1, and slave 2 cabinets, and measure the current. The results are shown in **Table 2**.

Table 2. Three phase current record table. (Main cabinet+slave cabinet 1+slave cabinet 2+current compensation function enable)

	P848.4=255 && P848.1=7		
	U	**V**	**W**
M	140	126	21
S1	64	68	130
S2	75	68	116
S3			
Sum	279	262	267

The third step is to use the main cabinet, slave 1, and slave 3 cabinets to start the motor with current compensation function, and conduct current measurement. The results are shown in **Table 3**.

Table 3. Three phase current record table. (Main cabinet+slave cabinet 1+slave cabinet 3+current compensation function enable)

	P848.4=255 && P848.1=11		
	U	**V**	**W**
M	105	93	21
S1	40	57	130
S2			
S3	144	88	171
Sum	289	238	226

The fourth step is to use the main cabinet, slave 2, and slave 3 cabinets to start the motor with current compensation function, and conduct current measurement. The results are shown in **Table 4**.

Table 4. Three phase current record table. (Main cabinet+slave cabinet 2+slave cabinet 3+current compensation function enable)

	P848.4=255 && P848.1=13		
	U	**V**	**W**
M	116	103	14
S1			
S2	56	56	90
S3	126	88	140
Sum	298	247	244

The fifth step is to start the motor from cabinets 1, 2, and 3 with current compensation function for current measurement. The results are shown in **Table 5**.

Table 5. Three phase current record table. (Slave cabinet 1+slave cabinet 2+slave cabinet 3+current compensation function enable)

	P848.4=255 && P848.1=14		
	U	**V**	**W**
M			
S1	46	53	53
S2	46	65	65
S3	150	133	120
Sum	242	251	238

Finally, the motor was started using 4 parallel cabinets and the current compensation function was cancelled for current measurement. The results are shown in **Table 6**.

Table 6. Three phase current recording table. (4 parallel cabinets+cancellation of current compensation function)

	P848.4=255 && P848.1=255		
	U	**V**	**W**
M	59	57	57
S1	62	59	65
S2	63	63	61
S3	56	52	65
Sum	240	231	248

By comparing the above tables, it can be seen that when the system is equipped with current compensation function, the total three-phase current is approximately balanced. However, upon inspection of each individual cabinet, it was found that the three-phase current is severely unbalanced. Multiple combinations were attempted and the results were almost the same. Finally, by modifying the parameters, the current compensation function was cancelled, and it was found that both the individual cabinet and the total three-phase current are balanced. From this, it can be seen that the problem is still unclear. We request service personnel to bring oscilloscopes and other equipment to the site for more careful inspection work.

After the service personnel arrived at the site, they used an oscilloscope to monitor the current of the frequency converter and repeated the above steps several times to analyze that the problem may be in the current measurement detection and calculation circuit.

(4) Handling on-site issues. The first thing that came to mind was to replace the CUVC control board. Even after the replacement, the problem persisted. Then, we replaced the IMPI board and measured it. The problem did not change. At the same time, we also used a test box to test a single electrical cabinet and checked

the CT of the current transformer, but there were no problems. Then consider replacing the IN/OUT board used to transmit trigger signals between cabinets. After replacement, it was found that the problem was eliminated and the IN/OUT board was basically locked. However, there were not enough IN/OUT boards on site for replacement, so the current compensation function could only be temporarily cancelled. After the subsequent IN/OUT board arrives at the site and is replaced, the system has been running for almost a year without any problems.

(5) Result feedback. Of course, this project only experienced F011 failure in the early stages of debugging. If the system reports F011 failure after running for a period of time, there may be many factors that can cause it, such as the CT of the frequency converter current transformer and the motor encoder. Specific problems need to be analyzed and then targeted.

2.3. F011

The reason for listing the F011 fault again is because the reasons for the two faults are different. This time, the situation is as follows: the frequency converter is 4 * 1000kW, and the motor is 3600kW. At the beginning of motor optimization, the F011 fault was reported. Upon inspection of the frequency converter, it was found that the fiber optic sequence on the IN/OUT board was mistakenly connected by the SEDL electrical cabinet factory, as shown in **Figure 7**.

Figure 7. Fiber optic wiring diagram of frequency converter IN/OUT board.

From the figure, it can be seen that the fiber optic cables used to transmit IGBT trigger pulses are connected in the wrong order, and the fiber optic cables numbered 54 and 56 are connected incorrectly. After the changes are made, the motor optimization work is carried out again, and everything is normal.

2.4. F023

The temperature fault of F023 inverter often occurs in the application of 4-parallel operation frequency converters, and the cause of the fault is shown in **Figure 8**. In the past two years of projects, with the development of the national wind power generation industry, the business of wind power gearbox test bench has also made significant progress. As the power level of the gearbox continues to increase, the increasing power of the dynamometer and corresponding multi parallel frequency converters have also emerged. With the widespread application of multi parallel frequency converters, temperature faults in F023 inverters also occur frequently. According to the frequency converter user manual, this fault expresses that the temperature of the frequency converter exceeds the limit temperature. Once this fault occurs, the frequency converter will stop and cannot operate. According to the specific situation on site, many times the frequency converter reports F023 fault as soon as it starts up, and the temperature is basically room temperature. This fault is considered a false trigger, and despite multiple attempts to contact Siemens technical support, it cannot be resolved. The final conclusion is that there is a problem with the circuit board corresponding to the temperature acquisition and control circuit of the frequency converter, which has been replaced on site but still cannot solve the problem.

F023	**Inverter temperature** Exceeding inverter limit temperature Alarm: (r949): Bit 0 Inverter temperature Bit 1 Temperature sensor cable disconnected Bit 4 Temperature sensor number Bit 5 Bit 6 Bit 8 Parallel circuit: driven device number Bit 9 Bit 10 For example: R949=1: The inverter temperature exceeds the limit value R949=2: Sensor 1: Sensor cable open circuit or sensor damaged R949=18: Sensor 2: Sensor cable open circuit or sensor damaged R949=34: Sensor 3: Sensor cable open circuit or sensor damaged R949=50: Sensor 4: Sensor cable open circuit or sensor damaged	Measure the intake and ambient temperatures. When 0>40C or 0>50 ℃ (enhanced book type), pay attention to checking the load reduction curve: • Is Fan-E1 connected and rotating in the correct direction • Is the air inlet and outlet blocked • -Temperature sensor at X30 end

Figure 8. F023 fault information.

(1) Basic information of the project. The 7.2MW wind power test bench project has an inverter capacity of 4 * 1000kW and a motor of 3600kW imported from Germany. These four motors are used for single machine or series gearbox testing work.

(2) Description of on-site issues. The frequency converter reported F023 fault while the motor was not running. Using Drive Monitor to monitor the temperature of the frequency converter, it was found that the normal temperature value was around 40℃ degrees Celsius.

(3) On site problem analysis. When using Drive Monitor to monitor the parameters of the frequency converter, it was found that when the frequency converter reported an F023 fault, the temperature of the frequency converter was around 40℃. Under normal circumstances, it should be around 70℃ before the F023 fault was reported. There may be two possible causes of the malfunction, one of which is a problem with the NTC temperature sensor; The second issue is that there is a problem with the measurement and processing circuit. The NTC temperature sensor has been replaced before, but the fault still persists. The problem is likely caused by the measurement and processing circuit. The temperature processing is mainly related to the CUVC control board and IMPI temperature acquisition board. After replacing the CUVC board and IMPI board, the fault will still occur as scheduled. The problem was previously escalated to Siemens Germany headquarters, but no clear solution has been provided, and only a roundabout approach can be used to solve the problem.

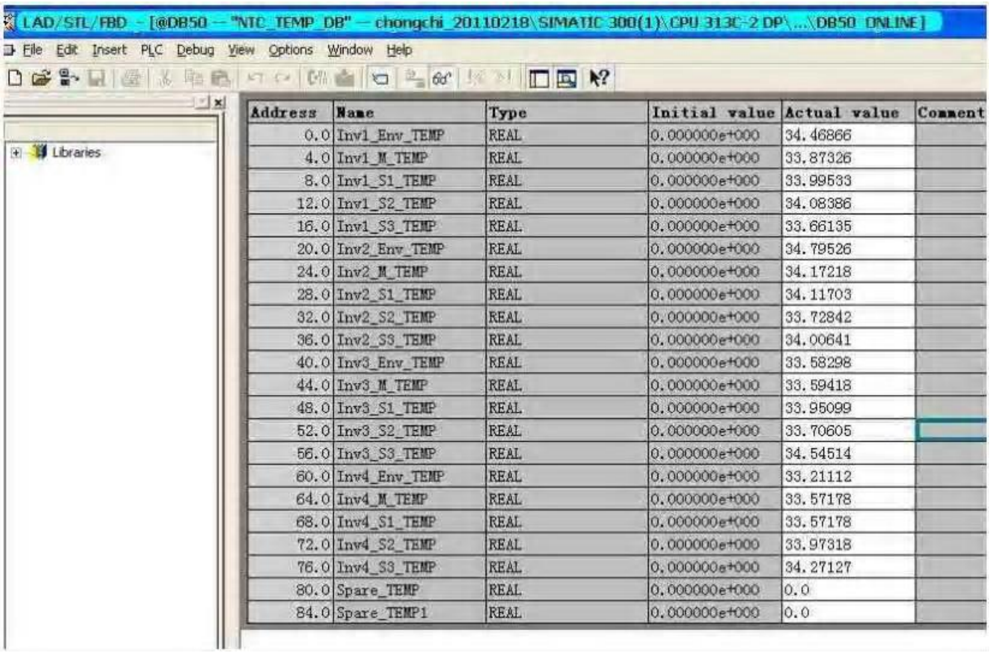
(4) Handling on-site issues. The temperature collection of the frequency converter uses NTC thermistors. To address this specific situation, the following methods are used: 1) Connect the NTC temperature sensor to the SIEMENS analog template for collection. As the resistance value of the NTC temperature sensor is around kΩ, in order to adapt to the range of the analog template, a fixed value resistor of about 600Ω needs to be

connected in parallel for the NTC temperature sensor. The PLC program is used to collect the temperature of the NTC sensor and make corresponding fault and alarm processing based on the collected temperature to ensure the safe operation of the frequency converter; The temperature calculation formula for NTC thermistor is Rt=R * EXP (B * (1/T1-1/T2)). T1 and T2 refer to K degrees, Kelvin temperature; B is the main parameter of a thermistor; Convert the above formula into a PLC control logic program to achieve temperature acquisition of the frequency converter. 2) Connect a fixed value resistor with a resistance value of around 4.7kΩ to the temperature acquisition input terminal of the IMPI board, with the intention of making the frequency converter control system believe that the temperature of the frequency converter is about 45℃ and remains constant. This can prevent the frequency converter from misreporting F023 faults.

The specific on-site processing is shown in **Figures 9, 10, and 11**.

Figure 9. Inverter IMPI board.

Figure 10. NTC thermistor PLC acquisition hardware diagram.



Address	Name	Type	Initial value	Actual value	Comment
0.0	Inv1_Env_TEMP	REAL	0.000000e+000	34.46866	
4.0	Inv1_M_TEMP	REAL	0.000000e+000	33.87326	
8.0	Inv1_S1_TEMP	REAL	0.000000e+000	33.99533	
12.0	Inv1_S2_TEMP	REAL	0.000000e+000	34.08386	
16.0	Inv1_S3_TEMP	REAL	0.000000e+000	33.66135	
20.0	Inv2_Env_TEMP	REAL	0.000000e+000	34.79526	
24.0	Inv2_M_TEMP	REAL	0.000000e+000	34.17218	
28.0	Inv2_S1_TEMP	REAL	0.000000e+000	34.11703	
32.0	Inv2_S2_TEMP	REAL	0.000000e+000	33.72842	
36.0	Inv2_S3_TEMP	REAL	0.000000e+000	34.00641	
40.0	Inv3_Env_TEMP	REAL	0.000000e+000	33.58298	
44.0	Inv3_M_TEMP	REAL	0.000000e+000	33.59418	
48.0	Inv3_S1_TEMP	REAL	0.000000e+000	33.95099	
52.0	Inv3_S2_TEMP	REAL	0.000000e+000	33.70605	
56.0	Inv3_S3_TEMP	REAL	0.000000e+000	34.54514	
60.0	Inv4_Env_TEMP	REAL	0.000000e+000	33.21112	
64.0	Inv4_M_TEMP	REAL	0.000000e+000	33.57178	
68.0	Inv4_S1_TEMP	REAL	0.000000e+000	33.57178	
72.0	Inv4_S2_TEMP	REAL	0.000000e+000	33.97318	
76.0	Inv4_S3_TEMP	REAL	0.000000e+000	34.27127	
80.0	Spare_TEMP	REAL	0.000000e+000	0.0	
84.0	Spare_TEMP1	REAL	0.000000e+000	0.0	

Figure 11. Online monitoring diagram of PLC data block for frequency converter temperature.

Connect the NTC temperature fault output in the PLC to the CUVC digital input terminal as an external fault input to the control system, as shown in **Figure 12**.

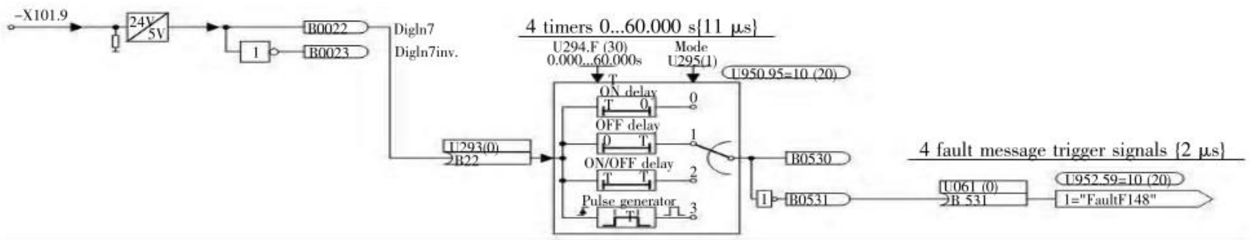


Figure 12. F148 external fault trigger logic diagram.

Once the actual collected NTC temperature exceeds the fault value set by the PLC program, an F148 external fault will be triggered, causing the frequency converter to stop running and protecting the frequency converter.

(5) Result feedback. After using this method to handle the temperature of the frequency converter, the system has been used for nearly 3 years without any problems.

2.5. F029

The F029 fault mainly refers to the malfunction of the measurement value sensor system. The cause and solution measures are shown in **Figure 13**: (1) Basic information of the project. The 5.6MW wind power test bench project has an inverter capacity of 4 * 1000kW and a motor of 2800kW imported from Germany. These four motors are used for single machine or series gearbox testing work. (2) Description of on-site issues. After nearly a year and a half of operation, the system frequently reported F029 faults, which caused the gearbox testing work to be unable to proceed normally and seriously affected the customer's production schedule. (3) On site problem analysis. Based on the general description of the fault in the encyclopedia, it can be determined that the problem may be in the measurement value sensor or processing system. After arriving at the site, use Drive Monitor to monitor the frequency converter parameters. It should be noted that in order to accurately observe the situation, the above parameter monitoring is carried out when the frequency converter is not running. It can be seen that the frequency converter is not running yet, while the L3 phase current transformer has several hundred readings. It can be seen that the problem lies in the current transformer or the current transformer acquisition channel. Once the cause is identified, the next step is to handle the fault. As the current transformer acquisition part involves several electronic boards that need to be eliminated one by one, it is still necessary to start with the current transformer. As it is a 4-parallel cabinet, the slave cabinet is disconnected one by one for elimination. Finally, one of the slave cabinets is locked, and a brand new current transformer is replaced. After re powering on, it is found that the current reading of the r832 inverter is normal. (4) Result feedback. After replacing the current transformer, the system has been running for almost a year now and everything is normal.

F029	**Meas.value sensing** The measurement value sensing system has malfunctioned: • (r949=1) Correction of L1 phase bias is impossible • (r949=2) It is impossible to perform bias correction in L3 phase • (r949=3) It is impossible to perform bias correction in L1 and L3 phases • (r949=65) Analog input cannot be automatically adjusted	Damaged measurement value sensing system Power section damage (pipe cannot be turned off) CU damaged

Figure 13. F029 fault information.

3. Alarms

3.1. A001

The A001 Alarm Vector Complete Collection has made it very clear that the calculation time is too long. Generally speaking, increasing the P357 sampling time can eliminate it. The specific reason is shown in **Figure 14**.

F001	**Calculating time** CUVC board calculation time is too long	• Observing the free operation time of r829 • Increase P357 sampling time • Reduce P340 pulse frequency

Figure 14. A001 alarm information.

3.2. A002

This problem is quite common in frequency converter systems that use SIMOLINK communication boards for master-slave control. The main reason is that the communication parameters on the SIMOLINK board are not fully configured, or the communication fiber on the master-slave SIMOLINK board is not connected or the fiber is disconnected. This problem is generally easy to solve, and the specific reason is shown in **Figure 15**.

F002	**SIMOLINK start alarm** SIMOLINK ring cannot start	Inspect • Is the fiber optic cable ring disconnected • Is there no voltage applied to the SLB in the loop • Is there an SLB fault in the loop

Figure 15. A002 alarm information.

3.3. A017

A017 alarm, for those who have used frequency converters equipped with safety shutdown, they should be familiar with it. This alarm appeared before the safety shutdown was closed. But for the frequency converter that was not originally parked safely, other reasons need to be found, as shown in **Figure 16**.

F017	**SAFE OFF alarm active** The switch used to block the inverter pulse has been opened (X9 terminal 56) (Only for devices with order numbers No... -11,... -21,... -31... 61)	Turn off switch X95-6 to release the inverter pulse

Figure 16. A017 alarm information.

(1) Basic information of the project. The 3.7MW wind power test bench project has an inverter capacity of 2 * 1000kW and a motor of 1850kW produced by Tianjin SEDL.

(2) Description of on-site issues. During the normal loading test of the gearbox, the system reported A017 repeatedly, which affected the normal testing work.

(3) On site problem analysis. Check the frequency converter, first of all, the CUVC control board. If a new CUVC board is replaced, the alarm still persists. Further inspection inside the frequency converter revealed that a fiber optic cable had come into contact with the resistance on the voltage distribution board on the side of the frequency converter. Upon closer inspection, it was found that the black sheath of the fiber optic cable had been scorched by the resistance. Turning off the lighting, red light could be seen on the fiber optic cable at that location. The problem should have been caused by the frequency converter factory's failure to fully consider during assembly. The fiber optic cable was replaced and kept away from the resistance. The specific situation is recorded in **Figures 17 and 18**.

Figure 17. Trigger fiber optic lapping to resistance.

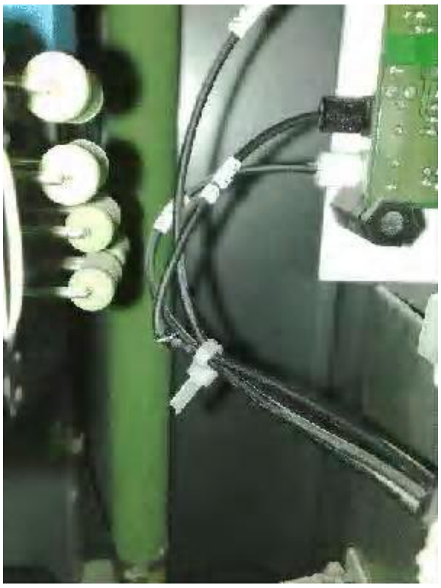


Figure 18. Trigger fiber after processing.

(4) Result feedback. After dealing with the damaged fiber optic cable, the system has been running for 1 and a half years now and everything is normal.

4. Conclusion

This article explores the common faults, alarms, and detailed handling processes that occur during the application of Siemens MASTERDRIVES 6SE70 series frequency converters in engineering projects, deepening our understanding of this series of frequency converters and providing a reference for the engineering applications of other series of frequency converters.

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