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Troubleshooting Principles

Always Verify:

Power
↓
Ground
↓
Communication
↓
Inputs
↓
Logic
↓
Outputs
↓
Mechanical/Hydraulic Action
↓
Feedback

Never Assume:

- Voltage = current capability
- Output = mechanical action
- Sensor fault = bad sensor
- Communication fault = failed controller
- Hydraulic fault = hydraulic-only issue

Root-Cause Thinking

Do not ask: "What part failed?"

Ask:

1. What should happen?
2. What condition is missing?
3. Why is it missing?
4. What upstream issue caused it?
5. What downstream effects resulted?

Technician Standards

- Troubleshoot methodically
- Verify before replacing
- Record measurements
- Understand system interaction
- Diagnose root causes
- Validate repairs completely

Guide 1 — Master Electrical Diagnostic Quick Guide

Technician Principle

Do *NOT* ask: “What part failed?”

Ask: “What condition is missing?”

Electrical Diagnostic Priority Order

1. Verify complaint
2. Check battery voltage
3. Check grounds
4. Check fuses/breakers
5. Check power distribution
6. Check communication
7. Check inputs/interlocks
8. Check outputs
9. Check actuator response
10. Verify feedback

Field Diagnostic Rules

Voltage Rules

- Always test under load
- Unloaded voltage can lie
- Low voltage creates false faults
- Ground problems mimic bad components

Connector Rules

Inspect for:

- Corrosion
- Loose pins
- Water intrusion
- Pin spread
- Broken locks
- Heat damage
- Harness Rules

Check:

- Chafing
- Pinch points
- Vibration damage
- Oil saturation
- Improper repairs
- Tight bends

Fast Power Checks

Check	Expected
24V System Battery	24–28VDC
12V System Battery	12–14VDC
CAN Resistance	~60 Ohms
Sensor Supply	5VDC
Ground Voltage Drop	<0.2V preferred

Most Common Failure Sources

Symptom	Common Cause
Random resets	Low voltage
Intermittent faults	Ground issues
Multiple failures	Power distribution
Communication loss	CAN wiring
False sensor readings	5V reference fault
Weak hydraulics	Low control voltage

Guide 2 — Power & Ground Quick Guide

Power Flow Checklist

Battery
↓
Disconnect
↓
Breaker/Fuse
↓
Relay
↓
Distribution Module
↓
Controller/Load
↓
Ground Return

Voltage Drop Rule

Excessive voltage drop indicates:

- Corrosion
- Loose connections
- Damaged wiring
- Weak grounds
- Overloaded circuit

Good Ground Requirements

- Clean metal contact
- No paint/rust
- Proper torque
- Low resistance
- Protected from moisture

Fast Power Checks

Problem	Check
No power	Main breaker/fuse
Intermittent power	Grounds/connectors
Low voltage	Battery/load test
Voltage present but no operation	Voltage under load
Multiple dead systems	Main distribution

Ground Failure Symptoms

Symptom	Likely Cause
Random controller resets	Poor ground
Dim lighting	High resistance
Sensor instability	Shared ground issue
Communication noise	Ground/shield issue
Hot connectors	Resistance

Field Test

Voltage drop test: Ground stud to battery negative while system is loaded

Preferred: < 0.2V drop

Guide 3 — Sensor Diagnostic Quick Guide

Sensor Troubleshooting Order

1. Verify supply voltage
2. Verify ground
3. Verify signal output
4. Verify connector integrity
5. Verify controller input
6. Verify calibration

Common Sensor Values

Sensor Type	Typical Signal
5V Transducer	0.5–4.5V
Proximity Sensor	Switching output
Temperature Sensor	Resistance change
Encoder	Pulse signal
Pressure Switch	Open/closed

Sensor Failure Clues

Symptom	Possible Cause
Frozen reading	Open circuit
Erratic reading	Ground issue
No response	No supply voltage
Intermittent signal	Connector issue
False alarms	Sensor drift

Sensor Diagnostic Rules

- Never assume sensor failure
- Compare live readings to known-good values
- Wiggle-test harnesses during live monitoring
- Check reference voltage stability

Field Sensor Tests

Analog Sensors

Verify:

- Supply voltage
- Ground quality
- Signal sweep

Digital Sensors

Verify:

- Switching state
- LED indicators
- Target alignment

Encoders

Verify:

- Pulse output
- Proper spacing
- Shield integrity
- Verify sensor power FIRST

Guide 4 — Can Bus & Network Quick Guide

CAN Diagnostic Order

1. Verify node power
2. Measure resistance
3. Verify CAN voltage
4. Inspect termination
5. Check shielding
6. Isolate failed nodes

Standard CAN Values

Test	Expected
CAN Resistance	~60 Ohms
CAN High	~2.5–3.5V
CAN Low	~2.5–1.5V
Terminators	Two 120Ω

Network Failure Clues

Symptom	Likely Cause
Entire network offline	Missing power
Intermittent communication	Harness damage
Random node loss	Bad ground
CAN resistance incorrect	Missing terminator
Noise/errors	Shield issue

CAN BUS Rules

- One failed node can crash network
- Poor grounds create communication noise
- Shield drains matter
- Stub lengths matter
- Corrosion changes resistance

Quick Isolation Method

Disconnect nodes ONE AT A TIME.

If network restores:

- Last disconnected node is suspect

Fast Harness Checks

Inspect for:

- Pinched twisted pair
- Improper splices
- Water intrusion
- Shield damage
- Connector corrosion

Guide 5 — PLC & Control System Quick Guide

PLC Diagnostic Order

1. Verify PLC power
2. Check status LEDs
3. Verify communication
4. Verify inputs
5. Verify logic conditions
6. Verify outputs
7. Verify feedback

Control Failure Clues

Symptom	Likely Cause
PLC dead	No power
Inputs missing	Sensor/interlock issue
Outputs inactive	Logic condition unmet
Random faults	Voltage instability
No communication	CAN/Ethernet issue

Input Logic Principle

Controller outputs only activate when:

- Inputs valid
- Interlocks satisfied
- Safety conditions met
- No active inhibits

Fast PLC Checks

Verify:

- Power supply voltage
- Ground stability
- Input state LEDs
- Output LEDs
- Communication indicators
- Fault indicators

Output Diagnostic Rule

Output LED ON does NOT guarantee:

- Voltage at device
- Wiring integrity
- Load operation
- Hydraulic movement

Control System Rule

Always verify:

Command → Output → Action → Feedback

Guide 6 — Electro-Hydraulic Quick Guide

Electro-Hydraulic Diagnostic Order

1. Verify command
2. Verify output voltage
3. Verify solenoid coil
4. Verify valve shift
5. Verify hydraulic pressure
6. Verify actuator movement
7. Verify feedback

Common Failure Clues

Symptom	Possible Cause
No movement	No electrical output
Weak movement	Low voltage
Slow operation	Hydraulic restriction
Intermittent operation	Coil overheating
No pressure	Pump issue

Solenoid Rule

Electrical click does NOT guarantee:

- Valve movement
- Hydraulic flow
- Pressure generation

Hydraulic Electrical Rules

- Verify voltage UNDER LOAD
- Heat changes coil resistance
- Pressure feedback matters
- Sticking valves mimic electrical faults
- Hydraulic failures can create electrical alarms

Quick Field Checks

Verify:

- Coil resistance
- Coil voltage
- Valve temperature
- Hydraulic pressure
- Actuator movement
- Feedback sensor status

Guide 7 — Safety Interlock Quick Guide

Safety Diagnostic Order

1. Verify E-stop status
2. Verify guard switches
3. Verify safety relay
4. Verify safety PLC
5. Verify reset conditions
6. Verify enable output

Safety Failure Clues

Symptom	Likely Cause
Machine inhibited	Interlock open
No hydraulic enable	Safety relay
No start condition	E-stop active
Reset failure	Safety logic issue

Safety Rule

Never bypass:

- E-stop systems
- Overspeed protection
- Brake safety
- Crush protection
- Guard interlocks

Unless specifically authorized by RRP procedures.

Safety Circuit Rules

- Safety systems fail SAFE
- Open circuit often = shutdown
- Safety relays require proper reset sequence
- Interlocks may be dual-channel

Quick Safety Checks

Verify:

- Relay LEDs
- E-stop continuity
- Guard alignment
- Reset logic
- Safe shutdown function

Guide 8 — Vision System Quick Guide

Vision Diagnostic Order

1. Verify camera power
2. Verify network connection
3. Verify image quality
4. Verify lighting
5. Verify processor status
6. Verify PLC integration

Common Vision Failures

Symptom	Likely Cause
No image	No power/network
Poor image	Dirty lens
False detection	Lighting issue
Auto mode disabled	Processor fault
Delayed response	Network latency

Camera Rule

Dirty lenses create:

- False negatives
- False positives
- Tracking loss
- Poor alignment

Fast Vision Checks

Verify:

- Lens cleanliness
- Camera mounting
- Ethernet connection
- Lighting quality
- Processor communication
- Calibration status

Vision System Rules

- Lighting matters as much as camera quality
- Vibration affects image quality
- Ethernet issues mimic camera failures
- Poor grounding creates image noise

Guide 9 — Intermittent Failure Quick Guide

Intermittent Failure Order

1. Attempt to reproduce
2. Monitor live data
3. Perform wiggle test
4. Heat/cool suspect areas
5. Check grounds
6. Monitor voltage under load

Intermittent Failure Clues

Symptom	Likely Cause
Happens during vibration	Harness damage
Happens when hot	Thermal failure
Happens in rain	Moisture intrusion
Random resets	Power instability
Multiple false faults	Ground issue

Most Common Intermittent Causes

- Loose grounds
- Connector corrosion
- Broken strands inside insulation
- Heat-sensitive electronics
- Water intrusion
- Vibration damage

Wiggle Test Method

Monitor:

- Live voltage
- CAN traffic
- PLC inputs
- Sensor readings

While moving:

- Harnesses
- Connectors
- Relays
- Fuse blocks

Thermal Failure Rule

Many failures only appear:

- Hot
- Cold
- Vibrating
- Wet
- Under load