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Diagnosis and Repair of Low-voltage Power-up Fault in the New Energy Vehicle

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Abstract: Aiming at a low-voltage power-up failure of a 2019 BYD Qin EV battery electric vehicle (BEV)—manifested as an inoperative remote keyless entry (RKE) function and an instrument cluster message of "Key not detected" during the push-button start sequence, this paper establishes a standardized diagnostic workflow of "symptom confirmation—cause analysis—stepwise troubleshooting—data verification." The case study shows that after the diagnostic scan tool failed to establish communication with the intelligent key electronic control unit (ECU), an abnormal supply voltage was measured at the intelligent key system controller; given that the wiring-harness continuity was within specification, the root cause was isolated to internal burnout (open circuit) of the supply fuse , and the system returned to normal operation after fuse replacement. This case verifies the effectiveness of the diagnostic strategy of "starting from system principles, tracing the signal flow step by step, and locating the fault point with measured data" in the maintenance of low-voltage control systems of new energy vehicles (NEVs), and provides a useful reference for the teaching and repair of similar keyless starting system faults.

Keywords: new energy vehicle;low-voltage power-up; intelligent key ECU; fault diagnosis; redundancy design

1. INTRODUCTION

With the rapid popularization of new energy vehicles (NEVs), the push-button start and passive keyless entry (PKE) systems have become standard equipment of battery electric passenger vehicles. Such systems involve signal interaction among multiple electronic control units (ECUs), including the body control module (BCM), the intelligent key (IK) ECU, and the instrument cluster. Their failure modes are often not the physical damage of a single component but the interruption of a certain link in the signal chain, which places higher demands on the service technician's understanding of system principles and logical troubleshooting capability.

In a repair case received by a franchised dealership, a BYD Qin EV exhibited the following symptoms: actuating the remote key produced no lock/unlock response; after entering the vehicle with the mechanical key and depressing the brake pedal and the start/stop button simultaneously, the instrument cluster displayed "Key not detected. Please bring the key close to the RF card reader to start the vehicle," and the vehicle failed to complete the low-voltage power-up sequence.

Although this fault does not involve the high-voltage (HV) system, it directly renders the vehicle inoperative, and the fault point is concealed, giving the case strong value for diagnostic teaching and repair practice. Taking this case as the research object, this paper first analyzes the low-voltage power-up process and the key signal design of the BYD Qin EV starting system, then performs fault diagnosis following a standardized procedure, and finally summarizes and discusses the diagnostic strategy, in order to provide a methodological reference for troubleshooting similar starting faults on the same vehicle model.

2. PRINCIPLE ANALYSIS OF THE KEYLESS START SYSTEM

2.1 Low-Voltage Power-Up Control Logic

The low-voltage power-up of the BYD Qin EV follows the control logic of "dual-condition confirmation—key authentication—relay engagement." After the driver unlocks the vehicle remotely with the smart key or enters via keyless access, the key is placed inside the vehicle and the driver depresses the brake pedal and the start/stop button simultaneously. Upon receiving the brake signal and the start request at the same time, the BCM interrogates the IK ECU for key information through the dedicated start subnet. The IK ECU searches for the key through the in-vehicle antennas and receives the key response; after successful authentication, it returns the valid key information to the BCM via the start subnet.

On receiving the correct key information, the BCM drives the IG1 relay to supply the instrument cluster with wake-up power; the cluster illuminates and the low-voltage power-up is completed. The above logic shows that a successful push-button start depends on three serial conditions: first, the brake signal and the start signal are received by the BCM simultaneously; second, start-subnet communication is normal; third, the IK ECU completes key authentication and returns the result. Failure of any link prevents the system from entering the power-up process, which is exactly the logical entry point of fault isolation in this case.

2.2 Dual-Path Power Supply Structure of the Instrument Cluster

The instrument cluster adopts a dual-path power supply architecture: one path is constant battery power (B+), fed through fuse F2/42 as the working supply of the cluster; the other is ignition-switched (IG) power, fed by the IG1 relay through fuse

F2/33 as the wake-up supply. Only when both supply paths and both ground paths are normal can the cluster illuminate. The dual-path structure implies that a cluster fault may originate from the loss of either the working supply or the wake-up supply, and both must be measured and verified separately during diagnosis.

2.3 Dual-Channel Redundancy Design of the Brake Switch

The start-request signal is the first condition of the power-up sequence, and its reliability directly determines system safety and availability. The brake switch of the BYD Qin EV employs a dual-contact configuration consisting of a normally closed (NC) contact and a normally open (NO) contact: the NC contact is supplied by the BCM, while the NO contact is fed with constant B+ from the instrument-panel fuse F2/4. When the driver depresses the brake pedal, the NO contact closes and connects to the F2/4 supply, transmitting the brake signal to the BCM and simultaneously energizing the brake lamps.

For brake-signal validation, the BCM requires the two channel signals to satisfy an inverse (complementary) logic; if either signal is implausible, the BCM rejects the brake-pedal signal as invalid. This design approach—using two signals for the plausibility monitoring of safety-related inputs—is also applied to signals such as the ignition switch and the accelerator pedal position, and constitutes a typical dual-channel redundancy design. The redundancy improves system fault tolerance, but it also means that both channels must be measured separately during diagnosis, since an abnormality in either path may cause a failed power-up.

The brake-switch signals can be verified at the G28 connector. With the vehicle in the battery-on state, a digital multimeter (DMM) in DC-voltage mode is used to back-probe the voltage between each terminal of the G28 connector and ground (GND) under the two pedal states of “released” and “depressed.” The standard measurement data are listed in Table 1.

Table 1. Brake-Switch Signal Acquisition at the G28 Connector

Terminal	Terminal Definition	Measuring Condition	Measured Signal
G28-1	Brake signal (ground-referenced) to BCM	Pedal released→depressed	0 V→12 V
G28-2	Normally grounded	Pedal released→depressed	0 V
G28-3	Brake signal (12 V) to BCM	Pedal released→depressed	12 V→0V
G28-4	Constant B+ supply	Pedal released→depressed	12 V

3. FAULT DIAGNOSIS PROCESS AND RESULTS

3.1 Fault Symptoms and Preliminary Analysis

The subject vehicle is a 2019 BYD Qin EV. The smart remote key failed to lock/unlock the doors; after entering the vehicle with the mechanical key and depressing the brake pedal and the start/stop button simultaneously, the instrument cluster displayed “Key not detected. Please bring the key close to the RF card reader to start the vehicle.” According to the control principle of the starting system, the cluster message indicates that the BCM failed to obtain valid key-authentication information, so the fault range can be confined to the key-authentication chain. Candidate root causes include: (1) a fault of the smart key fob itself (depleted transmitter battery or transmitter failure); (2) a fault of the IK ECU; (3) loss of the IK supply voltage or ground; (4) a start-subnet communication fault of the intelligent key system controller.

3.2 Step-by-Step Troubleshooting Procedure

Step 1—Rule out the smart key itself. When the remote key was actuated, the key indicator flashed normally, preliminarily ruling out a depleted key-fob battery. The key fob was then disassembled and its battery voltage measured with a voltmeter at approximately 3 V, within the normal range, confirming that the key itself operated normally.

Step 2—Verify the diagnostic communication link. A diagnostic scan tool was connected; selecting the “Intelligent Key” module indicated that the tester could not establish communication with the vehicle ECU. This phenomenon further narrowed the fault range from the entire “key-authentication chain” to the “IK ECU and its supply/ground circuit.”

Step 3—Measure the module supply voltage. Referring to the electrical schematic of the intelligent key system controller, the voltage between the supply pin KG25(A)-1 and GND was measured and found to be abnormal—below the specified range (specification: 11–14 V)—indicating a loss of module supply voltage.

Step 4—Measure the harness resistance to discriminate between a wiring fault and a component fault. With the negative battery terminal disconnected, the G2E connector of the instrument-panel junction box and the KG25(A) connector of the IK ECU were disconnected, and the end-to-end resistance of each harness circuit was measured with the voltmeter in resistance mode. The results and acceptance criteria are listed in Table 2. All measured values were within specification; the supply wiring was judged intact, and the fault was excluded from the harness and connectors.

Step 5—Inspect the supply fuse and confirm the root cause. Supply fuse F2/46 was checked with the DMM and found internally blown (open circuit). To exclude the secondary risk of “harness short-to-ground re-blowing the fuse,” the intelligent-key control circuit was restored, and the resistance from both the upstream (line) and downstream (load) sides of F2/46 to GND was measured in resistance mode; both readings indicated infinite resistance (no continuity). A short-to-ground in the wiring was thereby excluded, and the fuse was judged to have failed intrinsically.

Step 6—Replacement and verification. A fuse of identical specification was installed and the circuit restored. Remote keyless entry and the push-button start function returned to normal, the low-voltage power-up sequence completed normally, and the fault was rectified.

Table 2. Continuity Test Results of the KG25(A)–G2E Harness

Terminal	Terminal Definition	Condition	Spec./Ω	Judgment
KG25(A)-1—G2E-1	IK ECU supply	Power off	<1	Within spec
KG25(A)-9—GND	IK ECU ground	Power off	<1	Within spec
KG25(A)-10—GND	IK ECU ground	Power off	<1	Within spec

3.3 Diagnostic Result

The root cause of this case is the internal burnout (open circuit) of supply fuse F2/46 of the intelligent key system controller. The blown fuse deprived the IK ECU of its operating supply, so it could neither respond to the BCM's key-authentication request nor establish communication with automotive diagnostic scanner. Meanwhile, due to the interruption of the key-authentication chain, the instrument cluster displayed "Key not detected" according to the design logic. After fuse replacement, the fault symptom was completely eliminated, and the infinite resistance-to-ground measured on both sides of the fuse confirmed the absence of a short-circuit hazard, ruling out the cause of fault recurrence.

4. DISCUSSION

(1) The diagnostic path "from principle to measurement" is the key to success in this case. Instead of blind part replacement or disassembly inspection, the diagnosis started from the low-voltage power-up control logic. The cluster message first confined the fault range to the "key-authentication chain," which was then narrowed step by step through symptom observation (key indicator), communication verification (scan tool), voltage measurement (abnormal supply), and resistance measurement (intact harness), until the fault point was located at the fuse. The whole process used only two conventional tools—a voltmeter and a diagnostic scan tool—demonstrating the leading role of signal-flow analysis in fault diagnosis.

5. CONCLUSION

Taking the "Key not detected" starting fault of the BYD Qin EV as a case study, this paper presents a complete analysis from system principle to repair practice. The study shows that: (1) the root cause of the fault is the internal burnout of supply fuse F2/46 of the intelligent key system controller, and the fault was completely rectified after replacement; (2) the standardized diagnostic workflow of "symptom confirmation—cause hypothesis—voltage measurement—resistance measurement—component inspection—replacement verification"can accurately isolate the fault point without relying on parts substitution (swap testing), significantly improving diagnostic efficiency; (3) the dual-channel redundancy design of the brake switch requires the principle of "channel-by-channel measurement and cross-verification" in diagnosis. On this basis, future work may expand a case library of similar keyless start system faults and consolidate the diagnostic path of this paper into task worksheets for hands-on training, serving the cultivation of talent in NEV inspection and maintenance.

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