Intelligent Integrated Solution White Paper for Online Temperature Monitoring of Compact Bus Ducts

密集母线槽温度在线监测智能一体化解决方案白皮书

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Preface / 编写说明

1. Compiled in accordance with the construction planning of China's new power system, industrial intelligent upgrading, and power distribution renovation standards for data centers and high-end manufacturing. This white paper complies with IEC bus equipment monitoring standards and State Grid operation specifications, systematically sorting out the technical principles, integrated architecture, practical values, benchmark projects and industrial development strategies of compact bus duct temperature monitoring solutions.
本白皮书依托国内新型电力系统建设、工业智能化改造、数据中心与高端制造配电升级规划，遵循 IEC 母线设备监测标准、国网配电运维规范编制，系统梳理密集母线槽测温解决方案的技术原理、一体化架构、落地价值、标杆工程及行业发展战略。

2. This document focuses on the **full-domain online intelligent temperature monitoring solution for compact bus ducts**. It serves core scenarios including data centers, high-end manufacturing, commercial complexes, rail transit, new energy lithium batteries and power transmission & distribution. Targeting core heating hazards such as bus duct joints, plug-in boxes and feed terminals, it builds an early warning, intelligent diagnosis and closed-loop operation & maintenance system to form a standardized intelligent monitoring system for bus ducts.
本文核心推广**密集母线槽全域温度在线智能监测方案**，覆盖数据中心、工业高端制造、商业综合体、轨道交通、新能源锂电、电力输配等核心场景，聚焦母线槽接头、插接箱、馈电端核心发热隐患，构建主动预警、智能诊断、闭环运维体系，打造母线槽智能监测标准化技术体系。

3. All quantitative indicators, fault data and operation & maintenance benefits in this white paper are sourced from State Grid field test projects, industrial power

distribution operation reports and authoritative industry think tanks. It is applicable for bidding technical response, business promotion, project approval and professional technical exchanges.
全文所有量化指标、故障数据、运维成效均来源于国网实测工程、工业配电运维年报及权威行业智库，可直接用于招投标技术应答、商务宣讲、项目立项与专业技术交流。

1 Industry Insight: Development Challenges & Market Opportunities / 行业洞察：密集母线槽运维挑战与市场机遇

1.1 Policy & Market Dual-Driven: Optical Fiber Intelligent Temperature Monitoring Becomes a Rigid Demand / 政策市场双驱动：光纤智能测温成为母线槽运维刚需

1.1.1 National Policy Mandatory Requirements / 国内顶层政策硬性驱动

1. The new power system construction plan clearly requires core power distribution equipment to realize **state perception, online monitoring and active early warning**, completely eliminating the traditional passive maintenance mode of post-fault repair. As the core high-current power distribution equipment, intelligent upgrading of compact bus ducts has been included in the digital assessment indicators of power grids.
新型电力系统建设规划明确要求：配网核心输配电设备实现**状态感知、在线监测、主动预警**，全面淘汰事后抢修的传统运维模式，密集母线槽作为大电流配电核心设备，其智能化改造已纳入电网数字化考核指标。

2. Industrial digital transformation standards and data center infrastructure operation specifications mandate that key power distribution bus systems shall be equipped with full-domain temperature monitoring devices to realize 24/7 uninterrupted online monitoring, eliminate bus overheating fire and power outage risks, and ensure stable operation of high-end manufacturing, computing centers and new energy industries.
工信部数字化转型标准、数据中心基础设施运维规范明确要求：核心配电母线系统必须配置全域温度监测装置，实现 24 小时不间断在线监测，杜绝母线过热起火、停电宕机事故，保障高端制造、算力中心、新能源产业稳定运行。

3. Special fire safety rectification regulations stipulate that compact bus ducts installed in confined ceilings, computer rooms and enclosed interlayers shall be equipped with online temperature monitoring systems for ultra-early fire warning, which is included in building fire acceptance and regular inspection scope.

消防安全专项整治新规明确：吊顶、机房、密闭夹层内敷设的密集母线槽必须安装温度在线监测系统，实现极早期火情预警，纳入建筑消防验收及常态化巡检核查范围。

1.1.2 Continuous Expansion of Industry Market Scale / 全行业市场规模持续扩容

1. Domestic Market: The market scale of domestic compact bus ducts exceeded **32 billion RMB** in 2026, with supporting intelligent monitoring equipment market exceeding **6.8 billion RMB**. The intelligent upgrading demand for old industrial parks, commercial complexes and stock data centers continues to surge.
国内市场：2026 年国内密集母线槽市场规模突破 **320 亿元**，配套智能监测设备市场规模超 **68 亿元**；老旧厂区、商业综合体、存量数据中心配电改造落地，持续释放智能化升级需求。

2. Emerging Segmented Market: The penetration rate of high-current compact bus ducts in new energy lithium batteries, semiconductor manufacturing, supercomputing data centers and rail transit exceeds 90%. The annual compound growth rate of intelligent temperature monitoring equipment reaches **22.3%**, becoming a core incremental track for power distribution intelligence.
细分增量市场：新能源锂电、半导体、超算数据中心、轨道交通等高端场景大电流密集母线槽渗透率超 90%，智能测温设备年复合增长率达 **22.3%**，是配电智能化核心增量赛道。

3. Overseas Market: Infrastructure construction in Southeast Asia and power distribution upgrading of overseas data centers and new energy power stations continue to release incremental demands, making intelligent online monitoring solutions the global standard for bus duct operation & maintenance.
海外市场：东南亚工业基建、海外数据中心、新能源电站配电升级持续释放增量，母线槽智能监测方案逐步成为全球配电运维标准化配置。

1.4 Four Core Fatal Pain Points of Traditional Bus Duct Operation / 传统运维四大核心痛点

Compact bus ducts are widely laid in hidden spaces such as ceilings, pipe galleries and confined inter layers. Long-term high-load operation easily causes joint oxidation, bolt loosening, increased contact resistance and overheating. Industry fault statistics show that **92% of bus duct fire and power outage accidents are caused by joint overheating**, and traditional maintenance modes have inherent defects.
密集母线槽多敷设于吊顶、管廊、密闭夹层等隐蔽空间，长期高负荷运行易出现接头氧化、螺栓松动、接触电阻增大、过载发热等问题。行业故障数据显示，**92%的母线槽火灾、停电事故由接头过热引发**，传统运维模式存在根本性短板。

Pain Point 1: Blind Inspection Zones & Unpredictable Hidden Dangers / 痛点一：隐蔽工况盲区多，隐患无法前置排查

The fully enclosed structure of compact bus ducts makes internal operating conditions invisible to manual inspection. Traditional handheld infrared inspection only detects surface temperature, failing to capture hidden temperature rise risks at internal joints and busbar connection points. Accumulated minor overheating defects eventually lead to insulation breakdown, short circuit, fire and large-scale power outages.
密集母线槽全封闭结构导致内部工况人工不可视，传统手持红外巡检仅能检测表层温度，无法捕捉内部接头、母排连接点隐性温升隐患，微小缺陷持续累积，最终引发绝缘击穿、短路起火、大面积停电事故。

Pain Point 2: Passive Maintenance & Post-Fault Remediation / 痛点二：运维模式被动，完全依赖事后抢修

The industry’s mainstream "periodic inspection + fault repair" mode lacks real-time online perception capability. Bus duct temperature rise is gradual and concealed, and regular monthly/quarterly inspections cannot capture intermittent overload and aging temperature rise. Dangers are only discovered after accidents with uncontrollable losses.
行业主流“定期巡检+故障抢修”模式无实时感知能力，母线温升具备隐蔽性、渐进性特征，常规巡检无法捕捉短时过载、间歇发热隐患，隐患发现即事故，无前置处置窗口，故障损失不可控。

Pain Point 3: High Labor Cost, Low Efficiency & High Operation Risk / 痛点三：人工成本高、效率低、作业风险大

Bus ducts cover wide and scattered areas, mostly located in high-altitude and confined spaces. Full manual inspection of a single park requires 3-5 working days with high omission and error rates, resulting in rising labor costs and high operational safety risks.
母线槽覆盖范围广、点位分散，多处于高空、密闭复杂工况，单园区全覆盖人工巡检需 3-5 个工作日，漏检误检率高，人工运维成本逐年攀升，作业安全风险突出。

Pain Point 4: Huge & Irreversible Fault Losses in High-Risk Scenarios / 痛点四：高危场景故障损失大、不可逆

Bus ducts undertake core power supply tasks for data centers, semiconductor factories and lithium battery parks. A single overheating fault will cause shutdown, production halt and equipment burnout. Industry data shows that the average hourly loss of bus faults in high-end manufacturing factories reaches **186,000 RMB**, while data center power outage losses show exponential growth, easily triggering fire accidents and safety liability risks.
数据中心、半导体、锂电园区等场景中，母线槽承载核心设备供电，单次过热故障将引发宕机、停产、设备损毁。行业数据显示，高端制造厂区母线故障单次小时损失达**18.6 万元**，数据中心停电损失呈指数级增长，易引发火灾及安全生产责任事故。

2 Solution: Intelligent Online Temperature Monitoring

Integrated System / 解决方案：密集母线槽温度智能在线监测一体化系统

2.1 Core Architecture: Full-Domain Perception + Edge-Cloud Collaborative AI Design / 核心架构：全域无感监测+端云协同 AI 一体化设计

Abandoning traditional point-based temperature measurement and manual inspection modes, this solution takes**Distributed Temperature Sensing (DTS) optical fiber technology** as the core. It realizes full-coverage, blind-spot-free, 24/7 high-precision temperature monitoring for the entire bus duct line, joints, plug-in boxes and inlet/outlet terminals. Supported by edge computing and cloud AI diagnosis, it builds a full closed-loop intelligent operation system of "perception-analysis-warning-disposal-review". It adapts to new project installation and in-service renovation without power cut, no damage to original power distribution structure and zero live operation risks.

本方案摒弃传统点式测温、人工巡检模式，以**分布式光纤测温（DTS）技术**为核心，对母线槽全线、接头、插接箱、进出线端实现无盲区、全天候高精度测温。依托边缘计算+云端 AI 诊断，构建“感知-分析-预警-处置-复盘”全闭环智能运维体系，适配新建配套安装、存量不停电改造场景，不破坏原有配电结构、无带电作业风险。

2.2 Three-Tier System Operation Architecture / 系统三层运行体系

Tier 1: Full-Domain Blind-Spot-Free High-Precision Perception Network / 第一层：全域无盲区高精度感知网络

Special armored optical fibers are laid along the entire bus duct for non-contact passive monitoring. Free from direct contact with live high-voltage parts, the system features intrinsic safety and strong anti-electromagnetic interference capability. It realizes **24/7 millisecond-level data collection**, accurately capturing tiny temperature rises and abnormal temperature differences to eliminate manual inspection blind spots completely.

沿母线槽全线敷设铠装感温光纤，采用无源非接触式监测，与高压带电体无直接接触，本质安全、抗强电磁干扰。实现 **7×24 小时毫秒级数据采集**，精准捕捉微度温升、温差异常隐患，彻底消除巡检盲区。

Tier 2: Edge Intelligent Preprocessing Engine / 第二层：边缘端智能预处理引擎

Industrial edge gateways are deployed on-site for local data cleaning, filtering and

comparative analysis, avoiding network delay and signal interference caused by full cloud transmission. Built-in bus duct fault algorithm models can identify steady temperature rise, sudden temperature surge and local overheating in milliseconds, supporting local acousto-optic alarm and on-site pop-up reminders.
现场部署工业级边缘网关，实现温度数据本地清洗、滤波、比对分析，规避全量上云带来的延迟与干扰。内置母线故障算法模型，毫秒级识别稳态温升、突变温升、局部过热等故障，支持就地声光报警、弹窗提示。

Tier 3: Cloud AI Operation & Maintenance Platform (Core Hub) / 第三层：云端 AI 运维管理平台（核心中枢）

The cloud platform aggregates full-domain temperature data, equipped with AI intelligent diagnosis, trend analysis, fault tracing, statistical report and authority management functions. It automatically generates bus duct temperature thermal diagrams, temperature rise trend curves and equipment health scores, accurately locates fault points, predicts aging trends and pushes maintenance orders automatically. It realizes the transformation from "manual inspection" to "intelligent prediction and targeted maintenance" and supports docking with DCS, smart power platforms and fire control systems.
云端平台汇聚全域测温数据，搭载 AI 诊断、趋势分析、故障溯源、报表统计、权限管理功能，自动生成温度热力图、温升曲线、设备健康度评分，精准定位故障、预判老化、推送运维工单，实现人工巡检向智能靶向运维升级，支持对接园区 DCS、智慧电力、消防系统。

2.3 Core Technology: Distributed Optical Fiber Temperature Monitoring (DTS) / 核心测温技术：分布式光纤测温（DTS）全域监测技术

2.3.1 Working Principle / 核心工作原理

Based on **optical fiber Raman scattering effect and Optical Time-Domain Reflectometry (OTDR) technology**, the system adopts special armored temperature-sensing optical fiber as the only sensing medium laid along the entire bus duct. The host emits laser pulses into the optical fiber, and the backward Raman scattering light is highly sensitive to temperature changes. By analyzing the intensity ratio of anti-Stokes light and Stokes light, combined with self-developed temperature compensation and spatial calibration algorithms, the system obtains real-time precise temperature data of every point along the fiber, realizing **continuous distributed full-line temperature measurement** and completely breaking the point limitation of traditional discrete monitoring.
系统基于**光纤拉曼散射效应与光时域反射（OTDR）技术**，以特种铠装感温光纤为唯一传感载体，沿母线槽全程敷设。主机发射激光脉冲，利用背向拉曼散射光的温度敏感特性，通过解析反斯托克斯光与斯托克斯光强度比值，结合自研补偿校准算法，实

时获取光纤沿线所有点位精准温度，实现**全线连续分布式测温**，彻底突破传统点式监测局限。

The sensing optical fiber is completely passive and unpowered, with no electrical components, no heating risk and no electromagnetic induction hazard. It is an intrinsically safe monitoring technology, perfectly adapting to high-voltage, strong electromagnetic, flammable, humid and dusty complex working conditions.
传感光纤全程无源无电、无电气元件、无发热隐患、无电磁干扰风险，属于本质安全型监测技术，完美适配高压、强电磁、易燃易爆、潮湿粉尘等复杂高危工况。

2.3.2 Industry-Top Core Technical Indicators / 行业顶尖核心技术指标

1. Temperature Measurement Accuracy: ±0.1℃, ultra-high resolution 0.01℃, capable of capturing micro temperature rise hidden dangers;
测温精度：±0.1℃，超高分辨率 0.01℃，可捕捉微度温升隐患；

2. Spatial Positioning Accuracy: ≤0.5m, customized high-precision version up to 0.1m, accurately locating tiny overheating points;
空间定位精度：≤0.5 米，高精度定制版可达 0.1 米，精准锁定微小过热点；

3. Maximum Monitoring Distance: Single channel supports up to 20km full-domain temperature measurement, adapting to long-distance multi-section bus duct networking;
超长监测距离：单通道最长 20km 全域测温，适配超长多分段母线组网；

4. Temperature Measurement Range: -20℃ ~ 180℃, covering full working conditions of low-temperature operation, normal load, overload fault and short-circuit high temperature;
测温范围：-20℃ ~ 180℃，覆盖低温运行、常规负荷、过载、短路高温全工况；

5. Data Response Speed: Millisecond-level data refresh, second-level abnormal early warning without delay;
响应速度：毫秒级刷新，秒级预警，无监测延迟；

6. Environmental Adaptability: Resists extreme temperatures of -30℃~+70℃, 1000kV strong electromagnetic interference, dust, moisture, corrosion and extrusion;
环境适配性：耐受-30℃~+70℃极端工况，抗 1000kV 强电磁干扰，防尘防潮防腐蚀；

7. Service Life: Passive maintenance-free design, service life ≥20 years, matching the full life cycle of bus ducts;
使用寿命：无源免维护设计，寿命≥20 年，与母线槽设备同周期；

8. Data Security: Original data is tamper-proof and fully traceable, meeting power audit, fire acceptance and GMP compliance standards.
数据安全：原始数据不可篡改、全程可追溯，满足电力审计、消防验收、GMP 合规要求。

2.3.3 Eight Exclusive Core Application Functions / 八大核心独家应用功能

1. Full-line blind-spot-free continuous temperature measurement: Single optical fiber covers the entire bus duct without monitoring breakpoints, eliminating section monitoring omission risks;
全线无盲区连续测温：单纤覆盖母线全程，无断点无盲区，杜绝分段漏检；

2. Ultra-early warning of micro hidden dangers: Accurately identify gradual temperature rise caused by joint oxidation and bolt loosening, predicting hidden faults 72 hours in advance;
微隐患极早期预警：精准识别接头氧化、螺栓松动引发的渐进温升，提前 72 小时预判故障；

3. Multi-dimensional intelligent fault judgment: AI filters environmental interference through full-line temperature trend and loop temperature difference analysis, with near-zero false alarm rate;
多维智能研判：结合全线温度、回路温差、负荷数据过滤干扰，误报率趋近于零；

4. Accurate fault location and tracing: Visual thermal diagram display of overheating points, no need for manual section-by-section inspection;
故障精准溯源：过热点位热力图可视化展示，无需人工逐段排查；

5. Load anomaly linkage analysis: Predict equipment aging and overload risks based on long-term temperature and load big data;
负荷联动分析：依托温变大数据预判设备老化、过载隐患，支撑状态检修；

6. Multi-level linkage early warning: Supports on-site acousto-optic alarm, cloud pop-up, APP and SMS graded early warning, adapting to unattended computer rooms;
多级联动预警：就地声光、云端弹窗、APP、短信分级告警，适配无人值守场景；

7. Optical fiber break self-diagnosis and recovery: Local fiber break can be recovered by fusion splicing without affecting overall monitoring continuity;
断纤自修复：光纤局部断裂可熔接恢复，不影响全线测温连续性；

8. Full-cycle data retention: Stores more than 5 years of original temperature and fault data for review and lifecycle management.
全周期数据留存：原始数据、故障记录留存超 5 年，支撑全生命周期运维复盘。

2.3.4 Horizontal Comparison of Mainstream Monitoring Solutions (DTS Absolute Advantages) / 主流方案横向对比（凸显 DTS 光纤技术绝对优越性）

At present, mainstream bus duct temperature monitoring solutions include manual infrared inspection, fixed infrared point temperature measurement, wireless sensor temperature measurement and DTS optical fiber distributed temperature measurement. DTS technology has no obvious shortcomings and is the optimal

solution for high-risk and long-distance bus duct monitoring scenarios.
当前行业主流母线测温方案包含人工红外巡检、红外定点测温、无线传感测温、分布式光纤测温四类，DTS 光纤技术无明显短板，是高危、长距离母线场景的最优监测方案。

1. Comparison with Manual Handheld Infrared Inspection / 对比人工红外巡检

✕ **Traditional Disadvantages**: Only detects surface temperature, unable to monitor internal busbar and joint temperature; high-altitude confined operation with high safety risks; only periodic sampling, unable to capture intermittent overload temperature rise; extremely high omission and error rates, faults are discovered only after accidents with high labor costs.
✕ **传统短板**：仅检测表层温度，无法监测内部母排、接头温升；高空密闭作业风险高；仅周期性抽检，无法捕捉间歇过载温升，漏检误检率极高，隐患发现即事故，人工成本高昂。

✓ **DTS Advantages**: 24/7 automatic full-line monitoring, no manual on-site inspection required, eliminating high-altitude operation risks; in-depth monitoring of internal core heating points with zero blind spots, improving operation efficiency by over 90%.
✓ **光纤优势**：7×24 小时全自动监测，无需人工现场作业，规避高空风险；深度监测内部核心发热点位，零盲区零漏检，运维效率提升 90%以上。

2. Comparison with Fixed Infrared Point Temperature Measurement / 对比红外定点测温方案

✕ **Traditional Disadvantages**: Discrete point monitoring with limited coverage, unable to realize full-line continuous monitoring; severely affected by dust, moisture, light and shielding with large temperature errors and weak anti-interference ability; prone to dust failure requiring frequent manual calibration, only supporting regional early warning without precise positioning.
✕ **传统短板**：单点离散监测，覆盖范围有限，无法全线连续测温；受粉尘、水汽、遮挡干扰极大，测温误差大、稳定性差；易积灰失效，需频繁校准，仅区域预警、无法精准定位。

✓ **DTS Advantages**: Full-line continuous distributed temperature measurement without point limitation; completely immune to dust, moisture, shielding and strong electromagnetic interference with stable high precision; passive maintenance-free design with no regular calibration required and long-term stable operation.
✓ **光纤优势**：全线连续分布式测温，无点位局限；无惧粉尘潮湿、遮挡、强电磁干扰，精度稳定；无源免维护，无需校准，长期运行稳定性极强。

3. Comparison with Wireless Sensor Monitoring (Bluetooth/4G/ZigBee) / 对比无线传感测温方案

✕ **Traditional Disadvantages**: Live powered sensors with short-circuit and spark risks, prohibited in high-risk flammable scenarios; wireless signals are susceptible to

strong electromagnetic interference causing delay and disconnection; battery-powered requiring regular replacement with short service life and high maintenance cost; data is easy to lose and tamper with, failing compliance requirements.
❌ **传统短板**：终端带电运行，存在打火短路隐患，高危防爆场景禁用；无线信号易受强电磁干扰，频繁断连延迟；电池供电需定期更换，寿命短、运维成本高；数据易丢失篡改，无法合规。

✅ **DTS Advantages**: Fully passive and unpowered, intrinsically safe with zero electrical hidden dangers; optical signal transmission with anti-interference, zero delay and zero disconnection; no power supply or accessory replacement required, 20-year maintenance-free operation; tamper-proof data fully compliant with power and fire safety standards.
✅ **光纤优势**：全程无源无电、本质安全，无任何电气隐患；光信号传输抗干扰、零延迟、零断连；无需供电换件，20 年免维护；数据不可篡改，完全满足电力、消防合规标准。

4. Comprehensive Advantage Summary / 方案综合优势总结

Compared with all traditional monitoring methods, **DTS distributed optical fiber temperature measurement technology** has six core advantages: full-domain blind-spot-free coverage, intrinsic safety, high precision & stability, maintenance-free operation, long service life and strong compliance. It completely solves the monitoring pain points of hidden working conditions, high-risk environments and long-distance networking, and is the officially recommended full-domain temperature monitoring solution for State Grid, data centers and high-end new energy manufacturing scenarios.
相较于所有传统监测方式，**DTS 分布式光纤测温技术**具备全域无盲区、本质安全、高精度高稳定、免维护、长寿命、合规性强六大核心优势，彻底解决隐蔽工况、高危环境、长距离组网监测痛点，是国网、数据中心、新能源高端制造场景官方推荐的全域测温方案。

2.4 Model Upgrade: From Passive Maintenance to Active Full-Domain Intelligent Operation / 方案范式升级：从被动抢修到主动免疫式全域运维

Traditional bus duct operation is limited by monitoring blind spots, delayed response and unpredictable hidden dangers, resulting in passive fault repair mode. Supported by **DTS full-domain temperature measurement + AI intelligent diagnosis** core technology, this solution realizes full-path, full-time and full-state precise monitoring of bus ducts, moving the operation threshold forward. It builds a closed-loop active operation system of "hidden danger prediction-precise positioning-graded warning-targeted disposal-data review", increasing fault response efficiency by more than 85%, and realizing full lifecycle safety, intelligence and compliance control of bus ducts.

传统母线运维受监测盲区、响应滞后、隐患难预判限制，始终处于被动抢修困境。本方案依托 **DTS 全域测温+AI 智能诊断**核心技术，实现母线全路径、全时段、全状态精准监测，运维关口全面前置，构建“隐患预判-精准定位-分级预警-靶向处置-数据复盘”闭环主动运维体系，故障响应效率提升 85%以上，实现母线槽全生命周期安全、智能、合规可控。

3 Value Proposition: Three-Dimensional Improvement of Safety, Efficiency & Cost / 价值主张：安全、效率、成本三维全面提升

3.1 Safety Value: Active Defense to Eliminate Major Power Distribution Accidents / 价值一：主动安全防御，杜绝重大配电事故

1. Bus duct fault rate reduced by **90%**, eliminating short circuit, fire and power outage accidents by pre-disposing joint aging and loosening hidden dangers;
母线故障发生率下降 **90%**，提前处置接头老化松动隐患，从源头杜绝短路、起火、停电事故;

2. Completely eliminate manual inspection omission and error risks, realizing 100% full coverage monitoring of confined and high-altitude hidden points;
消除人工漏检误检风险，密闭、高空隐蔽点位实现 100%全覆盖监测;

3. Mean Time To Repair (MTTR) shortened from 6 hours to 1.2 hours, greatly reducing power outage and production halt duration;
故障修复时长由 6 小时压缩至 1.2 小时，大幅缩短停产停电时长;

4. Ultra-early fire warning provides sufficient disposal window to eliminate bus fire, equipment burnout and safety liability accidents.
极早期火情预警预留充足处置窗口，彻底杜绝母线火灾、设备损毁、安全责任事故。

3.2 Efficiency Value: Digital Operation Reform to Boost Labor Efficiency / 价值二：运维数字化革新，人力效率指数提升

1. Manual on-site inspection frequency reduced by **70%-80%**, replacing regular manual patrol with intelligent online monitoring;
人工巡检频次降低 **70%-80%**，智能在线监测替代传统人工拉网巡检;

2. Offline preventive power-cut tests reduced by 85%, realizing zero-power-cut and zero-production-halt monitoring;
停电预防性试验减少 85%，实现零停电、零停产监测;

3. Operation mode upgraded from "blind periodic inspection" to "targeted condition-based maintenance", greatly improving troubleshooting efficiency;
运维从“周期盲巡”升级为“状态靶向运维”，大幅提升故障排查效率；

4. Labor cost of power distribution operation reduced by 60% for industrial parks, realizing significant cost reduction.
园区配电运维人力成本精简 60%，年度运维人力开支大幅压降。

3.3 Cost Value: Optimized Full Lifecycle Cost (LCC) / 价值三：资产全生命周期成本优化

Short-Term Benefits (Effective in the renovation year) / 短期收益（改造当年见效）

1. Annual manual operation cost saved by **40%-50%**, reducing on-site operation and fault maintenance expenses;
年度人工运维成本节约 **40%-50%**，减少外勤作业、故障抢修开支；

2. Hidden losses caused by equipment downtime and damage reduced by over**65%**, avoiding huge production halt losses;
故障停机、设备损毁隐性损失降低 **65%**以上，规避高额停产损失；

3. Overall operation cost reduced by **45%** after intelligent renovation, with static investment payback period of only 2.5 years.
智能化改造后综合运维成本下降 **45%**，项目静态投资回收期仅 2.5 年。

Long-Term Lifecycle Benefits (20-Year Full Cycle) / 长期全周期收益（20 年生命周期）

1. Real-time operation monitoring delays equipment aging, extending bus duct service life by **20%-30%**;
实时监测延缓设备老化，母线槽使用寿命延长 **20%-30%**；

2. Reduce long-term investment in bus duct overhaul, parts replacement and overall renovation;
减少母线大修、配件更换、整体改造的持续性投入；

3. Meet power and fire compliance inspection standards, avoiding rectification costs and administrative penalties.
满足电力、消防合规验收标准，规避整改成本与合规处罚。

3.4 Scenario-Specific Customized Values / 细分场景专属定制价值

1. Data Center Scenario: Ensure uninterrupted power supply for high-density

computing equipment, avoid server downtime and computing interruption, adapt to 24/7 operation requirements and meet T3/T4 data center operation standards.
数据中心场景：保障高密度算力设备不间断供电，杜绝宕机、算力中断，适配 7×24 小时运行要求，满足 T3/T4 级运维标准。

2. New Energy Lithium Battery & Semiconductor Scenario: Eliminate electrical spark and bus fire risks in high-risk production environments, realize intrinsic safety monitoring, protect precision equipment and avoid huge production losses and safety accidents.
新能源锂电/半导体场景：高危生产环境杜绝电气火花、母线起火隐患，实现本质安全监测，保障精密设备稳定运行，规避产能损失与安全事故。

3. High-End Manufacturing Scenario: Adapt to dusty, high-temperature, humid and strong electromagnetic interference working conditions, ensure continuous production line operation and reduce production halt losses.
工业高端制造场景：适配粉尘、高温、潮湿、强电磁工况，全天候监测大电流母线状态，保障生产线连续运转，降低停产损失。

4. Rail Transit & Commercial Complex Scenario: Cover hidden bus points in tunnels, ceilings and confined computer rooms, realize full-domain safety monitoring and reduce fire operation risks of public power distribution facilities.
轨道交通/商业综合体场景：覆盖隧道、吊顶、密闭机房隐蔽母线点位，实现全域安全监测，降低公共配电消防运维风险。

4 Practical Verification: Benchmark Project Analysis & Effect Summary / 实践验证：标杆工程剖析与成效汇总

4.1 Power Distribution Benchmark: Prefectural Power Supply Bureau Bus Duct Intelligent Renovation Project / 电力配网标杆：地市供电局母线智能化改造项目

Targeting aging hidden dangers of bus ducts in urban distribution rooms and switch houses, the project deployed full-domain DTS optical fiber temperature monitoring systems to cover all core points such as bus joints, plug-in boxes and inlet/outlet terminals, building a cloud intelligent operation platform for unattended online monitoring.
针对城区配网机房、开闭所母线老旧隐患，全域部署 DTS 光纤测温系统，覆盖接头、插接箱、进出线端所有核心点位，搭建云端智能运维平台，实现无人值守在线监测。

Project Achievements / 落地成效:

1. Successfully discovered and disposed 36 hidden temperature rise faults throughout the year, achieving zero bus short-circuit and fire accidents;
全年处置隐性温升隐患 36 起，实现母线短路、起火事故清零；

2. Manual inspection workload reduced by 75%, saving 4.8 million RMB in annual operation costs;
人工巡检工作量下降 75%，年度运维成本节约 480 万元；

3. AI fault recognition accuracy ≥96%, fault positioning error ≤0.5m, troubleshooting efficiency improved by 90%;
AI 故障识别准确率≥96%，定位误差≤0.5 米，排查效率提升 90%；

4. Bus duct equipment failure rate decreased by 92% year-on-year, power supply reliability increased to 99.99%.
设备故障率同比下降 92%，供电可靠性提升至 99.99%。

4.2 Data Center Benchmark: Supercomputing Center Bus Monitoring Project / 数据中心标杆：超算算力中心母线监测项目

A domestic large-scale supercomputing center deployed a full-domain DTS temperature monitoring system for high-voltage compact bus ducts, docking with the intelligent operation platform to realize real-time state perception, intelligent early warning and closed-loop disposal.
国内大型超算中心针对高压密集母线槽部署全域 DTS 测温系统，对接智慧运维平台，实现状态实时感知、智能预警、闭环处置。

Project Achievements / 落地成效:

1. Completely eliminate hidden inspection blind spots of ceiling hidden bus ducts, realizing 100% full coverage monitoring;
彻底解决吊顶隐蔽母线巡检盲区，实现 100%全覆盖监测；

2. Realize ultra-early temperature rise warning with zero downtime and power outage accidents;
实现极早期温升预警，全年无宕机、停电事故；

3. Predictive operation replaces fault repair, significantly slowing down equipment aging and extending asset service life.
预防性运维替代故障抢修，有效延缓设备老化，延长资产使用寿命。

4.3 New Energy Benchmark: Lithium Battery Industrial Park Bus Renovation Project / 新能源标杆：锂电产业园母线改造项目

A large lithium battery production park deployed an intrinsically safe DTS temperature monitoring system for bus ducts in high-risk production workshops, adapting to dusty, high-temperature and flammable working conditions to eliminate electrical safety hazards.
大型锂电产业园为高危生产车间母线部署本安型 DTS 测温系统，适配粉尘、高温、易

燃易爆工况，彻底杜绝电气安全隐患。

Project Achievements / 落地成效:

1. Zero electrical safety accidents of bus ducts, meeting strict new energy industry safety production standards;
母线电气安全事故清零，满足新能源行业严苛安全生产标准；

2. No power-cut detection required, ensuring full-load continuous production all year round;
无需停电检测，全年保障生产线满负荷连续生产；

3. Quantifiable and traceable equipment health status, realizing full lifecycle digital management.
设备健康度可量化、可追溯，实现全生命周期数字化管控。

4.4 Complex Working Condition Adaptability Summary / 复杂工况适配能力总结

The DTS optical fiber monitoring system stably adapts to complex working conditions such as confined ceilings, underground pipe galleries, high-temperature workshops, high dust and strong electromagnetic interference. It supports new project installation and in-service renovation without power cut, no damage to original power distribution structure, strong compatibility, low renovation cost and high long-term operation stability.
DTS 光纤监测系统可稳定适配密闭吊顶、地下管廊、高温车间、高粉尘、强电磁干扰、高危易燃易爆等复杂工况，支持新建配套安装、存量不停电改造，不破坏原有配电结构，兼容性强、改造成本低、运维稳定性高。

4.5 Unified Quantitative Benefit Summary / 项目量化成效汇总

1. Fault hidden danger positioning accuracy improved within 0.5m, up to 0.1m for high-precision scenarios;
故障隐患定位精度≤0.5 米，高精度场景可达 0.1 米；

2. Early warning response speed increased by 600%, realizing millisecond-level alarm and second-level disposal;
预警响应速度提升 600%，毫秒级告警、秒级处置；

3. System false alarm rate reduced by 95% via AI environmental interference filtering;
AI 智能过滤干扰，系统误报率下降 95%；

4. Annual manual operation cost reduced by 40%-50%, fault loss reduced by over 65%;
人工运维成本年均降幅 40%-50%，故障损失降幅超 65%；

5. Zero major safety accidents in all scenarios, reaching industry-leading power supply reliability.
全场景重大安全事故清零，供电可靠性达到行业顶尖水平。

5 Strategic Suggestions: Empower Industrial Digital & Safety Upgrading / 战略建议：赋能母线槽行业数字化安全升级

5.1 Enterprise Differentiation Strategic Positioning / 企业差异化战略定位

Build a professional integrated solution service provider integrating **bus duct intelligent temperature monitoring, AI cloud operation and customized full-scenario services**. Focus on the power distribution safety digital track, build independent software and hardware technical barriers, and provide standardized and customized intelligent safety solutions for power, computing, high-end manufacturing and new energy industries.
打造**母线槽智能测温+AI 云端运维+全场景定制**一体化服务商，聚焦配电安全数字化赛道，构建软硬件一体化技术壁垒，为电力、算力、高端制造、新能源行业提供标准化、定制化智能安全解决方案。

5.2 Three Core Development Directions / 三大核心发展方向

5.2.1 Independent & Controllable Core Technology / 核心技术自主可控

Continuously deepen the R&D of underlying algorithms such as distributed optical fiber sensing, multi-signal fusion and AI fault diagnosis, optimize environmental compensation and interference filtering technologies, realize full independent control of core software and hardware, and guarantee the safety and stability of power infrastructure.
深耕分布式光纤传感、多信号融合、AI 故障诊断底层算法研发，优化环境补偿、干扰过滤技术，实现核心软硬件自主可控，保障电力基础设施安全稳定运行。

5.2.2 In-Depth Scenario Customization / 行业场景深度定制

Abandon generalized universal products, customize exclusive monitoring strategies, early warning thresholds, operation models and platform functions for six core scenarios to accurately match working condition pain points and compliance requirements, realizing scenario-based precise empowerment.
摒弃通用化产品思路，针对六大核心场景定制专属监测策略、预警阈值、运维模型、

平台功能，精准匹配工况痛点与合规要求，实现场景化精准赋能。

5.2.3 Industrial Ecological Co-Construction / 全产业链生态共建

Cooperate with bus duct manufacturers, power system integrators, intelligent operation platforms and fire control service providers to jointly build industrial monitoring standards and data interconnection systems. Promote the upgrading of bus ducts from traditional electrical equipment to intelligent sensing terminals, reduce industrial operation costs and lead the digital, intelligent and safe upgrading of power distribution equipment.
联动母线厂家、电力集成商、智慧运维及消防服务商，共建行业监测标准与数据互通体系，推动母线设备智能化升级，降低行业运维成本，引领配电设备数字化、智能化、安全化发展。

Appendix: Core Data Summary Table / 附录 核心数据汇总表

Indicator / 指标名称	Value / 数值	Data Source / 数据来源
2026 Domestic Compact Bus Duct Market Scale / 2026 年国内密集母线槽市场规模	32 Billion RMB / 320 亿元	Power Equipment Industry Annual White Paper / 电力设备行业年度白皮书
Annual Compound Growth Rate of Intelligent Monitoring Equipment / 智能监测设备年复合增长率	22.3%	New Energy Distribution Industry Research Institute / 新能源配电产业研究院
Proportion of Bus Accidents Caused by Joint Overheating / 接头过热引发母线故障占比	92%	State Grid Distribution Equipment Fault Statistics Annual Report / 国网配电设备故障统计年报
Average Hourly Loss of Bus Faults in High-End Manufacturing / 高端制造母线故障单次小时损失	186,000 RMB / 18.6 万元	Industrial Safety Operation Report / 工业安全生产运维报告

Temperature Measurement Accuracy & Resolution / 测温精度/分辨率	±0.1℃ / 0.01℃	Industrial Sensing Equipment Test Report / 工业传感设备检测报告
AI Fault Recognition Accuracy / AI 故障识别准确率	≥96%	Power Grid Field Test Data / 电网实测工程数据
Annual Operation Cost Reduction Rate After Renovation / 改造后年度运维成本降幅	45%	Multi-Industry Renovation Project Measured Data / 多行业改造实测数据
Project Static Investment Payback Period / 项目静态投资回收期	2.5 Years / 2.5 年	Full Lifecycle Cost Calculation Model / 全生命周期成本测算模型
Annual Cost Saving of Single Power Bureau Project / 单供电局项目年度节约成本	4.8 Million RMB / 480 万元	Power Operation Project Annual Report / 电力运维项目落地年报
Manual Inspection Workload Reduction Rate / 人工巡检工作量降幅	70%-80%	Bus Intelligent Renovation Special Research Data / 母线智能化改造专项调研数据

Reference Website / 参考网站: www.adatpower.com