# Appendix D-3 Research papers, patents and projects

| Order number | Paper's title | Author (Author Ranking) | Publication, Publication Date |
|---|---|---|---|
| 1 | Prediction of superior thermoelectric performance in unexplored doped-BiCuSeO via machine learning | Peng Jinlin (1st author) | Materials & Design 2023, 229, 111868 |
| 2 | Clutter suppression algorithm with joint intrinsic clutter motion errors calibration and off-grid effects mitigation in airborne passive radars | Deng Yaqi (1st author) | Applied Sciences 2023, 13, 5653 |
| 3 | Misfit-strain phase diagram, electromechanical and electrocaloric responses in epitaxial PIN–PMN–PT thin films | Peng Jinlin (corresponding author) | Materials 2022, 15, 7660 |
| 4 | Consensus-based distributed secondary frequency control method for AC microgrid using ADRC technique | Li Wenguo (1st author) | Energies 2022, 15, 3184 |
| 5 | Clutter suppression method for off-grid effects mitigation in airborne passive radars with contaminated reference signals | Deng Yaqi (1st author) | Sensors 2021, 21, 6339 |
| 6 | A fully decentralized multi-agent fault location and isolation for distribution networks with DGs | Li Wenguo (1st author) | IEEE Access 2021, 9, 27748-27757 |
| 7 | Integrated multistage self-healing in smart distribution grids using decentralized multiagent | Li Wenguo (1st author) | IEEE Access 2021, 9, 159081-159090 |
| 8 | Clutter suppression methods based on reduced-dimension transformation for airborne passive radar with impure reference signals | Deng Yaqi (1st author) | Journal of Applied Remote Sensing 2021, 15(1), 016514 |
| 9 | Three-dimensional infinite element forward modeling of CSAMT based on equivalent field source method | Zhang Lincheng (1st author) | Oil Geophysical Prospecting 2021, 56(3): 622-630. |
| 10 | A full decentralized multi-agent service restoration for distribution network with DGs | Li Wenguo (1st author) | IEEE Transactions on Smart Grid, 2020, 11(2): 1100-1111 |
| 11 | On-Line PID parameters optimization control for wind power generation system based on genetic algorithm | Li Jiasheng (1st author) | IEEE Access 2020, 8: 137094-137100 |

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|---|---|---|---|
| 12 | Cascaded suppression method based on joint iterative optimization for airborne passive radar | Deng Yaqi (1st author) | Digital Signal Processing 2020, 100, 102686 |
| 13 | A new differential backup protection strategy for smart distribution networks: a fast and reliable approach | Li Wenguo (1st author) | IEEE Access 2019, 7: 38135-38141 |
| 14 | Maximizing network resilience against malicious attacks | Li Wenguo (1st author) | Scientific Reports 2019, 9, 2261 |

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# Prediction of superior thermoelectric performance in unexplored doped-BiCuSeO via machine learning

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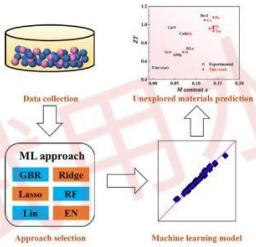
## HIGHLIGHTS

- A machine learning model for predicting the *ZT* value of thermoelectric materials has been established.
- The *ZT* values of doped BiCuSeO have been predicted by our machine learning model.
- Two new superior thermoelectric materials as $Bi_{0.86}Po_{0.14}CuSeO$ and $Bi_{0.88}Cs_{0.12}CuSeO$ have been predicted successfully.
- It provides an alternative way for exploration and design of high-performance thermoelectric materials.

## GRAPHICAL ABSTRACT

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## ABSTRACT

BiCuSeO compound is a promising thermoelectric material, which has attracted many experimental studies through trial-and-error approaches to improve its thermoelectric performance by element doping, such that a fast and efficient prediction of thermoelectric property for unexplored and rarely explored doped-BiCuSeO is highly desired. In this work, a machine learning (ML) model for predicting the *ZT* value of *M* element doped-BiCuSeO ($Bi_{1-x}M_xCuSeO$) has been established via the correlation analysis for descriptors and the comparison among different ML approaches. The results show that Gradient Boosting Regressor is the most appropriate approach for our ML model, which is well validated by comparing the predicted and experimental *ZT* values for the cases in the dataset. The ML model is also used to predict the *ZT* values of $Bi_{1-x}M_xCuSeO$ with unexplored and rarely explored doping element *M*, and the optimal doping elements as well as their doping contents are screened out. The results indicate that the *ZT* of $Bi_{0.86}Po_{0.14}CuSeO$ (Po-doped) and $Bi_{0.88}Cs_{0.12}CuSeO$ (Cs-doped) are higher than that of pure BiCuSeO, and are improved by 104 % and 98 % at the 923 K, respectively. The enhancement is well explained by the first-principles calculations. The findings offer a guideline for exploring superior thermoelectric performance in BiCuSeO.



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*Article*

# Clutter Suppression Algorithm with Joint Intrinsic Clutter Motion Errors Calibration and Off-Grid Effects Mitigation in Airborne Passive Radars

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**Abstract:** In an airborne passive radar, multipath (MP) clutter, which is caused by MP signals contained in the contaminated reference signal, degrades the space-time adaptive processing (STAP) performance. The MP clutter suppression algorithm before STAP can mitigate the influence of impure reference signals. However, the performances of the existing MP clutter suppression methods deteriorate when the intrinsic clutter motion (ICM) exists because the sparse model of MP clutter is disturbed. To eliminate the impacts of ICM on MP clutter suppression, a joint optimization algorithm is developed for airborne passive radar. Firstly, the sparse model of MP clutter is modified by taking ICM fluctuation into account. Subsequently, the joint optimization function of the ICM fluctuation and MP clutter profile is derived. Finally, based on the local search technique, MP clutter is suppressed with ICM error calibration and off-grid effects mitigation. A range of simulations verify the reliability and superiority of the proposed method.

**Keywords:** intrinsic clutter motion; joint optimization problem; space-time adaptive processing (STAP); airborne passive radar; reference signal



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## 1. Introduction

Airborne passive radars exploit the existing transmitters as emitters of opportunity, having attracted widespread attention in recent years [1–7]. Compared with airborne active radars, the lack of dedicated transmitters offers the advantages of low cost, strong survivability, and antijamming. However, the moving airborne platform leading to the received ground clutter is extended in terms of the Doppler frequencies and angle. Thus, it is difficult for a traditional spatial or temporal filter to detect targets.

Space-time adaptive processing (STAP), which uses multichannel spatial information across a sequence of temporal pulses to form a two-dimensional filter, is a crucial technology in airborne passive radar for clutter cancellation. However, the application of STAP is restricted by practical problems, such as excessively high computational complexity and a large number of the required training snapshots. Subsequently, extensive research on STAP mainly considered how to reduce the computational burden and enhance the convergence speed. However, the practical implementation of STAP in airborne passive radar is based on the assumption that the reference signal is uncontaminated. When this condition is not satisfied, the clutter caused by the direct-path (DP) signal (DP clutter) and multipath (MP) signal (MP clutter) affects the covariance matrix estimation. Consequently, the target self-nulling phenomenon may exist [8].

The MP clutter cancellation approach before STAP can eliminate the influence of impure reference signals in airborne passive radars. Existing MP clutter suppression

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# Misfit-Strain Phase Diagram, Electromechanical and Electrocaloric Responses in Epitaxial PIN–PMN–PT Thin Films

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**Abstract:** $x$Pb($In_{1/2}Nb_{1/2}$)$O_3$-(1−$x$−$y$)Pb($Mg_{1/3}Nb_{2/3}$)$O_3$−$y$$PbTiO_3$ (PIN–PMN–PT) bulks possess excellent electromechanical coupling and dielectric properties, but the corresponding epitaxial PIN–PMN–PT thin films have not yet been explored. This paper adopts a nonlinear thermodynamics analysis to investigate the influences of misfit strains on the phase structures, electromechanical properties, and electrocaloric responses in epitaxial PIN–PMN–PT thin films. The misfit strain–temperature phase diagram was constructed. The results reveal that the PIN–PMN–PT thin films may exist in tetragonal *c*-, orthorhombic *aa*-, monoclinic *M*-, and paraelectric PE phases. It is also found that the *c*-*M* and *aa*-PE phase boundaries exhibit a superior dielectric constant $\varepsilon_{11}$ which reached $1.979 \times 10^6$ with $u_m = -0.494\%$, as well as the *c*-*M* phase boundary showing a large piezoelectric response $d_{15}$ which reached $1.64 \times 10^5$ pm/V. In comparison, the c-PE and M-aa phase boundaries exhibit a superior dielectric constant $\varepsilon_{33}$ over $1 \times 10^5$ around um = 0.316% and the piezoelectric response $d_{33}$ reached 7235 pm/V. The large electrocaloric responses appear near the paraelectric-ferroelectric phase boundary. These insights offer a guidance for experiments in epitaxial PIN–PMN–PT thin films.

**Keywords:** misfit strain; PIN–PMN–PT; electrocaloric effect; ferroelectric thin films



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## 1. Introduction

Ferroelectric materials, which exhibit a polarization with electromechanical coupling [1,2], have been employed in actuators, sensors, piezoelectric energy harvesters, storage devices, etc. [3,4]. Excellent performance is the key to the application of ferroelectric materials, which prompts people to continuously explore ferroelectric materials with an excellent performance [5–7]. Piezoelectric materials contain defects such as ferroelectric domains, oxygen vacancies, defect dipoles, and the strain [8–10]. $PbMg_{1/3}Nb_{2/3}O_3$−$PbTiO_3$(PMN–PT) can reach an ultrahigh piezoelectric response ($d_{33}$ > 2000 pC/N) and has electromechanical coupling factors ($k_{33}$ > 0.9) [11], which have attracted much attention [12–15]. The novel ternary compound $x$Pb($In_{1/2}Nb_{1/2}$)$O_3$-(1−$x$−$y$)Pb($Mg_{1/3}Nb_{2/3}$)$O_3$−$y$$PbTiO_3$ (PIN–PMN–PT) has been proposed to increase the coercive field and phase transition temperature of these materials without a change in the piezoelectric properties [16–18]. Thus, compared with PMN–PT, PIN–PMN–PT remains a more ferroelectric state which is stable under high temperatures.

There are more studies on PIN–PMN–PT bulk. For instance, in the experimental aspect, Li et al. [11] investigated the ferroelectric, dielectric, elastic, piezoelectric, and electromechanical properties of tetragonal PIN–PMN–PT crystals. The electromechanical coupling exhibited a high dc bias electric field stability compared to its rhombohedral counterpart, and the single domain piezoelectric coefficients $d_{33}$ and $d_{15}$ were found to be

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# Consensus-Based Distributed Secondary Frequency Control Method for AC Microgrid Using ADRC Technique

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**Abstract:** To ensure safe and reliable operation, the ability to ride through various disturbances is vital for a microgrid with multi-inverters. As the voltage and frequency support comes from the power-electronic-based inverters, it is necessary to find a proper control strategy to improve the rejection ability of the DG inverter against disturbances. In this regard, this paper proposes a new distributed secondary frequency control approach for islanded microgrids, in which the main purpose is to remove the frequency deviation under droop control method with better disturbance rejection performance. Unlike many traditional approaches which rely on a detailed control model, the proposed one needs little model information thanks to the model-independent characteristic of active disturbance rejection control (ADRC) technique. A linear extended state observer is introduced to estimate the useless model dynamics (including unknown disturbances, unmodeled dynamics and nonlinear dynamics) which are then compensated in the control input. After the active compensation procedure, the nonlinear frequency control model can be converted into a quasi-linear model, based on which a proportional distributed control algorithm is established to restore the frequency and equalize the active power among the DGs. Simulation results based on a four-inverter-based microgrid show that the proposed approach achieves frequency restoration, active power sharing, as well as satisfactory disturbance rejection performance.

**Keywords:** distributed control; microgrid; frequency deviation; unmodeled dynamics; disturbance rejection



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## 1. Introduction

With the rapid development of industry and technology, there is a growing demand for electricity, which leads to a considerable increase in energy consumption. As the renewable energy is environmentally friendly, the development of renewable energy has become a hot topic in order to cope with the energy crisis [1–3]. Unlike fossil energy, it is difficult to utilize renewable energy in a centralized way because renewable energy is usually geographically dispersed. Therefore, distribution generation has become an effective way to utilize these energy resources [4,5].

As an important part of smart grid, a microgrid is a small-scaled power generation and distribution system to integrated renewable energy, which is composed of distributed generations (DGs), energy storage equipment, loads and other equipment [6,7]. A microgrid can work in grid-connected operation mode and islanded operation mode. At the normal operation of power grid, the microgrid works in grid-connected operation mode, and the voltage and frequency regulation of the microgrid depends on the power grid [8]. When the power grid goes through unexpected fault, the static switch will automatically act to disconnect the microgrid from the power grid, which means that microgrid enters the islanded operation mode. In this occasion, the DGs in the microgrid are responsible for maintaining the islanded system's operation as the support from power grid is unavailable [9].

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# Clutter Suppression Method for Off-Grid Effects Mitigation in Airborne Passive Radars with Contaminated Reference Signals

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**Abstract:** For an airborne passive radar with contaminated reference signals, the clutter caused by multipath (MP) signals involved in the reference channel (MP clutter) corrupts the covariance estimation in space-time adaptive processing (STAP). In order to overcome the severe STAP performance degradation caused by impure reference signals and off-grid effects, a novel MP clutter suppression method based on local search is proposed for airborne passive radar. In the proposed method, the global dictionary is constructed based on the sparse measurement model of MP clutter, and the global atoms that are most relevant to the residual are selected. Then, the local dictionary is designed iteratively, and local searches are performed to match real MP clutter points. Finally, the off-grid effects are mitigated, and the MP clutter is suppressed from all matched atoms. A range of simulations is conducted in order to demonstrate the effectiveness of the proposed method.

**Keywords:** passive radar; airborne radar; clutter suppression; off-grid effect; reference signal



**Citation:** Deng, Y.; Li, W.; Zhang, S.; Wang, F.; Xiao, W.; Cui, Z. Clutter Suppression Method for Off-Grid Effects Mitigation in Airborne Passive Radars with Contaminated Reference Signals. *Sensors* **2021**, *21*, 6339. https://doi.org/10.3390/s21196339

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## 1. Introduction

Passive radars, which utilize existing commercial sources as emitters of opportunity, offer advantages of low cost and strong survivability than compared to active radars [1,2]. Airborne passive radars apply passive radar technology on an airborne platform, providing the additional benefits of reduced terrain masking effect and improved detection abilities [3–6]. However, the motion of the platform causing ground clutter has angle and Doppler frequencies in airborne passive radars, which makes it challenging for conventional one-dimensional methods to separate targets from clutter.

Space-time adaptive processing (STAP) is a key tool for clutter suppression in airborne passive radar [7,8], where the reference signal is exploited for covariance matrix estimation. However, the traditional STAP requires a large number of independent and identically distributed training snapshots. It is difficult to collect the sufficient samples in heterogeneous environments. In addition, the high complexity in the computation of the high-dimensional covariance matrix inversion restricts the applicability of STAP. Many suboptimal STAP algorithms have been proposed to address these issues. Reduced-dimension STAP [9–11] and reduced-rank STAP [12,13] can reduce the number of required snapshots to twice of the reduced dimension or twice of the clutter rank. The training data selectors [14] can improve the target detection ability in heterogeneous environments with dense outliers. Recently, knowledge-aided STAP has demonstrated enhanced detection performances with minor training support by exploiting the prior knowledge [15–17]. Lately, Sparse representation technology has been widely considered in various fields [18,19], which encourages research on sparse-aware STAP. Sparse-aware STAP reconstructs the clutter covariance matrix by using sparse representation techniques, improving suppression capability and offering high-resolution imagery in a deficient-training-sample situation [20–22]. Assuming that

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# A Fully Decentralized Multi-Agent Fault Location and Isolation for Distribution Networks With DGs

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**ABSTRACT** The modern distribution automation suggests to enable decentralized self-healing of distribution networks using advance metering and controlling infrastructure. Decentralized fault location and isolation, as an essential and vital component of self-healing, has attracted considerable attention over the years. In this paper, an integrated fault location and isolation strategy based on fully decentralized multi-agents system (FDMAS) is presented for distribution system with distributed generators (DGs) by combining the primary protection with device failure protection (i.e., backup protection). The proposed FDMAS strategy can locate and isolate electrical fault rapidly even under device failures with minimum fault clearance time and range by using expert logical rules, meanwhile can detect and identify device failure adaptively. Furthermore, a unified programming framework is developed for generalization and application of the proposed strategy. The simulation studies are carried out on 22-bus distribution system by using dynamic model test platform. The test results show that the proposed strategy has an excellent performance on fault clearance time, fault isolation range and device failure detection.

**INDEX TERMS** Multi-agents, device failure protection, device failure detection, distribution networks.

## I. INTRODUCTION

### A. BACKGROUND

Distribution systems present the final link between utilities and customers. Generally, a distribution system works in radial configuration for a simple design, protection coordination and the minimum of fault current [1]. However, the ever-increasing structural complexities of distribution networks bring greater risk of fault occurrence [2], on the other hand, the volatility and uncertainty of renewable distributed generators (DGs) becomes a new challenge for system management and operation [3], [4]. Furthermore, the quality of electric power service is put on a high level in some high-quality-service areas such as industrial manufacturing center and Hi-tech Zone [5], [6]. In this connection, some new technical specifications [7], [8] have been issued currently, in which the power service interruption is limited to milliseconds and the device failure protection (i.e., backup protection) is recommended to be deployed aggressively and the backup fault isolation area is limited to the upper relay (or circuit breaker (CB)) level correspondingly. Hence, new self-healing operating paradigm equipped with intelligent measurement, communication and control infrastructures is suggested for modern distribution [9]. As a key building block of the self-healing capability, the fault detection is to discover and locate a fault by alarms based on high currents and/or low voltages, and fault isolation must segregate the fault from both directions by opening the first upstream and downstream switches quickly. While the device failure protection aims to furnish backup fault location and isolation with device failure detection function under primary protection failure (which, after all, must be caused by failed devices such as communication, current transducer (CT) and CB) [1]. In recent years, the multi-agent-based approaches, especially,

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# Integrated Multistage Self-Healing in Smart Distribution Grids Using Decentralized Multiagent

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**ABSTRACT** Smart self-healing is perceived as a new alternative to ensure reliability and quality of power supply with the development of intelligent communication and control technology. On the basis of multistage characteristics of self-healing control, this article proposes an integrated multistage self-healing strategy for smart distribution systems using multiagent system (MAS), in which the complex self-healing problem is decomposed into phased sub-problems and is addressed by a unified control framework composed of different algorithms of stages. In the proposed control framework, decision-making agents vary with fault points and transition between self-healing stages making the technique fully decentralized. Stressing on the coordination between stage algorithms composed of communication self-adaption, fault tolerance, fault location and isolation, service restoration and state regression, the proposed strategy features well real-time control performance and relatively complete self-healing functions. Comprehensive simulation studies are carried out on the 84-bus and 22-bus distribution systems using MATLAB and JADE and the self-healing test platform respectively, and the test results have shown the effectiveness of the proposed strategy.

**INDEX TERMS** Multiagent system, self-healing, service restoration, network reconfiguration.

## I. INTRODUCTION

### A. BACKGROUND

Distribution systems present the final link between utilities and customers. Practically, once a fault occurs in a distribution network without advanced automation, the feeder circuit breaker (CB) will generally shut down power on the entire feeder, interrupting the service to many customers such as industrial, commercial and residential ones [1]. Moreover, the growing penetration of distributed generators (DGs) has brought greater risk of fault occurrence due to bi-directional power flow, increased fault currents, voltage fluctuation and unpredictable operating parameters [2]. Bearing in mind the practical outage lessons, developing a smart distribution grid with self-healing capacity becomes of great indispensable and urgency. The concept of self-healing control is first defined by the Electric Power Research Institute (EPRI). It refers to self-perception, self-diagnosis, self-decision and self-recovery of the distribution grid under different conditions with minimal human intervention [3]. Self-healing control aims to optimize the operation and dispose of the hidden trouble during normal operation; while after fault, the main purpose of self-healing control is to detect and isolate the fault and restore service as soon as possible, and to assist the distribution system in returning to pre-fault configuration when the faulty section is repaired by crews [4].

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### B. PREVIOUS RESEARCH

Primary protection control mainly provides fault detection, location and isolation once a fault occurs. The traditional centralized location and isolation methods, including time-overcurrent method, recloser-fuse or relay coordination method [5], apparent impedance-based method [6], three-phase circuit analysis-based method [7], travelling wave-based method [8] and artificial intelligence-based method [9], are the currently mainstreams and effective ones, especially for radial distribution systems. However, the volatility and uncertainty of DGs bring a new dilemma for these methods,

# Clutter suppression methods based on reduced-dimension transformation for airborne passive radar with impure reference signals

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**Abstract.** For an airborne passive radar with impure reference signals, the clutter caused by multipath (MP) signals involved in the reference channel (MP clutter) corrupts the space–time adaptive processing performances. To eliminate the influence of the MP clutter, two clutter suppression methods based on reduced-dimension (RD) transformation are proposed herein. RD transformation is exploited to reduce the size of the sparse recovery dictionary. Subsequently, the sparse recovery problem is revised, and the MP clutter is suppressed using the least mean square (LMS) algorithm and the exponentially forgetting window LMS algorithm. Compared with the existing $L_1$-based recursive least square algorithm, the proposed algorithms significantly reduce computational complexity without degrading the MP clutter suppression performance. In addition, the proposed algorithms provide more robust characteristics to the errors in prior knowledge than the modified blind equalization method. A range of simulations is conducted to test the proposed algorithms. © *2021 Society of Photo-Optical Instrumentation Engineers (SPIE)* [DOI: 10.1117/1.JRS.15.016514]

**Keywords:** airborne radar; passive radar; reference signal; space–time adaptive processing; sparse recovery.

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## 1 Introduction

Traditional passive radar, which utilizes the existing transmitter as an illustrator of opportunity, offers the advantages of cost-effectiveness and covert operation as compared with an active radar.[1–4] Passive radar technology has been widely considered in various fields and has grown exponentially in the past few decades. These developments encourage studies on airborne passive radars. Airborne passive radar is an attractive technology for situational awareness because of its additional advantages, such as effective target detection ability and enhanced wave propagation condition.[5–8] However, because of the moving receiver, the ground clutter received by an airborne passive radar is extended in terms of the angle and Doppler frequencies, which makes it challenging for airborne passive radars to detect targets when using a traditional one-dimensional filter, that is, a spatial filter or temporal filter.

Space-time adaptive processing (STAP) is considered a leading technology for clutter suppression and target detection in airborne radar systems.[9–11] However, several limitations of airborne passive radars restrict the applicability of the full-dimension STAP algorithm. A full-dimension STAP algorithm requires a large number of independent and identically distributed training snapshots, which is impractical in heterogeneous environments. In addition, the high-dimensional covariance matrix inversion involves highly complex computations. This hinders the employment of the STAP method in real-time applications. Finally, in airborne passive radars, the reference signal contaminated by multipath (MP) signals results in spectrum expansion and performance degradation of the optimal STAP algorithm.

To overcome these drawbacks, several suboptimal STAP algorithms have been developed. Reduced-dimension (RD) STAP algorithms,[12–16] such as the multiple Doppler channels joint

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# 等效场源法的 CSAMT 三维无限元正演模拟

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**张林成,胡宏伶,汤井田,肖卫初,肖晓,原源.等效场源法的 CSAMT 三维无限元正演模拟.石油地球物理勘探,2021,56(3):622-630.**

**摘要**　针对传统 CSAMT 三维正演场源奇异性及无穷边界处理等问题,提出了一种基于等效场源的 CSAMT 三维无限元快速高精度正演模拟算法。首先,通过精确计算场源附近一定范围内网格节点的电磁场,实现水平电偶极源的精确模拟;然后,采用无限元代替传统截断边界条件,通过有限元—无限元耦合法和并行直接求解方法,实现基于等效场源的 CSAMT 三维快速精确求解。均匀半空间模型测试结果验证了算法的正确性。同时,以趋肤深度公式为基础,开展了场源等效模拟的最佳范围研究,数值结果表明对于场源的等效加载范围最好不低于 1.5 倍趋肤深度。

**关键词**　等效场源　无限元　并行直接求解　趋肤深度

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## 0　引言

随着深部资源勘探的不断深入,要求可探测深度越来越大[1]。可控源音频大地电磁测深法(CSAMT,Controlled Source Audio Electromagnetic Method)[2]以勘探深度大、抗干扰能力强、工作效率高等特点成为研究热点,是中深部资源勘探的重要手段之一。该方法在隐伏矿体勘察、复杂地区页岩气勘探、地热资源调查及海洋油气勘探等领域都取得了良好效果[3-4],成为发展快且前景可期的地球物理勘探方法之一。

CSAMT 电磁场正演的主流方法主要有边界单元法、有限差分法、积分方程法和有限单元法四种,其中有限单元法以其理论系统化、适应性强、计算精度高、弱解可微等优点得到了更多的重视和应用。Coggon[5]于 1971 年提出了大地电磁问题的有限元模拟方法,自此有限元计算在电磁领域得到了极大的发展。CSAMT 有限元数值模拟中,边值问题包括控制方程和边界条件两个方面。对于控制方程,由于场源存在奇异性,场源的处理方式是关键,常用的方法有二次场法和总场法,其中二次场法是主流。二次场法将场分解为背景场和异常场,背景场利用均匀半空间或层状模型解析解可直接计算,二次场则通过有限元法求取[6-12]。总场法直接从总场着手,采用近似法模拟奇异性场源特征(例如伪 delta 函数法),然后通过有限元求解场值[13-22]。在 CSAMT 三维有限元正演模拟中,无论采用总场法还是二次场法,场值的求解精度都是正演模拟是否成功的标志,因此开展不同场源方案下场值求解精度的研究十分必要。

一般来说,对于边界条件的处理基本上采用传统截断边界方法[6-22],即在一个相对较大的区域内,将无穷边界问题近似为有限区域,这往往会造成有限元计算区域太大、节点数太多、存储量过大和计算耗时过长等问题。较合理的边界处理策略应该是将

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# A Full Decentralized Multi-Agent Service Restoration for Distribution Network With DGs

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***Abstract*—The ever-growing requirement for reliability and quality of power supply suggests to enable self-healing features of smart distribution network using intelligent communication and control. In this article, a concept of fully decentralized multi-agent system (FDMAS) automation is proposed to build a unified restoration service framework for distribution network with distribution generators (DGs), where an FDMAS interaction mechanism is designed for establishing a reduced model which can significantly reduce the computational dimensions of service restoration. Furthermore, an FDMAS-based strategy is proposed for service restoration by combining network reconfiguration with intentional islanding; especially a network reconfiguration algorithm based on network flow model is presented, which, along with parameter justification, can mitigate the variations of loads and intermittence of DGs. The simulation studies are carried out on the 84-bus and 22-bus distribution system, respectively, using MATLAB and java agent development framework (JADE) simulation system and dynamic model test platform. The test results show that the proposed strategy can maximize restoration of out-of-service loads with minimum switching times and has an excellent performance on service restoration time.**

***Index Terms*—Distribution system, distributed generators (DGs), intentional islanding, network reconfiguration, service restoration, fully decentralized multi-agent system (FDMAS).**

## I. Introduction

THE GROWING expansion of structural complexity in modern distribution systems, along with higher penetration of distributed generators (DGs), has brought greater risk of fault occurrence [1]. Even though technologies can be employed to mitigate possible fault to some extent, most faults and outages are inevitable in distribution systems [2]. When a fault occurs in the distribution system, the fault may be insulated by corresponding protection devices but the out-of-service areas with no faults will lose power [3]. Therefore, an effective and reasonable service restoration procedure is a critical way to improve the power supply reliability and the customer satisfaction. Service restoration aims to find the appropriate healthy paths or the intentional islands powered by DGs [4], [5], at the maximization of out-of-service load restoration within the shortest time interval to minimize the number of switching operations and preserve distribution system operation limits [6].

The centralized restoration service methods, including mathematical optimization algorithms [7], [8], heuristic algorithms [9] and artificial intelligence algorithms [10]–[12], are the currently mainstream and effective ones because they can provide global optimization solution, especially for small-scale systems. However, these methods depend solely on a control center, i.e., a supervisory control and data acquisition (SCADA) system. The communication and computation become prohibitive for large-scale networks as all decisions are taken by such a control center [13]. Moreover, these centralized methods would lead to single points of failure, which in turn, may cause a large-scale blackout [6], [13].

Owing to their extensibility, maintainability and concurrency, the intelligent multi-agent-systems (MASs) have been deployed as a new technology for control and service restoration of distribution systems in recent years [14]. The MASs are distributed problem-solving systems, and generally a complex problem in MASs can be decomposed into many simpler sub-problems and can be collaboratively addressed by different agents, each of which possesses the capability to take critical decisions based on circumstance. According to architectures, the MAS-based methods can be classified into centralized, decentralized, and hierarchical (or hybrid) ones.

In centralized multi-agent system (CMAS) there is a central agent that will coordinate and communicate with other agents to control the entire distribution system for system management, maintenance and restoration [15]. The data jams and the need for high-performance central agent are distinct disadvantage of this method [16]. To solve the problems aforementioned above, the hierarchical multi-agent-system (HMAS) has been introduced recently, in which the highest level agent makes decision while the lower level agents communicate

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# On-Line PID Parameters Optimization Control for Wind Power Generation System Based on Genetic Algorithm

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**ABSTRACT** An on-line PID parameter optimization control for the wind power generation system based on a genetic algorithm is proposed in this paper. Firstly, the anti-saturation PID control strategy is involved with considering the instability and complexity of the wind power source. Further, a genetic algorithm is introduced for an on-line optimization of the PID parameters. The simulation studies are carried out on a control model of wind power, using MATLAB simulation system. It is demonstrated that the proposed control strategy can not only solve the integral saturation, but also suppress the harmonics in the output waveform and enhance the power factor of system.

**INDEX TERMS** Anti-saturation, genetic algorithm, online optimizing, PID parameters.

## I. INTRODUCTION

Nowadays, owing to the shortage of fossil energy, the wind power is considered as a primary candidate of the primary energy source in the future. However, an instability of the wind power brings a great challenge for the practical applications [1]–[5]. It is therefore necessary to find an effective control method to address this issues aforementioned above.

Many researchers have focused on the wind power. In [6], a control algorithm was proposed to realize the maximum wind energy tracking by using a rotational inertia power of a rotor. The proportional controllers in [7], [8] were added to a traditional power control algorithm, which speeded up to capture a wind energy. A review of the currently applied methods of a wind power generation forecasting was presented in [9]. Due to different properties of the input data, there are some difference between the physical and statistical methods. The physical method is usually based on numerical weather prediction models, using data related to atmospheric conditions, terrain, and wind farm characteristics. However, the statistical method uses historical data sets to determine the dependence of output variables on input parameters.

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From the perspective of the quality of results, the hybrid methods are the most favorable ones. Determining the best model depended on many factors is a complicated task. The applied model may be highly accurate at given conditions, but it may be completely unsuitable for other wind farm. Reference [10] emphasized on various available harmonic mitigation techniques, which ensured the safeguarding of grid connected doubly fed induction generators from the harmful effects of harmonics. According to the principle of dual power flow wind power generation system and the mathematical model of EVT motor, herein a control strategy of the wind power generation system is presented, including the maximum wind energy tracking control under the rated wind speed, the pitch control above the rated wind speed, EVT Internal rotor speed control, grid-connected power control, energy storage unit charge and discharge control. The dual power flow wind power generation system can effectively mitigate the wind energy fluctuations. As a consequence, wind energy efficiency has been improved. In [11], a nonlinear control method based on sliding mode theory was proposed, which can realize the maximum wind energy tracking control. Reference [12] proposed a multi-resonant PR control in the basis of grid-connected current feedback capacitor current feedback, which can realize no static control of AC

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# Cascaded suppression method based on joint iterative optimization for airborne passive radar

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ABSTRACT

To overcome the severe space-time adaptive processing (STAP) performance degradation caused by array gain/phase (GP) errors and undesirable random range sidelobe couplings, a novel cascaded suppression method based on joint iterative optimization is proposed for airborne passive radar. The proposed cascaded method (CM) exploits the sparse nature of these undesirable sidelobe couplings, reformulates the sparsity recovery problem as a joint optimization problem of the spatio-temporal profile and array GP errors, and achieves sidelobe couplings suppression before STAP. A range of simulations is conducted to test the proposed method.



## 1. Introduction

The passive radar system uses existing transmitters, such as frequency modulation broadcast, digital video broadcasting-terrestrial (DVB-T) and global position system, as the illuminator of opportunity [1–5]. Compared with traditional active radar, passive radar has advantages of strong survivability and covert operation, thereby attracting wide attention from different fields. The development of passive radar technology has prompted a study applying this technology to an airborne platform, i.e. airborne passive radar. The elevated position of the receiver platform provides additional advantages, including increased visible detection range and a better wave propagation condition [6,7]. However, owing to the motion of the receiver platform, the ground clutter is spread over a region in Doppler frequency, which restricts the applicability of the conventional one-dimension filter.

Space-time adaptive processing (STAP) is a critical technology that is widely used in airborne radar systems for clutter suppression [8–10]. However, in the optimal STAP processor, the number of required independent and identically distributed (IID) training snapshots is considerably large, and the computational complexity is excessively high. Many suboptimal STAP algorithms have been proposed to overcome such limitations [11–17]. Reduced-dimension STAP algorithms, such as joint-domain localization [13] and auxiliary channel processor [14], and reduced-rank STAP algorithms, such as multistage Wiener filter [15] and principal component analysis [16], can reduce the number of IID snapshots required to achieve less than 3 dB of signal-to-interference-plus-noise-ratio (SINR) loss than clairvoyant STAP [18]. Recently, knowledge-aided STAP, which exploits some prior knowledge, has been developed to improve the target detection performance [19,20]. More recently, STAP based on sparse recovery (SR-STAP) algorithms have gained a lot of attention [21–23]. SR-STAP applies the SR algorithms to construct the clutter covariance matrix, thereby providing high-resolution imagery with small training support. All of these STAP algorithms could obtain the desired performance in real environments for an airborne radar system. The main obstacle hindering these methods for airborne passive radar system is the random range sidelobe couplings of the strong clutter and direct path signal, which significantly affect the clutter suppression performance [24].

The cascaded method (CM), which aims at eliminating sidelobe couplings before STAP, is a practical approach for airborne passive radar [24–26]. By applying a least-squares (LS)-based adaptive algorithm before STAP, CM-LS can alleviate the effect of sidelobe couplings on STAP [24]. However, this method requires a high computational complexity for matrix inversion, thereby restricting its applicability. Based on the distribution property of strong clutter, two improved CMs have been proposed [25,26]. In CM-LMS [25], the sparse nature of undesirable sidelobe couplings is exploited, and the reconstruction algorithm is used to suppress these couplings with low computational complexity. In CM based on the range-Doppler-space algorithm (CM-RDS), making use of the directional dependence of strong clutter, the designed range-Doppler-space cancellation algorithm can cancel clutter along the ridge and avoid the cancellation of targets [26]. However, array gain/phase (GP) errors, which are hardly avoided in practice [27,28], disturb

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# A New Differential Backup Protection Strategy for Smart Distribution Networks: A Fast and Reliable Approach

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**ABSTRACT** The integration of distributed generations (DGs) is transforming the traditional radial single-source distribution system into a complex multi-source one which requires its related protection is able to maintain proper coordination under bidirectional power flow conditions. Although the conventional backup protection methods are effective up to a certain level of DG penetration, they are incompetent for higher service demands such as high DG penetration and protective rapidity. To deal with such a problem, a fast and reliable backup protection strategy is presented on the basis of a proposed device detection method. In the proposed backup strategy, the device failure-related backup protection is started in advance to accelerate the fault isolation by locking the failed primary protection which can be predicted by the proposed device detection method. The presented strategy possesses an excellent performance on rapidity and stability. Particularly, the fault isolation area is only expanded to the upper level circuit breaker via our protection strategy. The performance of the proposed backup strategy has been validated by the realistic system and the real-time digital simulator (RTDS) system.

**INDEX TERMS** Backup protection, differential protection, device detection, distribution networks.

## I. INTRODUCTION

With growing power demand and increasing concern about low-carbon environment, the new paradigm of distributed generation (DG) is gaining commercial and technical importance across the globe, especially in distribution networks [1]. Actually, economic incentives for renewables in most countries provide a boost to pervasion of DG, which is expected to grow further. Owing to the increasing penetration of DGs, the traditional distribution network is undergoing a change from the single source and radial system to the complex multi-source one, which in turn, would result in conflicts with the correct protection operations/procedures of the present distribution networks [2]. Integration of DGs requires that its related protection is capable of maintaining proper coordination under bidirectional power flow conditions (i.e., remaining the grid-connection of DGs for a short time under fault conditions) [3]. The protection must also be effective under unpredictable fault currents.

Furthermore, the quality of electric power service is put on a high level in some high-quality-service areas with high penetration DGs such as industrial manufacturing center and Hi-tech Zone [4], [5]. In China Southern Power Grid and State Grid, some new technical specifications for distribution automation system (DL/T 721-2013, DL/T 814 [6] and Q/CSG1203017-2016 [7]) require that power service interruption is limited to milliseconds and the backup failure isolation area can be only extended to the upper relay (or breaker) level. In such cases, a fast and reasonable backup protection procedure is therefore necessary for improving the power supply reliability and the customer satisfaction.

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# Maximizing Network Resilience against Malicious Attacks

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**The threat of a malicious attack is one of the major security problems in complex networks. Resilience is the system-level self-adjusting ability of a complex network to retain its basic functionality and recover rapidly from major disruptions. Despite numerous heuristic enhancement methods, there is a research gap in maximizing network resilience: current heuristic methods are designed to immunize vital nodes or modify a network to a specific onion-like structure and cannot maximize resilience theoretically via network structure. Here we map complex networks onto a physical elastic system to introduce indices of network resilience, and propose a unified theoretical framework and general approach, which can address the optimal problem of network resilience by slightly modifying network structures (i.e., by adding a set of structural edges). We demonstrate the high efficiency of this approach on three realistic networks as well as two artificial random networks. Case studies show that the proposed approach can maximize the resilience of complex networks while maintaining their topological functionality. This approach helps to unveil hitherto hidden functions of some inconspicuous components, which in turn, can be used to guide the design of resilient systems, offer an effective and efficient approach for mitigating malicious attacks, and furnish self-healing to reconstruct failed infrastructure systems.**

Maximizing network resilience is of great importance because it helps to mitigate the impact of perturbations or failures and suggests an emergency solution to repair the network[1–4]. Recently, considerable research effort has been devoted to enhancing network resilience against malicious attacks[5–25], including immunization strategies[5,6,10–16] and topological construction methods[17–25]. Most of the immunization strategies map the problem onto the identification of vital nodes, which, if immunized, would mitigate the diffusion of a large scale failure. However, the strategies cannot essentially improve network resilience from a topological structure, and it is impossible to find a universal index to quantify the importance of a node well in every situation[16].

The problem of maximizing network resilience with topological construction is to find an optimal set of edge swaps (or edge additions). The heuristic edge-swap (ES) methods[17–21] can enhance network resilience by modifying a network to a specific onion-like structure. However, the computations of these methods become prohibitively expensive, especially for the large scale networks; on the other hand, the networks optimized by the ES methods have a great change in topological structures (onion-like structures), which has an impact on the functionality of the original networks. In the heuristic edge-addition (EA) methods[22–25], for a given network, the new edges between the nodes with lowest degrees are added into the original network. The EA methods have a good performance on computational complexity; however, they possess few effect on resilience optimizations. Furthermore, both the ES and the EA methods cannot optimize network resilience globally. As a consequence, they cannot well maintain the topological functionality of a network and their performance on resilience improvement cannot be guaranteed.

Measurement of resilience is essential for addressing the resilience optimization problem, yet there are no universally accepted indices of network resilience. Conventionally, the resilience (or robustness) of networks is measured by critical (percolation) threshold[2–6] which is equivalent to the maximum external force in physical elastic systems. Hence, the measurement cannot fully characterize the elastic properties of nonlinear networks (see also Fig. S1). Ref.[17] defined a robustness measurement $R$, but without mathematical deductive inference and

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|---|---|---|---|
| 1 | A self-healing recovery method for distribution networks based on distributed multi-agent | Invention patent, March 2023 | Li Wenguo |
| 2 | A household inductive solar street light | Invention patent, February 2022 | Li Jiasheng |
| 3 | A battery module fixing and protecting device | Utility Model, November 2021 | Lin Lin |
| 4 | A synchronous cleaning device for solar street lights | Invention patent, October 2021 | Li Jiasheng |
| 5 | An automatic dishwasher with internal and external washing functions | Invention patent, October 2021 | Li Jiasheng |
| 6 | A damage-proof automatic dishwashe | Invention patent, October 2020 | Li Jiasheng |
| 7 | r A method for adjusting the proportion of ethanol-gasoline dual fuel injectors | Invention patent, September 2020 | Li Wenguo |
| 8 | An automated tile disassembly and assembly device | Invention patent, April 2020 | Hu Saichun |
| 9 | An automated tile installation device | Invention patent, April 2020 | Li Jiasheng |
| 10 | An intelligent temperature-controlled automatic flipping and frying device | Invention patent, September 2019 | Li Jiasheng |
| 11 | A mobile automatic intelligent flipping and frying vehicle | Invention patent, July 2019 | Li Jiasheng |
| 12 | A sock drying machine with sterilization and infrared remote control | Invention patent, December 2018 | Li Jiasheng |
| 13 | A portable electronic communication device | Utility Model, November 2018 | Lin Lin |
| 14 | A small-load industrial robot | Utility Model, September 2018 | Cui Zhi |
| 15 | A control method for a vehicle engine oil-electric-gas hybrid power output device | Utility Model, August 2018 | Li Wenguo |
| 16 | A foil and paper feeding device for capacitors | Invention patent, May 2018 | Zhang Xuejun |
| 17 | A quantity collection trolley for capacitor production | Utility Model, May 2018 | Zhang Xuejun |
| 18 | A visual inspection intelligent trolley for capacitor production | Utility Model, May 2018 | Zhang Xuejun |

| | | | |
|---|---|---|---|
| 19 | A system for cleaning street lights using raindrops | Invention patent, May 2018 | Li Jiasheng |
| 20 | A street light that maintains lighting intensity | Invention patent, May 2018 | Li Jiasheng |
| 21 | A pressure sensing system for street lights | Invention patent, May 2018 | Li Jiasheng |
| 22 | An online detection method and device for harmonics of distributed power sources | Invention patent, February 2018 | Li Jiasheng |
| 23 | An automatic rotating reciprocating high-efficiency street light cleaning system | Invention patent, January 2018 | Li Jiasheng |
| 24 | An intelligent control device for security and patrol monitoring in large communities | Invention patent, January 2018 | Li Jiasheng |

证书号第5765778号

# 发明专利证书

发 明 名 称：一种基于分布式多代理的配电网自愈恢复方法

发 明 人：李稳国;李勇;周迭辉;谭益;曹一家;彭衍健;曾子龙
张明敏

专 利 号：ZL 2020 1 1473696.1

专利申请日：2020年12月15日

专 利 权 人：珠海博威电气股份有限公司;湖南城市学院

地 址：519000 广东省珠海市香洲区金业一路128号3栋1-5层

授权公告日：2023年03月07日　　授权公告号：CN 112653138 B

国家知识产权局依照中华人民共和国专利法进行审查，决定授予专利权，颁发发明专利证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。专利权期限为二十年，自申请日起算。

专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

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申长雨

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2023年03月07日



其他事项参见续页

证书号第4913081号

# 发明专利证书

发明名称：一种家用感应式太阳能路灯

发 明 人：李加升;熊洁;李稳国;谭跃

专 利 号：ZL 2020 1 0325948.X

专利申请日：2020年04月22日

专利权人：湖南城市学院

地 址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2022年02月01日　　授权公告号：CN 111550728 B

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国家知识产权局

2022年02月01日



其他事项参见背面

证书号第14654234号

# 实用新型专利证书

实用新型名称：一种电瓶模组固定保护装置

发　明　人：林琳

专　利　号：ZL 2020 2 3312488.1

专利申请日：2020年12月31日

专利权人：湖南城市学院

地　　址：413000 湖南省益阳市迎宾东路518号湖南城市学院

授权公告日：2021年11月09日　　授权公告号：CN 214648754 U

国家知识产权局依照中华人民共和国专利法经过初步审查，决定授予专利权，颁发实用新型专利证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。专利权期限为十年，自申请日起算。

专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长
申长雨

国家知识产权局
2021年11月09日



其他事项参见续页

证书号第4725254号

# 发明专利证书

发明名称：一种太阳能路灯同步清洁装置

发　明　人：李加升;肖卫初;邓杨保;李稳国;谭跃

专　　利　　号：ZL 2020 1 0322070.4

专利申请日：2020年04月22日

专利权人：湖南城市学院

地　　址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2021年10月08日　　授权公告号：CN 111545489 B

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申长雨

国家知识产权局
2021年10月08日



其他事项参见续页

证书号第4187727号

# 发明专利证书

发明名称：一种带内外刷洗功能的自动洗碗机

发 明 人：李加升;熊洁;邓杨保;胡赛纯;肖卫初;邓曙光

专 利 号：ZL 2019 1 0227553.3

专利申请日：2019年03月25日

专利权人：湖南城市学院

地 址：413000 湖南省益阳市赫山区湖南城市学院

授权公告日：2021年01月05日　　授权公告号：CN 109820461 B

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专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

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国家知识产权局

2021年01月05日



其他事项参见背面

证书号第4025312号

# 发明专利证书

发明名称：一种防破损自动洗碗机

发　明　人：李加升;邓杨保;熊洁;胡赛纯;肖卫初;邓曙光

专　利　号：ZL 2019 1 0227552.9

专利申请日：2019年03月25日

专利权人：湖南城市学院

地　　址：413000 湖南省益阳市赫山区湖南城市学院

授权公告日：2020年10月09日　　授权公告号：CN 110169745 B

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国家知识产权局
2020年10月09日



其他事项参见背面

证书号第3971365号

# 发明专利证书

发明名称：一种可调比例乙醇-汽油双燃料喷油器的调节方法

发 明 人：李稳国

专 利 号：ZL 2017 1 1403155.X

专利申请日：2017年12月22日

专利权人：湖南城市学院

地 址：410082 湖南省益阳市迎宾东路518号

授权公告日：2020年09月04日　　授权公告号：CN 108131207 B

国家知识产权局依照中华人民共和国专利法进行审查，决定授予专利权，颁发发明专利证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。专利权期限为二十年，自申请日起算。

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国家知识产权局

2020年09月04日



其他事项参见背面

证书号第3757010号

# 发明专利证书

发明名称：一种自动化地砖拆装设备

发明人：胡赛纯;李加升;林琳

专利号：ZL 2018 1 0345209.X

专利申请日：2018年04月17日

专利权人：湖南城市学院

地址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2020年04月14日　　授权公告号：CN 108301295 B

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国家知识产权局

2020年04月14日

证书号第3755518号

# 发明专利证书

发明名称：一种自动化地砖铺装设备

发　明　人：李加升;胡赛纯;林琳

专　利　号：ZL 2018 1 0345210.2

专利申请日：2018年04月17日

专利权人：湖南城市学院

地　　址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2020年04月14日　　授权公告号：CN 108505422 B

国家知识产权局依照中华人民共和国专利法进行审查，决定授予专利权，颁发发明专利证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。专利权期限为二十年，自申请日起算。

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国家知识产权局
2020年04月14日



其他事项参见背面

证书号第3516044号

# 发明专利证书

发明名称：一种智能温控式自动翻煎装置

发 明 人：李加升;熊洁

专 利 号：ZL 2017 1 1035474.X

专利申请日：2017年10月30日

专利权人：湖南城市学院

地 址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2019年09月03日　　授权公告号：CN 107854006 B

国家知识产权局依照中华人民共和国专利法进行审查，决定授予专利权，颁发发明专利证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。专利权期限为二十年，自申请日起算。

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局长
申长雨

国家知识产权局
2019年09月03日



其他事项参见背面

证书号第3469117号

# 发明专利证书

发明名称：一种移动式自动智能翻煎车

发　明　人：李加升;蒋练军;胡赛纯

专　利　号：ZL 2017 1 1032250.3

专利申请日：2017年10月30日

专利权人：湖南城市学院

地　　址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2019年07月26日　　授权公告号：CN 107837003 B

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局长
申长雨

国家知识产权局
2019年07月26日



其他事项参见背面

证书号第3171917号

# 发明专利证书

发明名称：一种杀菌带红外遥控的袜子速干机

发　明　人：李加升;邓曙光;蒋练军

专　利　号：ZL 2016 1 0571144.1

专利申请日：2016年07月19日

专利权人：湖南城市学院

地　　址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2018年12月04日　　授权公告号：CN 106049005 B

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局长
申长雨

国家知识产权局

2018年12月04日



其他事项参见背面

证书号第8044361号

# 实用新型专利证书

实用新型名称：一种便携式电子通讯装置

发　明　人：林琳;龚吉清

专　利　号：ZL 2018 2 0250832.2

专利申请日：2018年02月12日

专利权人：湖南城市学院

地　　址：413000 湖南省益阳市迎宾东路518号湖南城市学院

授权公告日：2018年11月06日　　授权公告号：CN 208063196 U

本实用新型经过本局依照中华人民共和国专利法进行初步审查，决定授予专利权，颁发本证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。

本专利的专利权期限为十年，自申请日起算。专利权人应当依照专利法及其实施细则规定缴纳年费。本专利的年费应当在每年02月12日前缴纳。未按照规定缴纳年费的，专利权自应当缴纳年费期满之日起终止。

专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长
申长雨

国家知识产权局
2018年11月06日

证书号第7796036号

# 实用新型专利证书

实用新型名称：一种小负载工业机器人

发　明　人：崔治;李梦醒;肖卫初;李稳国

专　利　号：ZL 2017 2 1785930.8

专利申请日：2017年12月20日

专利权人：湖南城市学院

地　　址：413000 湖南省益阳市银城大道湖南城市学院通信与电子工程学院

授权公告日：2018年09月04日　　授权公告号：CN 207807716 U

本实用新型经过本局依照中华人民共和国专利法进行初步审查，决定授予专利权，颁发本证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。

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专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长
申长雨

国家知识产权局
2018年09月04日

证书号第3032924号

# 发明专利证书

发明名称：一种车用发动机油-电-气混合动力输出装置的控制方法

发明人：李稳国;崔治;李加升

专利号：ZL 2016 1 1232303.1

专利申请日：2016年12月28日

专利权人：湖南城市学院

地址：410082 湖南省益阳市迎宾东路518号

授权公告日：2018年08月14日　　授权公告号：CN 106585611 B

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本专利的专利权期限为二十年，自申请日起算。专利权人应当依照专利法及其实施细则规定缴纳年费。本专利的年费应当在每年12月28日前缴纳。未按照规定缴纳年费的，专利权自应当缴纳年费期满之日起终止。

专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长
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国家知识产权局

2018年08月14日

证书号第2934948号

# 发明专利证书

发明名称：一种电容器的送箔送纸装置

发明人：张学军;陈巍龙;郭高峰;陈宏志;曾万奇

专利号：ZL 2016 1 0159622.8

专利申请日：2016年03月21日

专利权人：益阳市和天电子有限公司

地址：413000 湖南省益阳市赫山区龙岭工业园

授权公告日：2018年05月22日　　授权公告号：CN 105679558 B

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局长
申长雨

中华人民共和国国家知识产权局
2018年05月22日

证书号第7290924号

# 实用新型专利证书

实用新型名称：电容器生产用的数量采集推车

发　明　人：张学军;陈巍龙;刘抗修;周志新;王瑞清;胡拥军

专　利　号：ZL 2017 2 1166802.5

专利申请日：2017年09月13日

专利权人：益阳市和天电子有限公司

地　　址：413000 湖南省益阳市赫山区龙岭工业园

授权公告日：2018年05月01日　　授权公告号：CN 207292069 U

本实用新型经过本局依照中华人民共和国专利法进行初步审查，决定授予专利权，颁发本证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。

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申长雨

中华人民共和国国家知识产权局
2018年05月01日

证书号第7380330号

# 实用新型专利证书

实用新型名称：电容生产用的视觉检测智能小推车

发　明　人：张学军;陈巍龙;刘抗修;周志新;王瑞清;胡拥军

专　利　号：ZL 2017 2 1166743.1

专利申请日：2017年09月13日

专 利 权 人：益阳市和天电子有限公司

地　　址：413000 湖南省益阳市赫山区龙岭工业园

授权公告日：2018年05月22日　　授权公告号：CN 207395587 U

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申长雨

中华人民共和国国家知识产权局
2018年05月22日

证书号第2915712号

# 发明专利证书

发明名称：利用雨滴清洁路灯的系统

发明人：李加升

专利号：ZL 2016 1 0380430.X

专利申请日：2016年06月01日

专利权人：湖南城市学院

地址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2018年05月08日　　授权公告号：CN 106016101 B

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中华人民共和国国家知识产权局

2018年05月08日

证书号第2918241号

# 发明专利证书

发明名称：一种保持照明强度的路灯

发明人：李加升

专利号：ZL 2016 1 0379377.1

专利申请日：2016年06月01日

专利权人：湖南城市学院

地址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2018年05月08日　　授权公告号：CN 106090726 B

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中华人民共和国国家知识产权局
2018年05月08日

证书号第3034130号

# 发明专利证书

发明名称：用于路灯的压力感应系统

发明人：李加升

专利号：ZL 2016 1 0380427.8

专利申请日：2016年06月01日

专利权人：湖南城市学院

地址：413000 湖南省益阳市赫山区迎宾东路518号

授权公告日：2018年08月14日　　授权公告号：CN 105910064 B

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局长
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国家知识产权局

2018年08月14日

证书号第2806811号

# 发明专利证书

发明名称：一种分布式电源谐波的在线检测方法及装置

发明人：李加升

专利号：ZL 2015 1 0310187.X

专利申请日：2015年06月08日

专利权人：湖南城市学院

授权公告日：2018年02月06日

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申长雨

中华人民共和国国家知识产权局
2018年02月06日

证书号第2772206号

# 发明专利证书

发明名称：一种全自动旋转往复式路灯高效清洗系统

发明人：李加升

专利号：ZL 2016 1 0378568.6

专利申请日：2016年06月01日

专利权人：湖南城市学院

授权公告日：2018年01月09日

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中华人民共和国国家知识产权局

2018年01月09日

证书号第2772201号

# 发明专利证书

发明名称：一种用于大型社区安防以及巡更监控的智能控制装置

发明人：李加升；邓曙光；肖卫初；熊洁

专利号：ZL 2015 1 0420445.X

专利申请日：2015年07月16日

专利权人：湖南城市学院

授权公告日：2018年01月09日

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中华人民共和国国家知识产权局

2018年01月09日

| Order number | Honor Name Award | Awardee | Award Date |
|---|---|---|---|
| 1 | Hunan Provincial Science and Technology Progress | Zhang Xuejun | May 2018 |
| 2 | Hunan Provincial Technology Invention Award | Li Jiasheng | July 2021 |
| 3 | Yiyang City's 3rd Natural Science Outstanding Academic Achievement Award | Zhu Qiuxiang, et al. | January 2019 |

湖南省
科学技术进步奖

证书

为表彰湖南省科学技术进步奖获得者，特颁发此证书。

获奖项目：氧族化合物/石墨烯杂化结构物性的调控研究及在储能器件中的应用

奖励等级：三等奖

获 奖 者：张学军（第1完成人）

湖南省人民政府

二〇[illegible]年[illegible]月

证书号：20174097-J3-109-R01

湖南省
技术发明奖

证书

为表彰湖南省技术发明奖获得者，特颁发此证书。

获奖项目：多功能智慧路灯

奖励等级：三等奖

获 奖 者：李加升（第1完成人）

湖南省人民政府

2021年07月

证书号：20203012-F3-109-R01

# 益阳市第三届自然科学优秀学术成果奖

为表彰益阳市第三届自然科学优秀学术成果奖获得者，特颁发此证书。

学术成果名称：Synergistic graphene/aluminum surface plasmon coupling for zinc oxide lasing improvement

获奖等级：一等奖

获 奖 者：祝秋香、秦飞飞、卢俊峰

获奖编号：20190112

益阳市人民政府

发证单位（盖章）

2019年1月

Project：

| Order number | Project Name | Fund Name | Project Initiation Time | Name | Role |
|---|---|---|---|---|---|
| 1 | Enhancing the Electrothermal Response of Ferroelectric Materials by Inducing the Coexistence of Positive and Negative Electrothermal Effects through Electric Field-Induced Phase Transitions: Multi-Field Coupling Mechanism and Experiment | National Natural Science Foundation of China - Youth Project | 2022 | Peng Jinlin | Principal Investigator |
| 2 | Capacitor Industry Chain Integration of Industry and Education Project | Hunan Provincial Department of Industry and Information Technology - Key Project for Manufacturing Power Province Reward | 2022 | Jiang Dongchu | Principal Investigator |
| 3 | Research on Resilience Optimization and Control Methods for Power Networks | Hunan Provincial Natural Science Foundation - General Project | 2020 | Li Wenguo | Principal Investigator |
| 4 | Research on Airborne Passive Radar Interference Suppression Methods Based on Sparse Recovery in Complex Environments | Hunan Provincial Natural Science Foundation - Youth Project | 2021 | Deng Yaqi | Principal Investigator |
| 5 | Three-Dimensional Forward Modeling of Controlled-Source Electromagnetic Method Based on the Coupling of Unstructured Finite Element and Infinite Element | Hunan Provincial Natural Science Foundation - Youth Project | 2021 | Zhang Lincheng | Principal Investigator |
| 6 | Research on Resilience Characterization, Measurement and Optimization Enhancement Methods for Power Networks | Hunan Provincial Department of Education - Key Project | 2019 | Li Wenguo | Principal Investigator |