The BP Information Model Based on AI-ESTATE

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Abstract — This paper proposes a new fault diagnosis strategy for analog circuit after analyzing diagnosis method based on the BP neural networks and AI-ESTATE standard. At present, The artificial intelligence algorithms such as SVM and BP has been widely adopted in analog circuit fault diagnosis, but it is not included in the IEEE AI-ESTATE standard. So there is no normalization of BP information model, and the interchange formats of the BP information model is application-dependent. Therefore, it has no portability and cannot share diagnostic knowledge and data across different platform or application in analog circuit fault diagnosis. For these problems, the BP information model based on AI-ESTATE standard is proposed. And it not only extends the standard of AI-ESTATE, but also presents a normalization of the BP information model in analog circuit fault diagnosis. The simulation result shows that the proposed BP information model can share data among different platform, while maintain the same diagnostic rate compared with the traditional method.

Keywords-AI-EATATE; BP information model; BP neural network; analog circuit; fault diagnosis

I. INTRODUCTION

With more and more widely used of intelligent diagnostic algorithms, it brings problems such as complex fault knowledge representation and transplant or shared difficulties and so on. In order to standardize the test diagnosis process and implement knowledge sharing, IEEE set common standards that artificial intelligence applied in the field of system test and diagnosis, that is, AI-ESTATE standard. The Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE) standard was developed by the Diagnostic and Maintenance Control Subcommittee of the IEEE Standards Coordinating Committee 20 (SCC20) on Test and Diagnosis for Electronic systems to serve as a standard for defining interfaces among diagnostic reasoners and users, test information knowledge bases, and more conventional databases[1]. In addition to interface standards, the AI-ESTATE standard includes a set of formal data specifications to facilitate the exchange of system under test related diagnostic information.

Although the AI-ESTATE standard facilitate portability of test related knowledge bases for intelligent system test and diagnosis, it is incomplete. It lacks specific implementation process of fault diagnosis and diagnosis model that apply artificial intelligence diagnosis algorithm. Artificial intelligence diagnosis algorithm includes SVM, BP, information entropy, wavelet and so on[2]. In the fault diagnosis of radar transmitter, Wei Jiangtao put forward the point that application of BP neural network can improve the accuracy of fault diagnosis[3]. In the intelligent fault diagnosis of air-condition system, Liu Shunbo applies SVM to solve the problems of nonlinear and dimension of feature data[4]. In the fault diagnosis of Motor, Wang Hongjun comes up with ideas that Wavelet packet analysis can effectively extract the fault feature vector and improve the frequency resolution[5]. So it is a trend to use artificial intelligence diagnosis algorithm in analog circuits fault diagnosis. But artificial intelligence diagnosis algorithm is not defined by uniform standard. And these algorithms has poor portability with each other.

In AI-ESTATE standard, some diagnosis models have been created, for example the Fault Tree Model. At the same time, you need to create some new diagnostic model. With the ability of Self-learning, nonlinear mapping, parallel computing and fault tolerance, the BP neural networks can overcome some of the limitations of expert systems based on logic and symbolic processing. It opened up new avenues for the study of fault diagnosis. So how to describe BP information model is also important in analog circuit fault diagnosis. In this paper the BP information model is created after analyzing the structure, definition and elements of the AI-ESTATE standard and the progress of BP diagnosis method.

II. AI-ESTATE AND BP NEURAL NETWORK

A. AI-ESTATE

AI-ESTATE is specification of data exchange and standards service under test and diagnosis environment, including the definition of architecture, the exchange of data and knowledge and serves. The purpose of AI-ESTATE is to standardize interfaces between functional elements of an intelligent diagnostic reasoner and diagnostic knowledge and data. In order to support exchanging and processing of diagnostic information and the control of diagnostic process, AI-ESTATE standard provides formal specifications. So a diagnostic model can be moved from one AI-ESTATE implementation to another by translating it into the interchange format. At the top level is the Common Element Model (CEM) that specifies elements common to the AI-ESTATE domain of equipment test and diagnosis in its entirety. Below the Common Element Model is a set of data and knowledge models that specialize the constructs in the Common Element Model and tailor the constructs to the application's particular reasoning requirements. AS is shown in Fig .1.

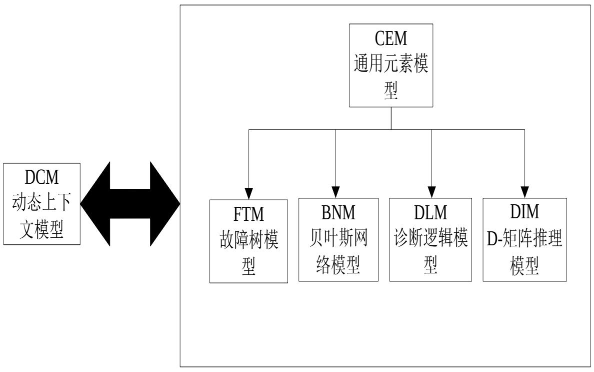

Figure 1. Hierarchical structure of the AI-ESTATE models

In Fig .1 a structure has been constructed for specifying these diagnostic data and knowledge. The structure can meet to different diagnostic application in analog circuit fault diagnosis. Formal models of diagnostic information can ensure unambiguous access to an understanding of the information supporting system test and diagnosis. So it is important to create diagnostic information model in analog circuit fault diagnosis.

B. BP diagnostic method

Neural network could be implemented as computer algorithms that could be used to describe a system in term of relations between input and output. When it was very difficult or impossible to use analytical approaches for describing systems, Neural network represent an alternative method. They had been used in a wide variety of applications. These applications include process control, quality control, industrial inspection, optimization, and modeling. Rvomelhart and Mcclelland brought forward error back propagation algorithm(BP algorithm for short). Because of simple structure, easily achieving, stronger robust, BP network is the most widely applied among the neural network models, especially in pattern recognition and category, system simulation, fault diagnosis, image processing, function matching, best forecast and so on[6]. This paper will introduce application of BP neural network in fault diagnosis. BP network is a multilayer feed forward neural network, and it is composed of input layer, hidden layer and output layer[7][8]. The structure of the BP network is shown in Fig .2.

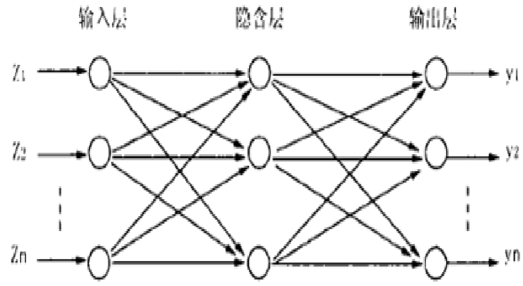

Figure 2. BP network model

BP neural network is a more layers hierarchical neural network with upper neurons full associated with lower neurons[9]. It has the ability to identify the non-linear pattern. The BP algorithm has more extensive applications because of its clear calculation methods and well-defined steps. The learning process of BP algorithm are composed of prior to the calculation process and the error back-propagation process. In the prior to the calculation process, the input information calculates layer by layer from the input layer to the hidden layer, and transmit to the output layer, the state of each layer's neuron only affect the status of the next layer's neurons. If the output is not expected in output layer, then it switches to error back propagation. Then it makes the network system error minimization by modifying the value of every layer's neuron[10]. Through these modification, the actual output of the network would be much closer to expectations. When the structure of neural network was defined, classic sample were needed to train the neural network. The following two principles were used to choose sample. (1) Integrity, which meant the status of sample should include normal status and fault status. (2) Number of the sample should be big enough .

C. Extensional structure of the AI-ESTATE models

With AI diagnostic methods promoted in the field of analog circuits, the current AI-ESTATE model structure cannot meet the test requirements. And AI-ESTATE do not provide integrated technology for widely used AI diagnostic methods such as SVM, BP and so on. But the BP neural network have the ability of arbitrary approximation and self-learning for nonlinear function, so it can be used for neural network techniques to fault test and diagnosis[11]. And it has put forward a new way to the fault diagnosis by combining neural network with expert system [12]. So it is a trend to use the BP neural network in analog circuits fault diagnosis. Although the BP information model has been widely used in diagnostic system, it has no unified standard. At present, the representation of the BP information model is varied. Because people use the specifications of the BP information model, which were defined by themselves. So the BP information model can't share data and knowledge, and has the poor portability. It is a trend for the integration of artificial intelligence diagnosis algorithm and AI-ESTATE standard in analog circuit fault diagnosis. Reference [13] shows the SVM information model based on AI-ESTATE. So It is feasible for the integration of artificial intelligence diagnosis algorithm and AI-ESTATE standard in analog circuit fault diagnosis.

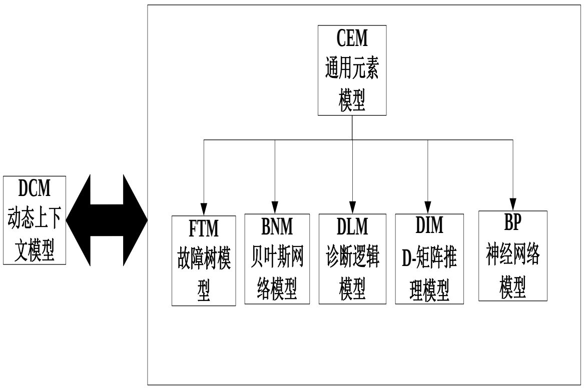

Figure 3. the new structure of the AI-ESTATE models

In this paper, the BP information model can be provided by using the extensibility of AI-ESTATE standard. AS is shown in Fig .3. The BP information is created by combining AI-ESTATE standard and BP algorithm. So like other diagnostic models the BP information models can take advantage of the constructs in the Common Element Model and tailor the constructs to the application's particular reasoning requirement. Then it can help better diagnosis method to share diagnosis knowledge or data in analog circuit fault diagnosis.

III. BP INFORMATION MODEL

AI-ESTATE standard provides formal specifications for supporting system diagnosis. These specifications support exchanging and processing of diagnostic information and the control of diagnostic processes[14]. So the purpose of AI-ESTATE standard is to provide formal information models of diagnosis information to ensure unambiguous exchange between test information and diagnosis information. To meet the actual needs of the diagnosis, it is needed to create BP diagnosis information model to test system or other diagnostic methods. BP diagnostic model , like other models, can use the elements of AI-ESTATE Common Element Model.

In the field of analog circuit fault diagnosis BP algorithm is common knowledge. Combining BP algorithm and AI - ESTATE can not only expand the AI-ESTATE standard, but also can make BP information model standardized and solve the problem of poor portability. Fig .4 shows the BP diagnostic model. The BP_diagnosis is a subtype of diagnosis, it inherits all of the characteristics of a diagnosis. And the diagnostic outcomes are required. It can make good use of test data to obtain diagnosis conclusion in the process of diagnosis, so the entity BP diagnostic-model must include entity BP_test and BP_diagnosis. The BP test data corresponds to the entity test-outcome. The BP-diagnosis conclusion is usually classified as different fault mode, so BP-diagnosis must include entity BP_fault or entity BP_failure.

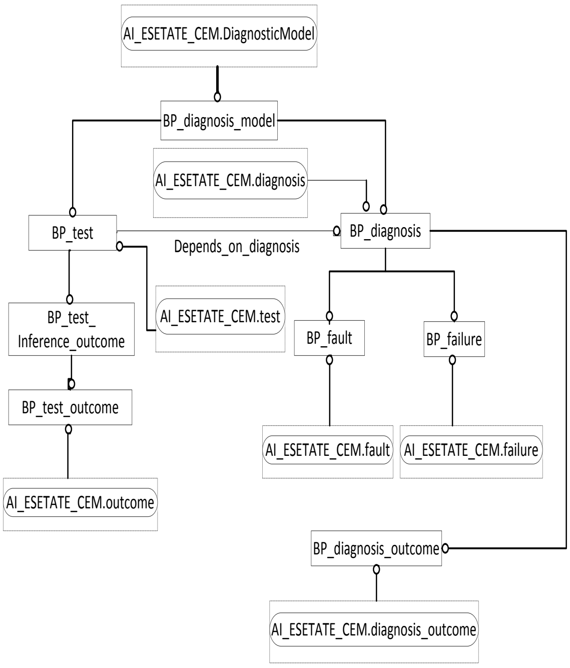

Figure 4. BP information model

The EXPRESS code of BP information model is shown as follows:

EXPRESS specification
*)
ENTITY BPModel
SUPERTYPE OF (ONEOF(BPFault,BPFailure));
SUBTYPE OF (Diagnosis);
SELF\Diagnosis.allowedOutcomes:LIST[2:?] OF UNIQUE BPDiagnosisOutcome;
END_ENTITY;
(*

IV. SIMULATION

As shown in Fig .4, the four op-amp biquad high-pass filter[15] is used as a benchmark to verify various algorithm in analog circuit fault diagnosis. So the feasibility of this proposed- BP information model is verified by using Fig .4. And the faulty component values for this circuit are shown in Table. 1.

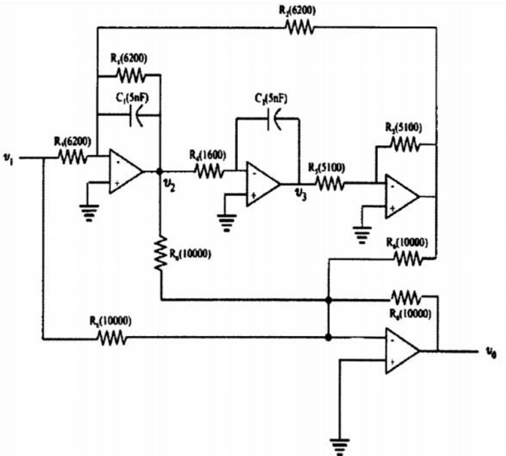

Figure 4. Four op-amp biquad high-pass filter

TABLE I. FAULT INJECTION LIST OF LM324 CIRCUIT

Failure Num	Failure Device	Failure Type
F0	NF	
F1	C1	H
F2	C1	L
F3	C2	H
F4	C2	L
F5	R1	H
F6	R1	L
F7	R2	H
F8	R2	L
F9	R3	H
F10	R3	L
F11	R4	H
F12	R4	L

The BP information model is used to generate testing data and get the diagnostic outcome in the experiment. Using p-spice simulation software carry through 50 times simulation for each normal model and failure model. The diagnostic reasoner extract the measured data using protocol of data exchange process to test the circuit. The experimental results are listed in TABLE 2. The simulation verify the effectiveness of the BP information model.

TABLE II. THE COMPARISON OF DIAGNOSTIC RATE BETWEEN THE BP INFORMATION MODEL AND THE SAMPLE CIRCUIT

Failure Num	LS_SVM%	BP %
F0	100	100
F1	100	100
F2	100	84
F3	100	100
F4	100	100
F5	100	100
F6	100	75
F7	100	100
F8	100	100
F9	80	100
F10	100	100
F11	80	98
F12	100	100
average	96.92	96.46

V. CONCLUSIONS

The focus of this paper is to propose a BP information model that meet standard of AI-ESTATE. And the simulation experiment results show that the BP information model not only maintain the same diagnostic rate compared with other information models, but also extends the standard of AI-ESTATE. Moreover, it helps share knowledge and data of fault diagnosis among different application. Therefore, the proposed BP information model can be applied as new model in analog circuits fault diagnosis.

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