DES Software for Computer Interlocking System

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Abstract

DES software is a Computer Aided Design(CAD) tool. It is built based on objected-oriented principle. Utilizing strong processing capability and quick calculation of computer, it can search out all possible routes, and give out interlocking table on the base of chosen routes by user. It can provide a large number of data for computers included in computer interlocking system. It is efficient and reliable.

1. Introduction

DES software plays an important role for signal engineering design, plays a supporting role for computer interlocking system, and is researched for increasing efficiency of signal design and production quality of computer interlocking system. On matter what scale of the station is, how complicated of the station configuration is, whether for a new station or

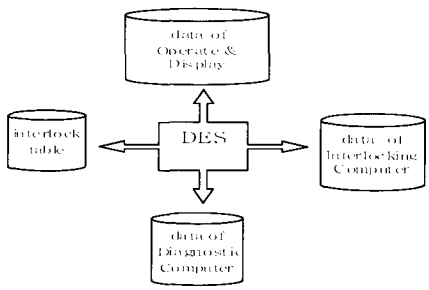

Fig. 1 Output data of DES

In computer interlocking system, computers as showed in Fig. 1 usually are included.

Diagnostic computer is maintenance terminal, through which the interlocking system's performance and fault status can be monitored.

Interlocking computer is central interlocking

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processor, which is mainly responsible for the safe operation of railway network. Operate & display computer displays current state of a station, indicates which routes are set and shows the current position of trains and so on. It is operated by user. These computers need a large number of data. DES software brings it to success. It increases design efficiency and simplifies data preparation largely.

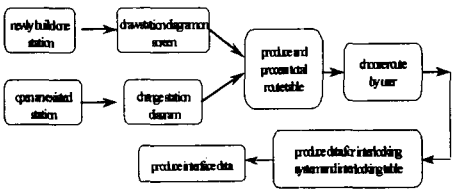

Fig. 2 Flow chart of DES

The flow chart of DES software is showed in Fig.2. There are two types, one is new building a station, drawing station diagram, then producing required data, the other is opening a existed station, changing its station diagram, then producing required data. The former is used for newly building a station, and the latter is usually used for an old reformed station.

2. Interlocking Elements

2.1 Entities of station

The entities include signal, track section, switch point and button.

Signal controls the linear movement of trains, and can give a speed indication to drivers by displaying one of a variety of aspects.

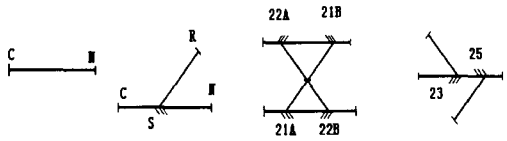

Fig. 3 A track, a single switch point and group switch point

(a) A track
(b) a switch point
(c) group switch point 1
(d) group switch point 2

Track section is an identified section of railway line that is controlled by a signal. Track sections are electrically isolated from one another.

Switch point is a mechanical device in the railway to change the path that trains may take through a junction. The switch position are called normal and reverse respectively, the former usually referring to the mainline, the latter to the branch.

Button is used to set the route.

Railway network is made up of above entities. One entrance signal and one exit button can set a route.

In DES, a track section has two marks as showed in Fig.3(a), C and N. We define a single switch point as four marks that are showed in Fig.3(b), C is sharp position, N is normal position, R is reverse position and S is turning center of switch point. In Fig.3(c), it is complex cross switch point. DES divides it into four single points, 21A, 21B, 22A and 22B. Similarly, that showed in Fig.3(d) is thought as two single points in DES, 23 and 25.

2.2 Route

Routes are definite paths between entrance signals and exit buttons. Entrance signal itself has an attached button that is used to be firstly operated when setting a route. Exit button is used to secondly operate, which decides the end point of the route.

2.3 Interlocking table

Interlocking table includes all of useful routes, and logical relationships between physical entities in the railway such as points, signals, track circuits and so on.

3. Object-Oriented Principle

Based on object-oriented principle, the scheme and architecture for DES software are built. We enclose the data of a station and its processing into an object which is regarded as the core of DES software. The system is built according to the core. Class repository applied for the systemclasses of track, signal, button and switch point are also designed respectively. The data of station are made up of class examples of track, signal, button and switch point. The structure of software system is super with benefits of reusability, easy reconstruction and easy for maintenance.

4. Realization of DES software

4.1 Procedure of producing interlocking table

The general procedure of producing interlocking table in DES is summarized briefly as follows.

1. generate position link relation of entities. It is explained in 3.3.

2. prepare route table. Usually one station has two vital passages(two throats), within the same throat, one entrance signal and one exit button with the same direction possibly form a route. DES finds out all of signal-button pairs here.

3. according to prepared routes, search every effective route one by one. Its details are showed in 3.4.

4. according to chosen routes, find opposite signal of every route and generate interlocking table.

4.2 Position link relation of entities

Railway network is made up of signals, buttons, track sections and switch points. Signal, button, track section and switch point have link relation between each other in position. Concretely speaking, a signal is possibly located at a track or a point, or has the same position with another signal. A track is maybe linked with another track or a point. A button is possibly located at a track or a point. A point is linked possibly with another point or a track. Their position link relations are showed in Fig.4.

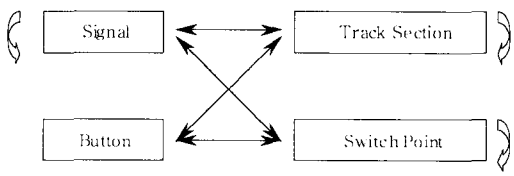

Fig. 4 Position link relation between signal, button, track and switch point

Arrow direction indicates link relation. DES first finds out the position link relationships between entities.

4.3 Route search

When setting a route, we must make sure its properties and the features of related monitored objects, including,

1. property of the route, route of receiving train, route of sending train or shutting route.
2. direction of the route, up or down.
3. two ends of the route, entrance signal and exit button.
4. tracks included in route, total number and their name.
5. switch points in route, total number and their name, position.
6. approach track and leaving track.

All of routes comprise total route table. Working out total route table manually is a complex job, especially for a large station. Something easily goes wrong with the table, so it usually needs to be checked strictly. DES software can produce total route table reliably and quickly. How to search a route for DES, giving out following example,

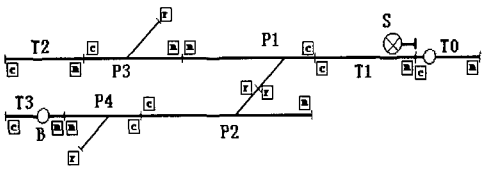

Fig. 5 A part of station diagram

In Fig.5, P and its following number stand for point name, T and its following number for track name, S for signal name and B for button name. If search a route from signal S to button B, according to operating command of route, we know that entrance signal is S, which is located at n side of T1, its attached button on T0, and exit end is button B, which belongs to T3. T0 is hold track of the route. T1 is first past track, its c side is connected to c side of P1. Suppose that we first search along with normal position when meeting with a switch point, then return back to search along with reverse position. According to this regulation, first from c side of P1 get to its n side, which is linked to n side of P3. From n side of P3 can only get to its c side, which is linked to n of T2... at last, we cant find button B. Then return to P1, along with its r side to go on searching, r of P1 is connected with r of P2. From r of P2 can only get to its c. For P4, first from its c get to n that is linked to n of T3. Because button B is on T3, destination exit point is found. T3 is the last track of the route. The all of tracks in this route includes T1, P1, P2, P4, and T3. The switch points include P1, P2, and P4. P1 and P2 are in reverse position. P4 is in normal position. Then return to r side of P4 to continue searching, but it connects nothing. Till now, searching routes between S and B is finished.

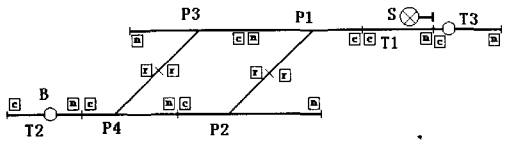

Fig. 6 An example of search parallel route

In Fig.6, we give an example of searching parallel routes from signal S to button B. T1 is first track. First along with normal position of P1 get to n side of P1 which is connected with c side of P3. Because n side of P3 isnt connected anything, we search along its r side. From r side of P4 can only get to its c side which is linked to n of T2. On T2, destination button B is found. This is the first route. Its

tracks include T1, P1, P3, P4, and T2. Its switch points include P1, P3, and P4. P1 and P3 is in normal position, P4 is in reverse position. We first search out above route along with the normal position of P1(from c to n). Now, return to reverse position of P1 to find whether there exists another route(from c to r) or not. The r side of P1 is linked to r side of P2. From r of P2 can only get to its c that is connected with n of P4. From n of P4 also can only get to c that is connected with n of T2. Encountering B button again, so another route is searched out. Its tracks include T1, P1, P2, P4, and T2. Its switch points include P1, P2, and P4. P1, P2 is in reverse position, P4 is normal position. So, there are two routes that are parallel to each other from signal S to button B, user can choose to keep useful one and discard unwanted one.

The flow chart of algorithm for search a route is showed in Fig.7. QD stands for track section, DC means switch point. nt is the object that is currently connected. It varies in pace with search procedure. If nt equals to 1, it means that the no object is connected. nd is the position of currently connected object. For a track section, if C side is connected, nd is 0, else N connected, it is 1. For a point, if R side is connected, nd is 0, if N connected, it is 1, else C connected, it is 2. Sometimes the hold track is a point. Under this situation, we neednt consider which is in normal position or reverse, so set nd to other value, if R side is connected, nd is 4, if N connected, it is 3, else C connected, it is 5. et is the object that end button is located on. When

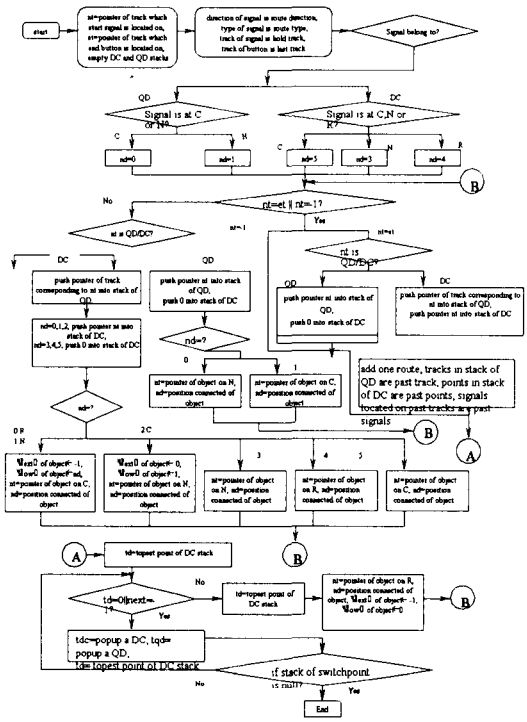

Fig. 7 Flow chart of algorithm for search one route

We use two stacks, one is stack for tracks, and the other is stack for switch points. Two stacks are pushed or popped at the same time. A switch point is also a track section, but with a point. Therefore during searching, if meeting with a switch point, push the pointer of track corresponding to the switch point into the stack of track, and push the pointer of switch point itself into stack of switch point, if encountering a track, push the pointer of track into stack of track, but push 0 into stack of switch point.

Because we first search along the normal position of a switch point, whether find out a route or not, still return back to its reverse position to search another route, set two marks for a switch point, one is now , the

other is next . The now stands for current searching position, 0 is reverse position, and 1 is normal position. If entering into a point to search from R, setting now to 0, and else from N or C, setting now to 1. next means whether to return back reverse position to search again. If entering into a point to search from R or N, next is set into 1, indicating not dividing road next time, else from C, next is set into 0, indicating allow dividing road, along C to N this time, then return to search along C to R next time.

DES automatically works out all of possible routes. Then signal engineer decides to keep or discard it.

4.4 Interlocking table output

On the base of chosen route, DES finds out all opposite signals for every route. The logical relationships of track circuits, switch points and their position are put into interlocking table. The direction and type of a route, entrance signal, exit button, hold track and so on are also given out in interlocking table.

5. Conclusion

It can not only process small station with 4 switch points, but also can process large station with thousands of routes and hundreds of switch points. It can be operated simply and quickly. Only by means of drawing station diagram, we can get all related interlocking tables and interface data for computer interlocking system automatically. It allows manually changing all data and has huge practical value.

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