FUNCTIONAL TESTING OF MICROCOMPUTER RAILWAY INTERLOCKING EQUIPMENT

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Abstract

The tests are carried out under real circumstances or by their simulation. Simulation is an excellent method if the tests to be performed on real systems are too expensive, slow or dangerous to the environment. Taking this into consideration it is worthwhile to test the station interlocking systems by the simulation of their operation and the railway traffic without connection to on-site equipment.

Functional testing means the control of the correct planned operation of the tested system.

Functional testing serves laboratory and other tests preceeding operation but may be part of the safety verification process, too [1].

The tests are carried out under real circumstances or by their simulation. Simulation is an excellent method if the tests to be performed on real systems are too expensive, slow or dangerous to the environment [4]. Taking this into consideration the station interlocking systems are worth to be tested by a simulation of their operation and the railway traffic without connection to on-site equipment [3], [4].

In the course of testing, first the subsystems constituting the whole system are to be tested and then, by connecting the faultless subsystems, the whole system is to be developed. The tests to be performed when testing the subsystems from a functional viewpoint are of two kinds:

— testing if the subsystem reacts to valid, input code words with functionally adequate valid code words;
— testing if the subsystem recognizes the invalidity of invalid input code words.

The tests can be carried out with or without traffic simulation.

Testing without interlocking logic and traffic simulation of the whole system the mainly logical, dependency like characteristics where time factor does not have any role (perhaps the succession of the events does but the period between them does not) can be undertaken.

If the period between the events is also important in the operation of the equipment or the estimation of its quality the test is to be performed by a test set completed with traffic simulator.

The task of the traffic simulator is the real time simulation of the train and shunting movements that can be carried out on the tracks and block section belonging to the tested station.

The basic principle of testing is the following:

The test set connects predetermined input signals to the input points of the object to be tested and records the answers at the output points. The answers obtained are compared with the predetermined reference values kept in storage by the test set. In case of coincidence the test (by giving new input signals, recording answers and by evaluation) is continued.

In case of difference between the answer of the tested object and the reference value, two cases are possible according to the algorithm of the test:

- the test is finished by releasing suitable concomitant information (error indications);
- the difference is recorded by the test set (with inside storage the detected error can be printed) but the test is continued.

In the former case the test can be continued after an intervention of the operator of the test.

In the latter case, after error detection, depending on the character of the error and the algorithm of the test, the test

- is continued in the original way
- is continued with ramifications.

With ramifications it is possible to activate a fault determining (fault locating) routine by which the location of the fault can be ascertained more accurately (the so-called diagnostic decomposition can be increased) than without it. A certain, coarse diagnostic decomposition (fault location) is also possible by testing without ramification if the logic of the sequence of the test steps is in accordance with it. In this case the serial number of the first faulty step following the faultlessly performed test steps (where the answer differs from the reference) and within it the bit pattern of the faulty answer (in other words: the character of the difference from the reference) refer to the location and character of the fault.

In case of an algorithm with ramification it is possible to continue the test until the last step by leaving out further test steps affected by the detected fault.

Test performed without traffic simulation

The tests of the central subsystem containing interlocking logic and those of the whole system that can be performed without traffic simulation are of two kinds:

testing if the tested object is able to carry out the permissible activities (e.g. to overthrow a not closed point);

— testing if the equipment is able to hinder every conceivable activity forbidden to it (e.g. to overthrow an engaged or locked point; in general, the tests of dependency belong to this group) [3], [4].

The test of the entire equipment is to be carried out when all the subsystems are connected but the circuits directly controlling the external objects are not. The test set is to be connected in place of the latter.

In course of the tests the test set simulates the operation state of the external equipment. This simulation must include *irregularities*, too (e.g. burn out of signal bulb, obstacle between the point rail and stock rail of the point).

Test of the whole system by traffic simulation

The task of the traffic simulator, as mentioned earlier is the real time simulation of railway and shunting movements on the tracks of the tested station and along the block section belonging to the station.

The traffic simulator, to perform its task, has to comply with the requirements in connection with the generation and cancellation of trains and shunting [4].

The traffic simulator should be suitable at the given station for the simulation of all the

— regular, normal,
— regular but special,
— irregular (not allowed), but physically possible train and shunting movements.

The highest train speed in the traffic simulation system should be at least so high as the speed limit on the line belonging to the tested station.

The following methods can be planned for changing the speed of train and shunting movements:

— according to time-table,
— according to place,
— in an event controlled way,
— by external (manual) intervention,
— by the combination of the previous methods.

The speed of the simulated train and shunting movements are to be changed in steps so fine as required by the testing of the interlocking system.

The processing frequency of the traffic simulator means how many times the simulator "deals with" the train and shunting movements by units of time. The frequency of processing must be coordinated with the disintegration capacity of the system in connection with time and place. For the reasonable limitation of the requirements in connection with the simulator the *differentiated* determination of the processing frequency must be planned. The basis of differentiation is the speed, length of the train and the length of the shortest insulated section within the route.

General pattern of the test program system, data necessary for program generation

The program system consists of three kinds of modules:

— permanent modules that are independent of the services of the interlocking system and the security principles considered for the interlocking system;
— modules dependent on security principles and services but independent of the track and environment of the given station;
— modules dependent on topography that are generated on the basis of tables containing the data of the track and environment of the station by a program generator suitable for this purpose. Instead of these modules, generally applicable modules written in advance whose topography dependent operation is controlled by the data of the table mentioned, can be used, too.

To generate the programs carrying out *subsystem* tests the following are to be laid down:

— electric specification of the signals required and appearing at the in and output points of the subsystems (including time characteristics, too);
— the description of the object to be tested as an automation (co-ordination of input signals, internal states and output signals).

To generate the central subsystem containing the logic of the interlocking system and the programs performing the test of the complete system the following are to be given:

— safety requirements to be carried out by the interlocking system,
— services expected from the interlocking system,
— the draft plans of the interlocking system with the scale layout (layout data).

Automation degree of the tests

Regarding the test methods the so-called algorithm based control should be used (Fig. 1), [4].

On the basis of the test steps determined by the test program generator the algorithm based generator produces the answers to be given by the tested equipment in case of suitable operation, followed by the comparator comparing them with the answer of the tested equipment.

Regarding the automation degree of the test three methods are possible:

— manual test,
— semiautomated test,
— automated test.

a) *Manual test*

In this case the person performing the test serves in the capacity of test program generator, algorithm based generator and comparator. He initiates the individual test steps and controls the results by using the in and output subsystem of the interlocking system.

The simulator that substitutes the "external world" as mentioned before is connected to the tested equipment (Fig. 2).

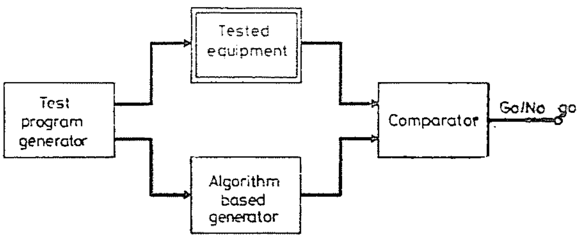

Fig. 1

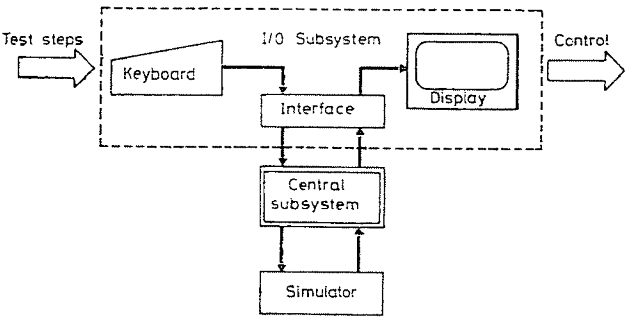

Fig. 2

b) *Semiautomated test*

In this case the person performing the test serves in the capacity of test program generator but the algorithm based generator and the comparator are special computers.

The answer to be given to the test steps initiated by the person is operated by the computer and later compared with the answer given by the interlocking system. In this way the control is automated.

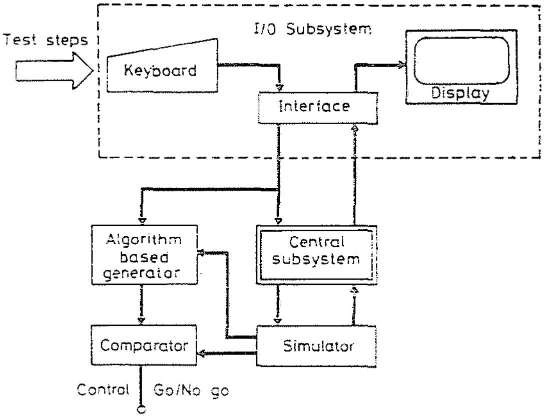

Fig. 3

The version shown in Fig. 3 has both the functions of the tested equipment and the functions of the simulator in the algorithm based generator.

The simulators provide information for the comparison. To do this the two simulators have to be in connection with each other. On the one hand, the external objects have to be in identical initial states at the beginning of the tests, on the other hand, identical traffic simulations are to be performed at both channels.

Synchronization requirement deriving from the latter becomes superfluous if the algorithm based generator contains only the functions of the tested equipment and the comparator compares the output signals obtained in this way. The only common simulator in this case is controlled by the output signal of the comparator (Fig. 4).

c) *Automated test*

In case of an automated test a special construction and operation computer serves in the capacity of test program generator, algorithm based generator, comparator and simulator (Fig. 5). This computer generates the necessary test steps, then produces the answers given for the test steps and compares them with the answers of the tested interlocking system.

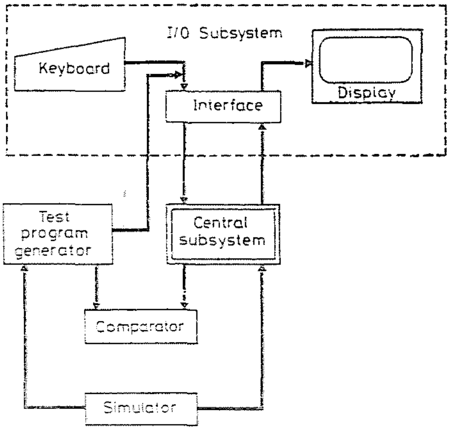

Fig. 4

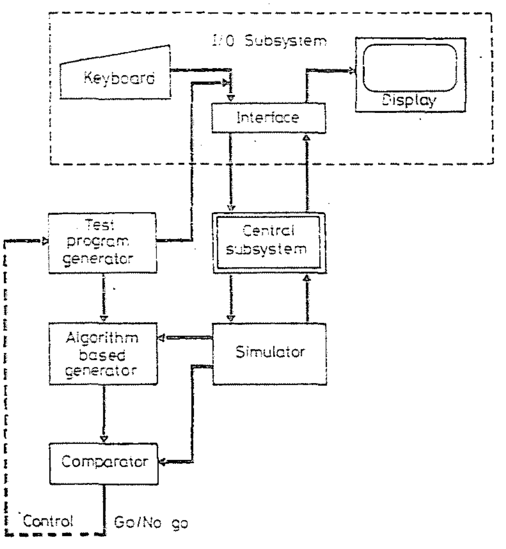

Fig. 5

A practical application

At the Department of Transport Automation of the Technical University, Budapest, a functional testing of microprocessor interlocking equipment, the RWS-3 (Railway Simulator) simulation based testing system has been developed.

The predecessors of the system (RWS-1 and RWS-2) were developed for studying railway interlocking equipment and traffic and are able to simulate a whole station relay based interlocking equipment and the train and shunting movements on the station and along the lines belonging to it.

System RWS-3 has been developed on the basis of the experiences obtained with RWS-1 and RWS-2 for testing the microcomputer interlocking equipment of the Bulgarian State Railways (BDZ). The equipment to be tested, the general construction of which is in Fig. 6 was developed at the Machinery, Electronics University in Sofia (VMEI) [2].

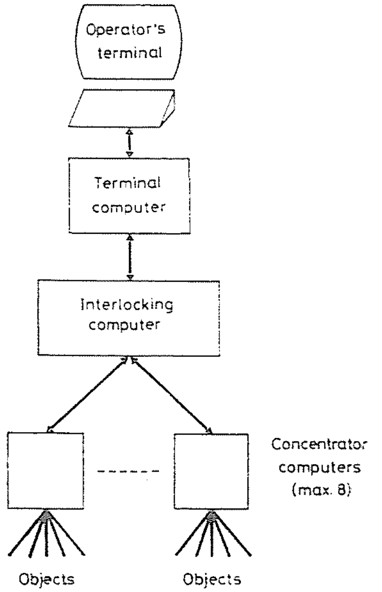

Fig. 6

In the first phase of the tests the RWS-3 is used for testing the central microcomputer containing the complete interlocking logic. The RWS-3 can be connected to the central interlocking computer instead of the concentrator microcomputers.

In the course of testing, the RWS-3 simulates the operation of the concentrator computers and external objects in a normal and all necessary fault states.

The train traffic and shunting in the course of the tests are also simulated by RWS-3.

The RWS-3 is of general solution, meaning that it can be used in any station topography within the system capacity.

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