AUTOMATIC TESTING OF MICROPROCESSOR SYSTEM UNIT BOARDS

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Summary

At the Department of Instrumentation and Metrology a special tester has been developed for testing MMT (Medicor Microprocessor Technology) system unit boards. The paper deals with the production environment, aspects of designing an automatic board tester, construction of the board tester, problems in writing and debugging test programs and with two special problems connected to the construction of the board tester: extended functional test and Worst Case bus test.

Production environment

In testing hierarchy of the production of an equipment consisting of plug-in boards, testing of boards is of special importance. On one hand, at this level the majority of errors — first of all, functional errors of digital elements — still can be detected and diagnosed at an acceptable efficiency. On the other hand, — considering backplane wiring as a board too — faultless equipment can most likely be put together from faultless boards.

In the MMT system — a system named Medicor Microprocessor Technology developed at the Department of Instrumentation and Metrology — the equipment consists of universal system unit boards — CPU, memory and peripheral interface boards, etc. — and special boards. The system unit boards are produced in advance in bigger series on the basis of demand surveys.

Aspects of designing an automatic board tester

Automatic testing of system unit boards is motivated by both economic and technical aspects. Automatic testing is rentable if the sum of the share of single and repeating expenses is smaller than the cost of manual testing. This is the condition over about 10 to 20.000 produced total of pieces — corresponding to the price of the automatic tester —, and over 100 to 200 pieces in each type. In the latter, expenses of developing the test are first to be considered.

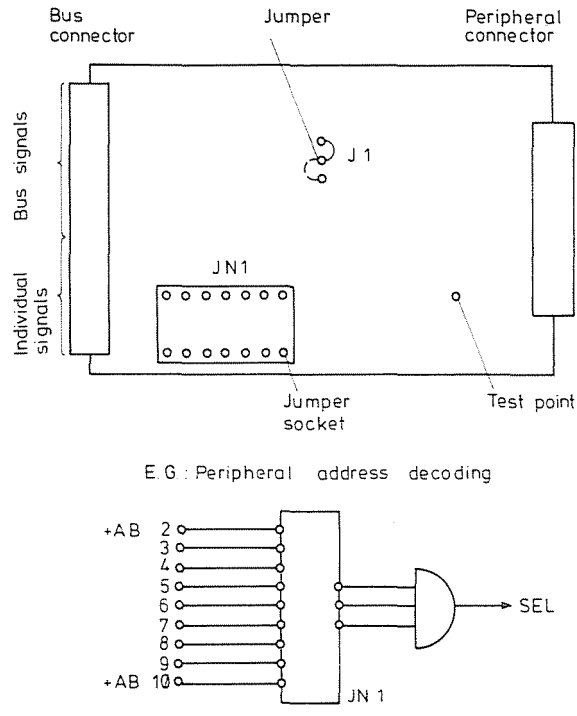

Fig. 1

The following technical aspect is at least of similar importance: Adequate testing of microprocessor system unit boards can practically be solved only through automated measurement series, partly because of complicated internal structure and operation of boards and partly because of the many measurements to do.

The structure of a system unit board from the aspect of testing is shown in Fig. 1.

In one hand, the board is connected to the bus, on the other hand, to the environment through the bus-connector — by special signals — or through the peripheral connector. On the board there are single jumpers and jumper sockets to configurate the cards for different applications — e.g.: address decoding circuit seen in Fig. 1 (in peripheral address decoding 3 ones of 9 coding is used) and test pins to help measuring the card. The bus interface of different boards is the same in every respect — the functions of the signals, the electrical and mechanical specifications, — the other signals are special in every respect, e.g. non TTL digital and analogue signals occur in a reasonable number.

Construction of the board tester

For automatic testing of the MMT boards a special tester has been developed expected to be much cheaper than a universal tester applied for the necessary tasks.

The block schematic of the tester is shown in Fig. 2. The board tester is a microprocessor equipment consisting of MMT system elements, completed by special elements necessary for testing.

Functions of the special units:

— Voltage and current limit of the power supplies can be programmed, thus marginal tests can be made and current consumption of the tested board can be checked.
— The Worst Case bus driver connects the test bus to the system bus, it ensures worst case timing of the test bus signals.
— The logical state storage (LSS) samples bus and non-bus signals connected to its inputs.

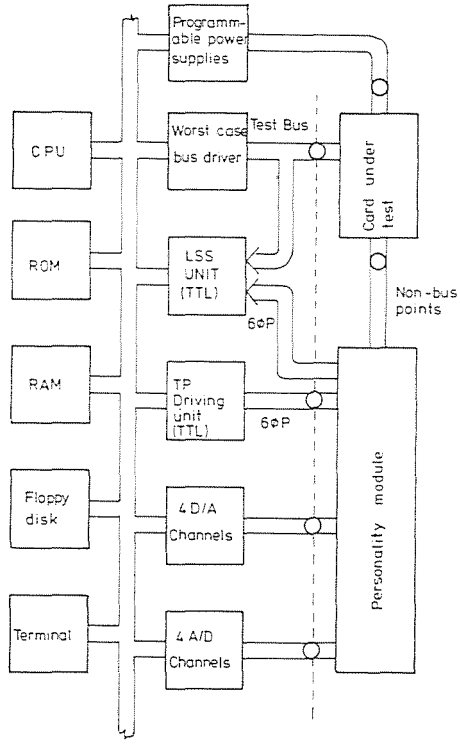

Fig. 2

Sampling is synchronised to the test bus operation, its position within the bus cycle can be set with 40 ns resolution.

— The test point driving unit drives non-bus points of the tested board directly or through level converters in a programmed way.
— The personality modul, different for each card type connects the tester and the non-bus points of the tested board, and may contain additional elements — mainly level converters.

Characteristics of the board tester thus constructed are the following:

— dynamic extended functional test of 40 ns resolution on the bus interface and on operations directly connected to it in time (the extended functional test will be discussed later);
— static extended functional test of the other program-speed functions;
— generation and test of non TTL level signals;
— program-speed generation and test of a few analogue signals;
— operations can also be tested with marginated supply voltage values.

Writing and debugging test programs

For writing test programs HUNTER, a high-level language has been elaborated which also contains instructions for handling tester HW and supporting testing besides of general software elements. It is presented by the test program detail below which tests the simple output peripheral controller in Fig. 3:

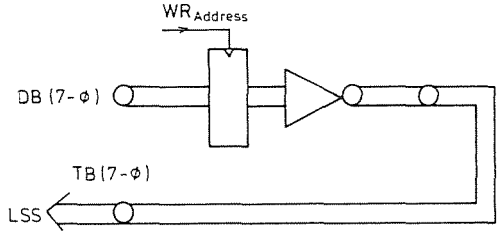

Fig. 3

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'PS' NO=1, VOLTAGE=5500, CURRENT=800.
'FOR' I=0 'TO' 255.
    IO (ADDRESS)=I.
    'TEST' TB(7-0)='CPL'I
    'ON ERROR'
('TYPES' "DATA OUT ERROR".
    'ERROR ROUTINE').
'NEXT' I.
```

Debugging of test programs on the tester is supported by HMONIT, a Hunter-level debugger which makes troubleshooting very effective and permits temporary correction of the majority of failures without recompiling.

Two interesting problems of the tester construction will be considered.

Extended functional test

Extended functional test is that where, besides of the functional test of inputs-outputs, current consumption of inputs and current driving capability of outputs are qualitatively tested.

The solution is sketched in Fig. 4:

— If the input current is too high, the voltage drop on R_S is high enough to be detected by LSS;

— if the output cannot drive enough current through resistor R_L biased in the opposite direction, the output cannot give out the voltage needed to be detected by the LSS.

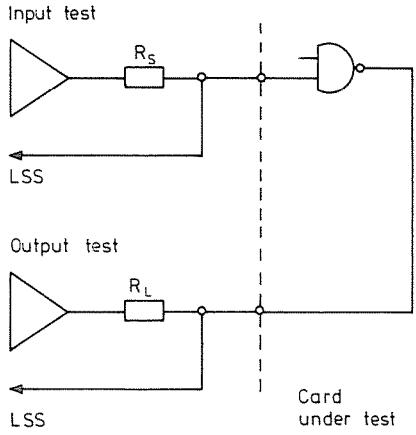

Fig. 4

The in- and outputs are seen to be tested by the same device, only the value of serial resistor is different.

Failures to reveal with the above solution:

— building in a different type IC (higher input current, or output of smaller current driving capacity) e.g.: exchange of LS TTL′ with normal;

— exchange of open collector and totem pole output IC-s;

— breaking of the pull up transistor of the totem pole output;
— short circuit of inputs of AND function;
— and of course, IC-s with rather wrong parameters.

The above solution is applied for every TTL level in- and output tested by the tester.

Worst Case bus test

The requirement of safely perfect operation for an equipment composed of faultless boards, can only be met if every board has appropriate reserve:
— driving ability of its bus outputs is at least the minimum required for the system;
— loading of its bus inputs is not more than the maximum enabled in the system;
— time conditions of outputs are not worse than the worst case required for the system;
— circuits connected to bus inputs are able to operate ever under worst case time conditions.

Meeting the above requirements is especially important because their failure may cause a defect hard to diagnose appearing — or not — in the final test of the system. E.g.: decrease of driving capability of an output causes a failure on putting a further board in, likely to be attributed the last board.

Because of this the bus-side test also examines the above four criteria beside the functional test.

The first two — static — criteria are examined with the extended functional test outlined above, which test the in- and output currents.

To test the dynamic criteria the Worst Case bus driver emits signals with the worst timing expected to operate the board. Signals emitted by the board are tested by LSS; e.g.: in a read operation, information on the data bus has to be good after the required access time.

Application of the board tester

Finally, some words about the application of the board tester. The board tester has been produced in four specimens so far. Two of these are used for production tests in factories of MEDICOR in Budapest and Esztergom. Since 1981 about 10.000 boards have been tested on the two testers, tests have been developed for about 60 versions of about 40 types of boards. Experiences are

unambiguously positive, the board tester reduces control and repair time by orders — automatic test of a sound board takes 1 to 5 minutes, the troubleshooting is typically less than 5 minutes by defect.

References

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