COMPUTER AIDED FAILURE ANALYSIS

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COMPUTER AIDED FAILURE ANALYSIS

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A computer aided failure analysis system is being developed to troubleshoot defects in electronic assemblies. Through a question and answer procedure, the system provides step by step directions to guide a troubleshooter to the fault location. A diagnostic logic routine has been established for one product and the software necessary to store and implement the routine has been developed. The TSO terminal has been installed and the completed system has been found to be functional. A visual aid catalog has been developed for the current CAFA routine.

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SUMMARY

A computer aided failure analysis (CAFA) system has been developed to assist production troubleshooters in locating defects in electronic assemblies and in reducing costs associated with present troubleshooting techniques. The system utilizes the computer facilities of the Mezzanine Data Acquisition System (MEZZDAS).¹ This system is being developed for one particular product; however, the facilities and techniques can be adapted to many different product types.

The basic approach is to store a diagnostic analysis program in a central computer (IBM 360/65) and access this program through a time share operation (TSO) terminal. The diagnostic routine consists of a series of questions to be answered by the troubleshooter which will eventually decide on possible causes of failure. All statements and questions are in English and can be answered simply by typing a number into the TSO terminal.

The learning curve associated with effectively troubleshooting a complex electronic assembly should be shortened with this system.

A diagnostic logic routine has been established for one product and the computer software necessary to store and implement this routine has been developed. The TSO terminal has been installed and the completed system has been found to be functional. A visual aid catalog has been developed for the current CAFA routine.

The next phase of work will include evaluating the failure analysis program and visual aids for their completeness and an evaluation of the effectiveness of the system using a production troubleshooter.

DISCUSSION

SCOPE AND PURPOSE

The purpose of this project is to reduce the time and cost of troubleshooting electrical test failures during electronic assembly manufacturing processes. Present troubleshooting procedures need to be improved to reduce the defect analysis time, to reduce the amount of engineering manpower required to train and assist troubleshooters, and to decrease the problems associated with personnel changes.

A computer aided failure analysis (CAFA) system is being developed. Although the development work is directed toward solving problems associated with one specific product, it is intended that the guidelines and basic tools developed to be used to troubleshoot many, if not all, of the electronic assemblies manufactured at the Kansas City Division.

PRIOR WORK

This is the third report on this project. The first report presented the basic considerations and guidelines for this project and outlined a proposed design for a computer aided failure analysis system. The second report presented the actual diagnostic logic routine that is now in use and the TSO terminal that is now operational.²

ACTIVITY

In a prior report, the following general guidelines were established for the design of a CAFA system.

- Emphasis should be placed on the resolution of test failures caused by assembly errors and defective components.
- The system should be adaptable to different types of electronic assemblies.
- Production troubleshooters should not need extensive new skills or training to operate the system.

Based on these guidelines, a CAFA system was designed and implemented in three steps for a digital logic timer currently in development.

Computer Hardware

The CAFA system uses the facilities of the Mezzanine Data Acquisition System (MEZZDAS). The CAFA program is stored on a disk storage device and accessed as needed by the central IBM 360/65 computer. The user (troubleshooter) communicates with the computer by using a time share operation (TSO) terminal. Figure 1 illustrates how the CAFA system is contained within the MEZZDAS hardware. The decision to use this type of system was based on several considerations.²

- No new main-frame computer equipment should be purchased. In some cases it might be necessary to add equipment such as a CRT terminal for a particular CAFA system, but this equipment expense is minor compared to the cost of a complete new computer system.
- The concept of multiple program storage in one central computer will significantly reduce the amount of new software development required for CAFA programs of new or additional products.
- The structure of the MEZZDAS system will allow access to a particular failure analysis program from more than one location.
- With this system approach, automated failure analysis is not tied to a particular product tester or manufacturing area. As a result, there should be minimal problems associated with such things as tester calibration and facilities changes.

The TSO terminal used for the CAFA system will be located close to the product tester which will allow product failures to be analyzed quickly. The TSO terminal consists of a CRT terminal and line printer.

Computer Software

The software for this system is designed to require minimum input from the user. The failure analysis routine consists of a series of questions by the computer which are answered by the troubleshooter. Questions and answers are presented in English and require no special knowledge of programming languages.

The software package consists of three separate but interactive parts. Part A (Figure 2) contains the wording of the questions presented to the user. Part B (Figure 3) contains the logic tree or the order in which the questions are presented to the user. Part C performs the input/output operations and the interconnection

Figure 1. CAFA System Block Diagram

3500	WHICH OF THE FOLLOWING DOES THE UNIT FAIL" (1)ALL OR MOST ALL FIRE TIMES, (2)ONLY TEST 16C AND/OR 17C, (3)ONLY TEST 27D AND/OR 28D, (4)ONLY THE LOW INPUT VOLTAGE TESTS (12,14,16,27,28)
0501	WHICH ONE OF THE FOLLOWING IS THE REASON FOR FAILURE (1)DOES NOT FIRE, (2)FIRE TIME SLIGHTLY OUT OF LIMITS, (3)FIRE TIME GROSSLY OUT OF TOLERANCE
0502	DURING RUNDOWN, WHAT IS THE CONDITION OF TIMER READ, PIN 13, (1)THERE IS NO SIGNAL, (2)SIGNAL PRESENT BUT INDICATES ALL ONES OR ZEROS, (3)SIGNAL NORMAL
0503	DURING RUNDOWN, IS THERE PROPER VOLTAGE ON VCC, PIN 1, (1)YES, (2)NO
0504	IS THERE AN OUTPUT FROM THE SPECIAL SWITCH DURING RUNDOWN (BRD 3-PIN 344 CLAMPED LOW AND BRD 3-PIN 341 CLAMPED HIGH)? (1)YES, (2)NO
0505	THE SPECIAL SWITCH CIRCUITRY IS DEFECTIVE. MOST LIKELY CANDIDATES FOR FAILURE ARE Q301, Q302, Q303, Q304 OR Q305. MAKE SURE THAT POLARITY OF CR312/CR315 IS OK.
0506	IS THERE A PROPER CLOCK OUTPUT AT PIN 327 OF BRD 3, FIGURE 11, (1)YES, (2)NO
0507	MOST UNUSUAL. POSSIBLY PIN 19 OF U204 IS SHORTED TO GND
0508	DURING RUNDOWN, IS THE COLLECTOR OF Q206 CLAMPED LOW, BRD 2-PIN 335, (1)YES, (2)NO
0509	DURING RUNDOWN, IS PIN 16 OF U204 CLAMPED LOW (1)YES, (2)NO
0510	DOES PIN 9 OF U204 REMAIN HIGH DURING RUNDOWN (1)YES, (2)NO
0511	MOST LIKELY, U204 OR ITS TRANSISTOR (PINS 9 TO 10) IS DEFECTIVE
0512	POSSIBLE CAUSES OF FAILURE ARE (A)OPEN VR202/R252/R227, (B)R227 SELECTED WRONG, (C)E231/R228/R230 SHORTED, (D)VCC TOO LOW, SELECT CAT 4 TO ANALYSE FAILURE
0513	DOES PIN 19 - U204 (BRD 2-PIN 333) REMAIN HIGH DURING RUNDOWN (1)YES, (2)NO
0514	DOES PIN 18 OF U204 REMAIN HIGH DURING RUNDOWN (1)YES, (2)NO
0515	POSSIBLE CAUSES OF FAILURE ARE (A)Q206 SHORTED C-E, (B)U204 DEFECTIVE
0516	DOES PIN 1 OF U205 (BRD 2-PIN 323) REMAIN HIGH DURING RUNDOWN (1)YES, (2)NO
0517	DOES THE BASE OF U204 HAVE PROPER BASE DRIVE DURING RUNDOWN (1)YES, (2)NO
0518	POSSIBLE CAUSES OF FAILURE ARE (A)Q204 DEFECTIVE, OPEN COLLECTOR, (B)TRANSISTOR OF U203 SHORTED C-E, (C)CR207 OR CR208 SHORTED TO GND
0519	DOES PIN 16 OF U205 REMAIN HIGH DURING RUNDOWN (1)YES, (2)NO
0520	POSSIBLE CAUSES OF FAILURE ARE (A)OPEN R253/R219/VR201, (B)OPEN OR REVERSED CR213, (C)SHORTED C206/R221/R220, (D)Q204 DEFECTIVE B-E

Figure 2. Software, Part A

Figure 3. Software, Part B

of Parts A and B. The troubleshooter will see and interact only with Part A of the program. Part C of the software will be essentially the same for any CAFA file; however, each product will require unique Part A/Part B software furnished by the appropriate product engineer.

Figure 4 is an example of a completed troubleshooting sequence. This example demonstrates the nature of the conversation between the computer and troubleshooter and shows that very little input is required from the troubleshooter. This sequence was chosen because of its shortness; most sequences will be longer than this one.

0001

THERE ARE NINE CATEGORIES OF TEST PERFORMED ON A TIMER. A UNIT MAY FAIL ONE OR MORE OF THESE CATEGORIES.

CATEGORY	NAME	PRODUCT SPEC TEST NUMBER
1	IMPEDANCE	1,2,3,4A,5A,6A,7A,9,10,11BC
2	DATA PULSE	4C---K,5C---K,6C---K,7C---K,8A---G
3	VERIFICATION	4L,5L,6L,7L,8H,11A,12A,13A,14A,15A,16AB,17AB,18A,19A,27A,28A,29A,30A,31A,32A,33A
4	PWR SUPPLY	48M,58M,68M,78M,12B,13B,14B,15B,18B,19B,28B
5	FIRE TIME	12E,13E,14E,15E,16C,17C,27D,28D,33D,30C
6	OPTION SEL.	12CD,13CD,14CD,15CD,16EF,17EF,30DE,32BC,33BC
7	NOISE	12F,13F,14F,15F,16BD,17BD,27C,28CE,29B,30B,31B,33E
8	OUTPUT PULSE	12GH,13GH,14GH,15GH,18CDE,19CDE,31DE,33FG
9	SPECIAL	20A,21A,22A,23,24A,25A,26A,27B,29C,31C,32D

WHICH OF THE FOLLOWING BEST DESCRIBES THE FAILURE MODE OF THIS UNIT?

- (1)CAT 1,(2)CAT 2,(3)CAT 3,(4)CAT 4,(5)CAT 5,(6)CAT 6,(7)CAT 7,(8)CAT 8
(9)CAT 9,(10)CAT 5 AND 6,(11)CAT 3,5,AND 6,(12)CAT 5 AND 7,(13)CAT 2 AND 3
(14)NONE OF THESE

1

OPERATOR INPUT

WHICH ONE OF THE FOLLOWING DOES THE UNIT FAIL? (1)TEST 1,2 OR 3,(2)TEST 4A,5A, 6A OR 7A,(3)TEST 9,(4)TEST 10,(5)TEST 11,(6)SOME COMBINATION OF 1 THRU 5

1

OPERATOR INPUT

DOES UNIT FAIL? (1)TEST 1 ONLY,(2)TEST 2 ONLY,(3)TEST 3 ONLY,(4)A COMBINATION OF TEST 1,2 AND 3

1

OPERATOR INPUT

POSSIBLE CAUSES OF FAILURE ARE (A)LEAKAGE BETWEEN THE WINDINGS OF T301, (B)MOISTURE/CONTAMINATION ON THE UNIT (C)LEAKAGE FROM T301,R301 OR PIN 5/6 TO SOME OTHER COMPONENT

9999

BASED ON THE INFORMATION SUPPLIED TO THE DIAGNOSTIC PROGRAM, THIS IS THE COMPLETION OF FAILURE ANALYSIS. IF THIS HAS NOT RESULTED IN A POSITIVE FAULT LOCATION, ONE OR MORE OF THE FOLLOWING ACTIONS SHOULD BE TAKEN:

- (A)REPEAT FAULT DIAGNOSIS USING DIFFERENT FAILURE CATEGORY,
(B)TROUBLESHOOT USING MANUAL PROCESSES,
(C)CONTACT ENGINEERING FOR ASSISTANCE

Figure 4. Troubleshooting Sequence

There are five main features of the CAFA software package.

- No special typing or programming skills are required of the troubleshooter.
- Only limited knowledge of computer programming is required for a product engineer to establish a CAFA file for a new product.
- The software design is adaptable to many different types of products and test systems.
- The software is adaptable to different types of iteration procedures.
- Changes to the logic tree and statement file are made by changing cards in a card deck. The program cannot be altered by a user from the TSO terminal.

Visual Aid Catalog

At various appropriate points in the troubleshooting question and answer sequence, the CAFA routine refers the user to a figure showing the correct waveform at an indicated point (Figure 5). Based on the presented waveform, the user decides whether or not the unit undergoing failure analysis is functioning correctly. The answer to the waveform question determines the sequence followed in the logic tree (Figure 3) of the CAFA routine.

These waveform figures are arranged in a Visual Aid Catalog (VAC) which could be in one of three forms.

- VAC waveforms could be stored and displayed on the TSO terminal. This would require a minimal programming effort by the product engineer. A disadvantage is the inability of the TSO terminal to present a fairly accurate plot.
- VAC waveforms could be stored and displayed on a microfiche card, but this would require an additional piece of equipment--a microfiche viewer.
- VAC waveforms could be displayed in a booklet.

The waveforms are now displayed in a booklet. Figure 6 shows a page out of the current booklet. It references the figure number in two places and also shows the user exactly where to place his oscilloscope probe to determine if the waveform in the failing unit is identical to the one displayed in the catalog. The VAC booklet could easily be converted to microfiche.

WELCOME TO FAILURE ANALYSIS FOR THE TIMER - GROUP 260.

THERE ARE NINE CATEGORIES OF TESTS PERFORMED ON A TIMER. A UNIT MAY FAIL ONE OR MORE OF THESE CATEGORIES.

CATEGORY	NAME	PRODUCT SPEC.	TEST NUMBER
1	IMPEDANCE	1, 2, 3, 4A, 5A, 9, 10, 11BC	
2	DATA PULSE	4B---I, 5B---I, 6B---I, 7B---I, 8A---H	
3	VERIFICATION	4J, 5J, 6J, 7J, 8I, 11A, 12A, 13A, 14A, 15A, 16AB, 17AB, 18A, 19A, 27A, 28A, 29A, 30A, 31A, 32A, 33A	
4	PWR. SUPPLY	6AK, 7AK, 12B, 13B, 14B, 15B, 18B, 19B, 28B	
5	FIRE TIME	12E, 13E, 14E, 15E, 16C, 17C, 27D, 28D, 33D, 30C	
6	OPTION SEL.	12CD, 13CD, 14CD, 15CD, 16EF, 17EF, 30DE, 32BC, 33BC	
7	NOISE	12F, 13F, 14F, 15F, 16BD, 17BD, 27C, 28CE, 29B, 30B, 31B, 33E	
8	OUTPUT PULSE	12GH, 13GH, 14GH, 15GH, 18CDE, 19CDE, 31DE, 33FG	
9	SPECIAL	20A, 21A, 22A, 23A, 24A, 27B, 29C, 31C, 32D, 34A	

WHICH OF THE FOLLOWING BEST DESCRIBES THE FAILURE MODE OF THIS UNIT?

(1) CAT 1, (2) CAT 2, (3) CAT 3, (4) CAT 4, (5) CAT 5, (6) CAT 6, (7) CAT 7, (8) CAT 8, (9) CAT 9, (10) CAT 5 AND 6, (11) CAT 3, 5 AND 6, (12) CAT 5 AND 7, (13) CAT 2 AND 3, (14) NONE OF THESE

ANSWER WAS (3).

DID THE UNIT FAIL FIRE TIME AND/OR OPTION SELECT IN ADDITION TO VERIFICATION

(1) YES, (2) NO

ANSWER WAS (2).

DID THE UNIT FAIL VERIFICATION BECAUSE (1) IT ALWAYS VERIFIES 77777, (2) IT ALWAYS VERIFIES 0000, (3) IT VERIFIES AN INCORRECT CODE OTHER THAN 77777/00000.

ANSWER WAS (1).

WHEN UNIT VERIFIES 77777, IS THERE (1) NO DATA REPLY PULSE AT PIN 9, OR (2) AN INCORRECTLY SHAPED OR POSITIONED REPLY PULSE ON PIN 9, SEE FIGURE 10.

ANSWER WAS (1).

IS THERE CORRECT BASE DRIVE TO Q205, FIGURE 2, DURING DATA SET? (1) YES, (2) NO

ANSWER WAS (1).

POSSIBLE CAUSES OF FAILURE ARE (A) R225 WRONG VALUE, (B) Q205 DEFECTIVE, (C) C207 OR C202 LEAKY OR SHORTED, (D) CR203 LEAKY, (4) CR204 HIGH FORWARD VOLTAGE/REVERSED

BASED ON THE INFORMATION SUPPLIED TO THE DIAGNOSTIC PROGRAM, THIS IS THE COMPLETION OF FAILURE ANALYSIS. IF THIS HAS NOT RESULTED IN A POSITIVE FAULT LOCATION, ONE OR MORE OF THE FOLLOWING ACTIONS SHOULD BE TAKEN:

(A) REPEAT FAULT DIAGNOSIS USING DIFFERENT FAILURE CATEGORY,

(B) TROUBLESHOOT USING MANUAL PROCESSES,

(C) CONTACT ENGINEERING FOR ASSISTANCE.

VISUAL AID CATALOG FIGURE REFERENCE

Figure 5. Software, Figure Reference

Initial Evaluation

The initial evaluation consisted of two parts. The first part was a TSO system checkout which confirmed that the TSO terminal and line printer were functional. The second part involved the introduction of component faults into a digital logic timer and then accessing the CAFA routine to troubleshoot the failures. The CAFA routine was found to be functional.

Numerous component orientation errors and defective components were encountered at the PWA level. A CAFA routine using the Visual Aid Catalog at the printed wiring assembly level is planned. There will be a CAFA routine for each printed wiring assembly in the digital timer.

FIGURE 23B
BASE OF Q306

Figure 6. Visual Aid Catalog Page

Problems were encountered in accessing the CAFA routine through the TSO terminal. The access and response time of the system was found to be slower than usual at certain times of the week because of the large number of other jobs being processed by the IBM 360/65 computer. These problems could be corrected by implementing the CAFA program on another system.

ACCOMPLISHMENTS

A diagnostic logic routine using the facilities of the Mezzanine Data Acquisition System (MEZZDAS) has been established for one product. The computer software necessary to store and implement this diagnostic logic routine on the IBM 360/65 computer has been developed. The TSO terminal has been declared operational and ready for CAFA evaluation. A Visual Aid Catalog has been developed for the current CAFA routine and is also ready for evaluation. Initial evaluation has begun using the current design of the digital logic timer.

FUTURE WORK

Future work will include an evaluation of the failure analysis program and visual aids for their completeness and an evaluation using a production troubleshooter to measure the effectiveness of the system. As the definitions and test specifications of the printed wiring assemblies become more stable, the CAFA system may be expanded to include them. Because of difficulties in accessing the CAFA routine, other methods of implementation will be examined to determine if any future work in this area is required. Because of advances in microprocessor technology, a stand-alone micro-computer system dedicated to failure analysis may be the best way to proceed.

REFERENCES

¹J. J. Hoefer, *A Cost-Effective Data Acquisition and Retrieval System for Hybrid Microcircuit Production*. Bendix Kansas City: BDX-613-1274, March 1975.

²D. W. Clements, *Computer Aided Failure Analysis*. Milestone Report on PDO 6984893. Bendix Kansas City: BDX-613-1369, July 1975.

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