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HIGH RELIABILITY ASSURANCE SYSTEM OF FUJI SEQUENCER

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I. FOREWORD

Recent sequence control systems have become increasingly more complex, diversified and wide ranging. With respect to this, the application of sequencers is steadily widening in a form which utilizes their superior features. In this case, the general usage method is mainly by direct connection with the objective equipment of the plant and operation without any kind of back-up system. Therefore, shut-down due to sequencer trouble immediately halts operation of directly connected facility equipment and system shut-down frequently occurs and the demand for high reliability of the sequence has increased accordingly.

The reliability of the equipment is based on the probable time between failure MTBF (Mean Time Between Failure), but with such systems in which repair is possible even if trouble should occur as the sequencer, not only reliability in the narrow sense, but reliability in the broad sense encompassing maintainability represented by the probable time from failure to repaire MTTR (MeanTime To Repair) must be considered. That is, high reliability systems or equipment must be given ample consideration so that the actual MTBF is as long as possible and the MTTR is short. Moreover, production and use must be a controlled type. With respect to this, the basic conceptions of the Fuji stored sequencer F-MATIC Series are given in *Fig. 1*. The important points of its contents are descreibed below.

II. QUALITY ASSURANCE SYSTEM

Control to produce high quality trouble-free products which amply satisfy the customer is actually extremely difficult and, of course, high facilities investment and manpower are required, and such products are first attained by executing a stringent program based on a consistent system and concepts related to quality assurance in the series of processes from product development to production, testing and shipment. The Fuji sequencer quality assurance system flow is given in *Fig. 2*. In the development and design stage, a parts approval, reliability design and testing system is established and in the production testing stage, various programs are executed for exhaustive reliability control and, furthermore, a reliability data acquisition and application system for each process is established.

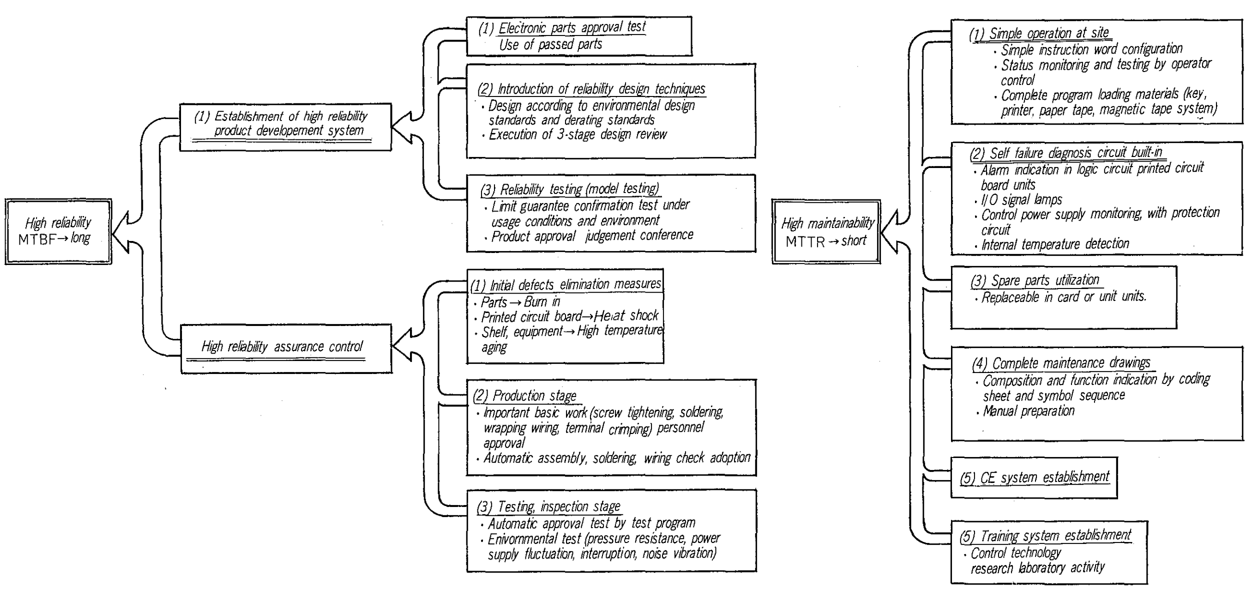

Fig. 1 High reliability assurance conception of Fuji sequencer

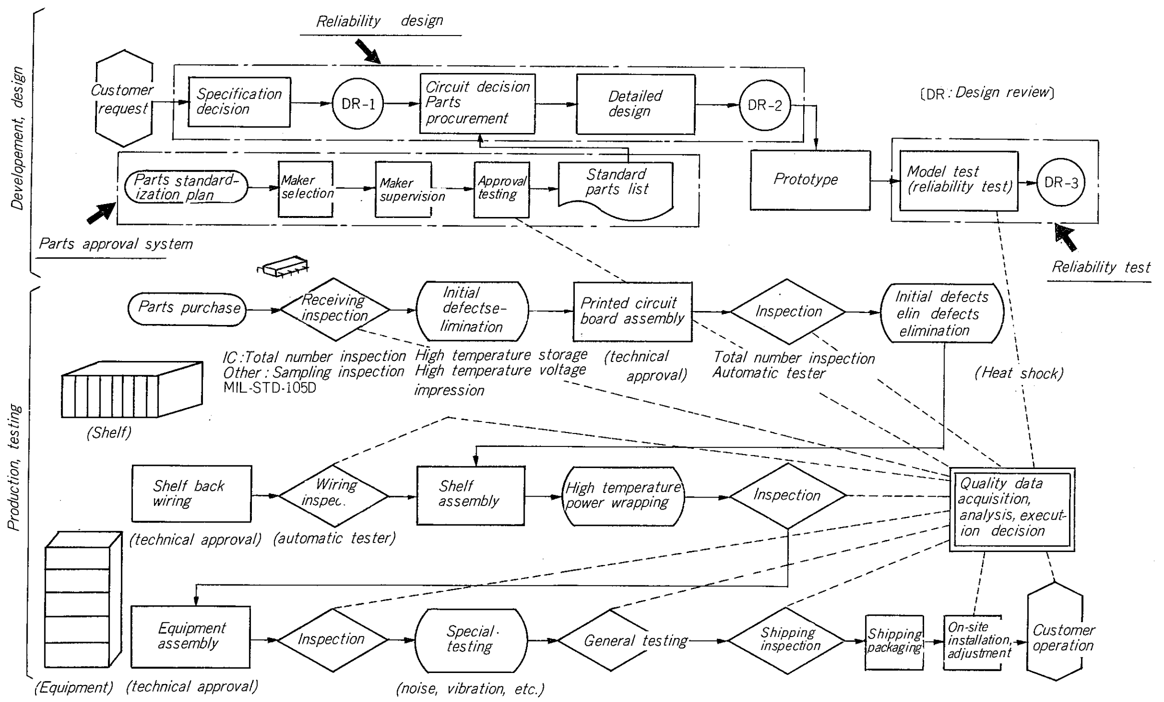

Fig. 2 Flow chart of Fuji high quality assurance system

1. Parts Approval

The failure of one part in an electronic control system is closely associated with system shutdown and there is no question as to the importance of selection and use of high quality parts also from examples of the introduction of noticeably large losses.

At Fuji, this situation is recognized and a parts approval system has been established and executed from the standpoint of the purchase and use of the parts of other companies. In this system, parts vendor production supervision is performed and only those parts that have passed 1000 hours or more of various environmental tests and high/low temperature continuous operation tests based on MIL STD-202 are approved and used. Approved parts are restudied every year.

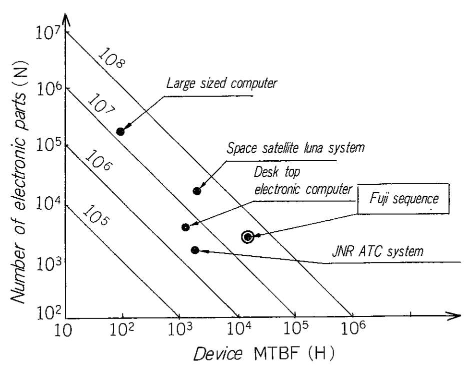

Fig. 3 Reliability rank of Fuji sequencer

2. Reliability Design

The target reliability is set at product development, but the actual value is calculated from the type, number, and collected reliability data at the end of design. At Fuji, the reliability rank is decided using the index of the product of the value of this MTBF and the number of parts used N. An example for the sequencer SC-20 is given in *Fig. 3*.

However, since the actual MTBF value depends on the actual environmental conditions, how environmental design is performed is extremely important, At Fuji, design rank standards are established based on the various environmental conditions, that is, temperature, humidity, vibration, shock, power supply variation and noise, gas, salt component, and other data collected as part of reliability data acquisition. The actual usage environment of the sequencer is considered and parts, circuit derating level, surfaceprocessing and printed card coating standards are selected so that the sequencer is within that environmental rank.

Moreover, design review is an important reliability design technique. In this review, 3 points are established at the design and development stage and multi-faceted group study is conducted on the specifications, quality, reliability, production, testing, cost and other related items for each of this points. Of course, the various items are restudied and improved for reliability in step with these established execution standards at the time of sequencer developments.

Table 1 Contents of reliability test

No.	Main test item	Contents
1	Power supply fluctuation test	Input power supply voltage within the allowable range, frequency variation, repeated ON-OFF, momentary interruption, abnormality monitoring, protection operation.
2	Temperature, humidity test	Normal operation is confirmed under the worst conditions of ambient temperature −10 ~ +50°C, 45°C 95% RH.
3	Temperature rise test	Temperature rise measurement of component part in the maximum load state.
4	Noise test	(1) 2000V, 10 minutes by noise simultator. (2) Noise impression by magnetic contactor, relay. (3) Buzzer, fluorescent lamp noise impression. (4) Transceiver, etc. noise impression.
5	Vibration test	Acceleration 1G, frequency 1~55Hz, resonant point confirmation. Resonant point 3 axis direction each 2 hours normal operation confirmation.
6	Shock test	3 axis direction each 30G 2 times impression.
7	Failure diagnosis test	Self failure diagnosis operation confirmation by referring to internal circuit FMEA.
8	Operability test	Operated by person unfamiliar with product and various confirmations performed.
9	Use test	Application in factory facility and failure condition confirmed after an extended period of time.

3. Reliability Testing

The prototypes based on the development specifications are stringently tested to ascertain if they sufficiently satisfy the required performances and functions and production of only those that have perfectly passed these tests is permitted. The test contents are performed by applying a more stringent strain than the normal nominal usage conditions. The main contents for the sequencer are given in *Table 1.*

4. Initial Defects Elimination Measures

The failure rate is clearly reduced by employing parts guaranteed by approval testing, but the initial failure of semiconductor parts, especially IC elements, is a grim reality separate from this. Consequently, measures to eliminate this initial failure before shipment of the product are necessary. With a sequencer, temperature and other strains are applied at each step as given below to eliminate initial failures.

1) Parts: Burn in test, parts allowable temperature conditions.
2) Printed circuit boards: Hit shock test, −10°C, +60°C, 5 cycles
3) Shelf: High temperature running test, +50°C, 96H.
4) Equipment: Simulation test, room temperature running, noise, vibration test.

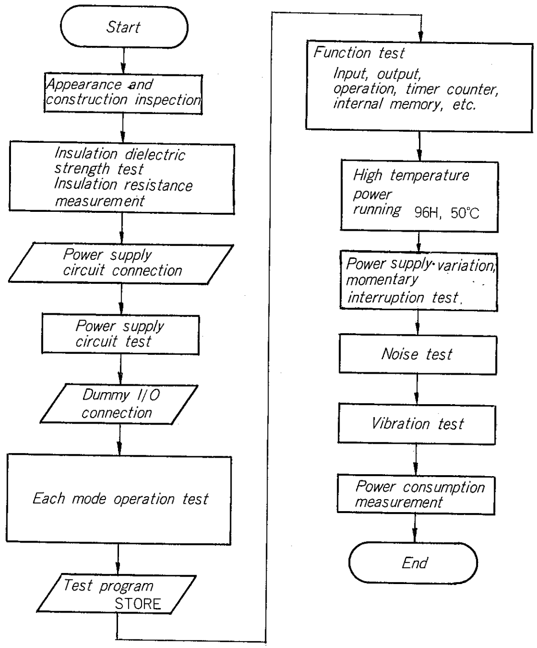

Fig. 4 Testing flow of sequencer shelf

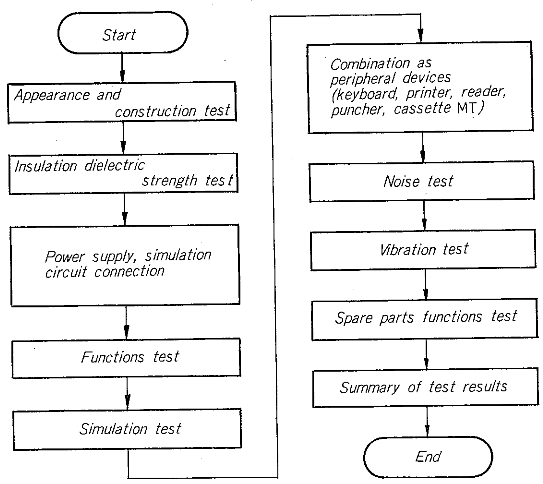

Fig. 5 Testing flow of sequencer device

5. Reliability Test at Production, Testing

Receiving inspection of the purchased parts used is performed based on the detailed inspection standards stipulated for each type of part. However, in order to quickly detect potentially faulty lots, tests established from the failure physical standpoint are conducted.

Since each production and assembly step is diagrammed and is performed in the decided procedure based on detailed common and individual work standards, stable products can be produced. This is an important point in maintaining the standards at reliability testing. However, since there is the fear of variations by the workers in wiring soldering, wrapping, crimping, screw tightening and other manual work, ample consideration is, of course, given to

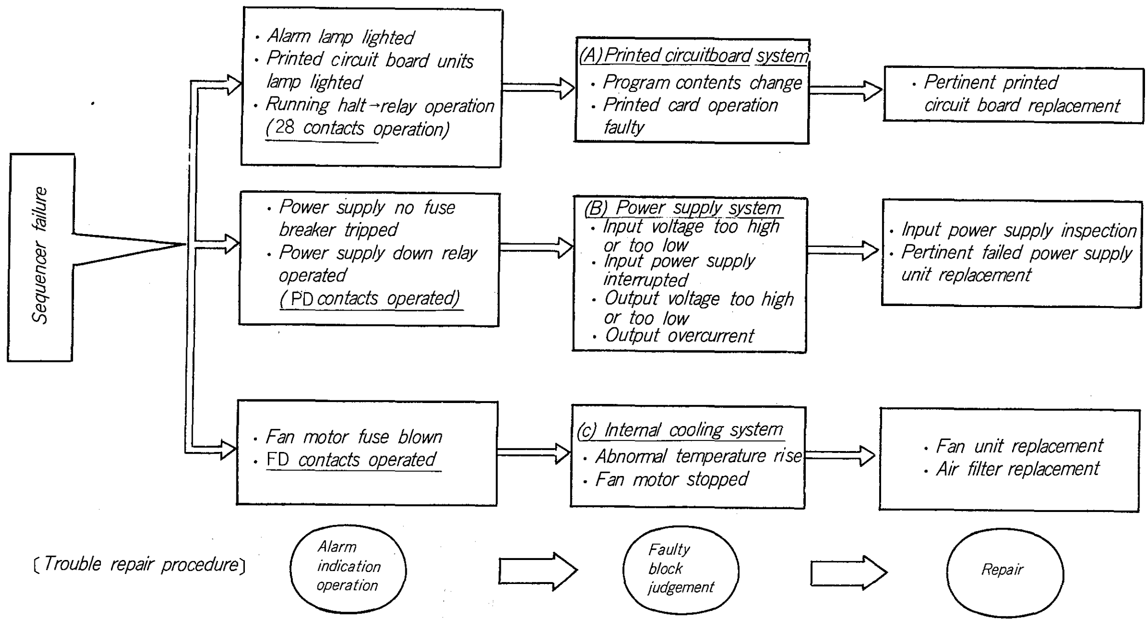

Fig. 6 Contents of self failure diagnosis

management of the tools, and these are especially taken up as important standard work and a technical approval system by rank is adopted and special force is poured into control of technical standards.

Product combination test is performed at the shelf and equipment stage. Since the normal performances and functions confirmation and combination with peripheral devices test are performed automatically by test program at the shelf stage, all the items are confirmed in a short time. The important point of the composite functions test in the equipment stage is, naturally, program debugging and environmental test (power supply variation, dielectric strength, noise, vibration, temperature) and powered running. The flow chart is given in *Fig. 4* and *Fig. 5*.

III. FAILURE DETECTION AND PROCESSING

A sequencer which can be used with confidence by the customer must be relatively trouble-free, difficult to damaged and highly reliable and repair time if a failure should occur must be short and integrity must be high. The especially important arithmetic circuit unit of the Fuji sequencer is redundant and a check and other failure self diagnosis circuits are self-contained and which point is faulty is displayed so that it can be determined at a glance.

1. Self Failure Diagnosis System

Sequencer failure causes are classified into the follwing 3 blocks:

(1) Printed circuit board
(2) Power supply
(3) Internal cooling

If a failure occurs at any of these blocks, the self diagnosis circuit of that block is operated and the alarms contacts for each block are operated and the faulty block is indicated. However, in the case of (1), the indication is also given in printed circuit board units. Therefore, repair can be performed quickly by searching the faulty printed circuit board or unit from the contents of these indications and replacing the faulty board or unit with a spare. Refer to *Fig. 6* for an outline of this self failure diagnosis.

2. CE System

Since a troubleshooting manual based on the self failure diagnosis function is compiled for quick, suitable troubleshooting when a failure occurs, repair can normally be performed by the user. Moreover, when the cause of the brouble is unclear, maintenance personnel distributed throughout the country can provided quick service through our nearest branch office.

3. Customer Training

The Fuji control technology research laboratory is a special training organization for Fuji products with the customer as the objective. Here, the operating principles, handling, operation, etc. of the sequencer is described in an easy to understand manner to the customers responsible personnel to deepen their understanding of the sequencer and make trouble repaire easy. These special classes are held periodically and have received favorable comment.

IV. CONCLUSION

The basic considerations and one incorporation method for the Fuji stored sequencer high reliability assurance system were introduced above. Although space considerations necessitated the omission of many points, this article should provide a general understanding.