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Trouble-Shooting Procedure Standardization to Increase the Overhaul Maintenance Efficiency of Avionics Components

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Abstract

To perform avionics Overhaul maintenance efficiently, this paper proposed trouble-shooting procedure standardization by using Control Panel, ****, one of avionics components and universal Automatic Test Equipment (ATE). In modern aircraft, more and more avionics components monitor and control aircraft by using the latest computer technology for easy operation of the pilot and prevention of human errors. Accordingly, Small and Medium-sized Enterprises (SMEs) trying to be engaged in avionics maintenance business are also increasing but the supply of skilled mechanics does not meet increasing maintenance demand. Thus, this study proposed procedure standardization using general purpose ATE that can systematically complete the insufficient part of skilled mechanics in the trouble- shooting process requiring the most skilled mechanics during the Overhaul maintenance process and reviewed the validity of the proposed method. This study will help to manage the production capacity of SMEs starting avionics maintenance business newly.

Keywords: Avionics, ATE, Overhaul Maintenance, Trouble-Shooting

1. Introduction

It is no exaggeration to say that the electronic technology controls its performance in modern aircraft. It is also proven through the fact that gas structures or technologies such as flight control have been hardly changed since the aircraft was born in aircraft technology but only avionics technology has developed rapidly. The avionics technology is a technology applied in the aircraft and aircraft usage sector and refers to a kind of electronic applications[1]. AVIONICS is a compound of AVIation and electrONICS and the concept of including all electronic and electrical units used to control electronic equipment and internal mechanical system mounted for functions such as communication, navigation, radar, flight control in aircraft and its relative importance is growing rapidly in aircraft[2]. As its relative importance of the avionics sector is increasing in aircraft, domestic and foreign companies that participate in the avionics Overhaul maintenance are also increasing such as military aircraft PBL maintenance business of Korea Aerospace Industries, Avionics MRO center for maintenance of F-15K avionics components recently established in Yeongcheon, Gyeongsangbuk-do by Boeing of the U.S.[3-5]. AVIONICS Overhaul maintenance is that the mechanic is to make defective avionics components of aircraft in operation function properly again through the process of "Incoming inspection > disassembly / cleaning > function test > trouble-shooting> repair exchange > assembly > follow up process > complete Inspection" by using DRAWING, T.O. (Technical Order) or CMM (Component Maintenance Manual). Of these processes, the trouble-shooting process is a very important process to store the original function of defective Avionics Component and time taken to perform the process varies significantly depending on advanced circuit knowledge, electronic device knowledge, maintenance experience or career for avionics components.

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Therefore, a maintenance company should always hold mechanics with excellent skills or prepare a method that can systematically complement this.

This paper proposes the procedure standardization of trouble-shooting that enables responsible mechanics to immediately identify and exchange components associated with nonconforming test items by identifying circuit and components related to nonconforming test items occurring in the functional test during Overhaul maintenance of avionics components by using general purpose ATE that can systemically complement maintenance on behalf of necessary skilled avionics Overhaul mechanics and popping up them in ATE screen and verifies the effect.

2. Related Work

2.1 Overhaul Maintenance

Generally, maintenance can be divided into 3 steps of front-line maintenance/field maintenance Overhaul maintenance. Generally, the failure rate pattern shows a bath tube curve as shown in Figure 1 as the failure rate increases rapidly when a certain period has elapsed and the purpose of Overhaul maintenance is to maintain the equipment operating rate by lowering the failure rate and extending the life of the equipment through Overhaul maintenance at the point of excessive fault occurrence. The current Overhaul maintenance method is the overhaul maintenance of a complete overhaul concept and goes through the procedure from dismantling · Inspection of complete equipment to components maintenance, assembly · Inspection, functional test and Overhaul maintenance cycle is Time-Based Maintenance (TBM) and equipment operation period and mileage are considered but first occurring standards are applied[6-8].

Overhaul maintenance of the general machinery sector and Overhaul maintenance of the avionics shows the different nature. Overhaul maintenance of the machinery sector is completed through cleaning, dimensional inspection, mandatory exchange, materials exchange,

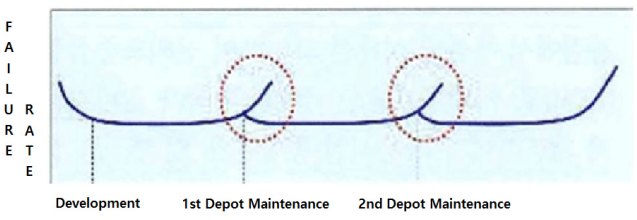

Figure 1. Overhaul Maintenance Concept[6].

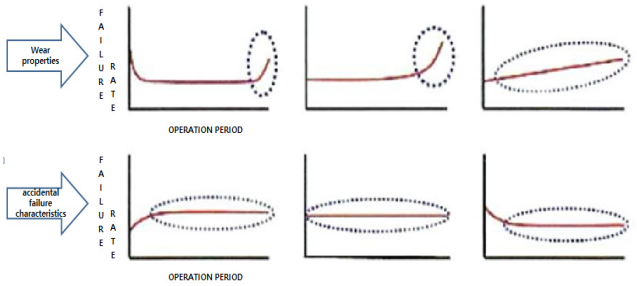

Figure 2. Failure Rate Distribution Pattern Depending on Equipment Operation Period[6].

assembly and function test by warehousing periodically and disassembling completely. But avionics Overhaul maintenance should have a system or a person with the ability to solve these defects as well as simple disassembly/inspection/replacement work because except for special cases, defects caused in orgarnization maintenance/field maintenance come to Overhaul maintenance.

2.2 ATE (Automatic Test Equipment)

ATS (Automatic Test System) is generally consist of ATE (Automatic Test Equipment), TRD (Test Requirement) and TPS (Test Program Set). ATE is used in order to guarantee the best conditions of avionics components with minimum intervention of mechanics to prevent quality problems caused by human factors from

Figure 3. General Purpose ATE(PASS3000).

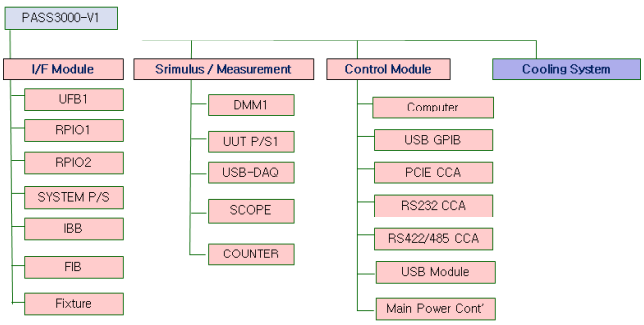

Figure 4. PASS 3000 Block Diagram.

occurring in the maintenance process. A power supplier, signal generator, oscilloscope and control computer are included in this equipment. ATE is generally classified into three kinds of Bench-top type, Dedicated type, General purpose type. Bench-top type is used in extremely limited avionics components tests and does not have any control computers. Dedicated type is easy in single kind and mass tests because there is a control computer and it is designed to check only certain components. General purpose type is designed to be used in almost all Avionics components and consists of Control computer, Power supply module, Stimulator module, Measurement Module, Interface Test Adapter Module, Cooling Module etc[9]. In this paper, PASS-3000 of General purpose type is used.

3. Trouble Shooting

General trouble-shooting procedures of avionics components are completed through the procedures of functional test>identification of nonconforming test items> review of related drawings > diagram and search of components> checking nonconforming components. Depending on whether to use ATE, functional test procedures are divided into the ATE way of conducting a functional test sequentially by programming the test procedures in equipment with all test environments and NON-ATE way that a mechanic sets test equipment according to test procedures and carries out the test as stated in the test procedures and writes a report. The functional test procedures are the procedures of checking the various functions of avionics components and the responsible person can check if these components can be mounted to the aircraft and operated normally. Civil aircraft is contained in CMM (Component Maintenance Manual) and military aircraft in T.O. (Technical Order), T.M. (Technical Manual) or DMWR (Overhaul Maintenance Work Requirement).

The defect identification procedures are the step of checking nonconforming test items caused during the functional test process and identify test items that do not satisfy the conditions given in the test procedures of avionics components. The scope of required data is determined depending on test items identified in this procedure. If a nonconforming test is identified, the overview should be checked to find out first for which function in the aircraft the test is carried out.

And then, in order to find out the pin-specific function of the connector of UUT (Unit Under Test), technical books for front-line maintenance of the component mounted aircraft are analyzed. In order to analyze the circuit card connection point within UUT connected with pin for power and signal checked in this manner, technical books for field/Overhaul maintenance are consulted. After checking CCA (Circuit Card Ass'y) connection

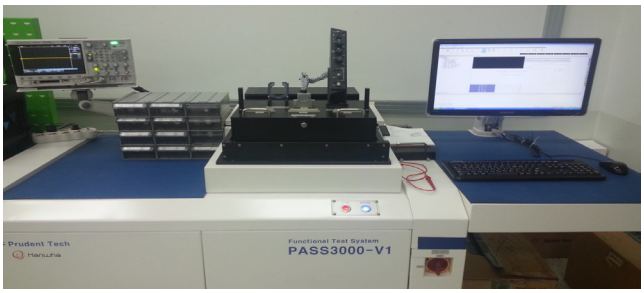

Figure 5. ATE Functional Test.

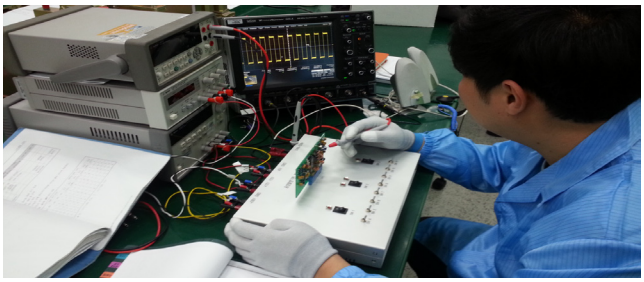

Figure 6. NON-ATE Functional Test.

SWITCH OR CONTROL	POSITION	METER/INDICATOR NORMAL RESULT
SERVO SIMULATION Group		
ILCA SIMULATION PITCH	RESET	
ILCA SIMULATION ROLL	RESET	
ILCA SIMULATION YAW	RESET	
ACTUATOR SIMULATION CCDA	NORM	
ACTUATOR SIMULATION DASH	TF2	
LCT	NORM	
CONTROL PANEL SIMULATION Group		
AFCS	SELECT	
CIRCUIT SELECT	00-0-B-0	
METER	AC	
RANGE	200V	
AFCS PO WER 115VAC/400-Hz	OFF	
AFCS POWER +28VDC	OFF	
LCT POWER +28VDC	OFF	
SELF TEST CIRCUIT SELECT	00-1	6 VAC MAX
AFCS POWER 115V/400-Hz	ON then OFF	112.2 to 117.7 VAC
METER	DC	
SELF TEST CIRCUIT SELECT	00-2	-0.6 to +0.6 VDC

Figure 7. Example of Functional Test Procedures[3].

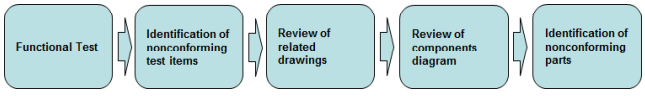

Figure 8. Trouble-Shooting Procedures.

information by pin checked in this way, full-fledged trouble-shooting is carried out and components causing nonconforming are checked by using the analysis of circuit such as OP-AMP, FLIP-FLOP and datasheet by device and the time difference between skilled mechanics and unskilled mechanics is clearly revealed here. The trouble-shooting process is completed by checking information of component number, i.e. IC U**, resistor R** in the electronic circuit diagram of avionics components and then, checking specifications, location information of U**, R** in ILLUSTRATED PART BREAKDOWN of the avionics part and then, finally checking the actual parts causing nonconforming.

4. TPS Design

TPS (Test Program Set) consists of TRD, TP, ITA. TPS is the output generated upon completion of maintenance development of the avionics sector and TRD is the most basic technical document required to automate functional test and trouble-shooting and type of input power, input point, type of input signal, input signal point, output point and input/output reference value are written in it. This document was created through the analysis of drawings, test procedures, Overhaul maintenance technical books and TP and ITA are written and created based on it. TP (Test Program) is a coded sequence, when executed by an ATE, provides instruction, UUT stimuli, measurements of UUT responses, detection of UUT faults, isolation of UUT faults, and alignment /adjustment procedures for fault correction. The test program is formatted in accordance with the targeted ATE style guides to provide uniformity in the functionality and appearance of the TP[9]. A TF (Test Fixture) is a fixture that provides additional circuitry to resolve incompatibilities between a UUT and an ATE, which is not appropriate for inclusion in an ID due to weight, size, signal conditioning or heat limitations. It may also be used as a fixture to secure a UUT[9]. The contents developed and implemented based on the above information are as follows: The entire test items are about 150 items and only the implemented contents of the functional test of Control Switch S1 are mentioned in this paper.

4.1 TRD (Test Requirement Document)

- The following figure is TRD for Control SWITCH S1 functional test of Control panel and basically sets types/paths of stimulus signal and includes MODE setting of DMM, OSCILLOSCOPE for Measurement and ACTION details of mechanics and LOW/HIGH LIMIT standards, the contents on electronic parts to be repaired or exchanged in the event of FAIL. The specific contents on the figure below are as follows:
- Set DC power supplier of PASS-3000 to (+28VDC/0.5A) and connect it to RELAY K1 POINT X1 of UUT through pin 31 of Connector J01 of UUT (Unit Under Test).
- Set DC power supplier of PASS-3000 to +28VD/0.5A and connect it to the terminal No. 5 of UUT S1 and RELAY K1 POINT B1 of UUT through No. pin 29 of Connector J01 of UUT (Unit Under Test).
- Connect DMM two lines of PASS-3000 to pin 27 and pin 59 of UUT J01, respectively. Connect pin 27 and pin 59 to S1 of UUT and diode CR25 of CCA (Circuit Card Ass'y) of UUT.
- When turning ON S1 of UUT, 27 ~ 29VDC will be out.
- If getting out of 27 ~ 29VDC, repair/exchange S1 and peripheral electronic circuit.

ac. A2 CCA(Circuit Card Ass'y) Opration Test

1) Test Overview

A) PASS-3000 DC P/S(+28V/0.5A) → UUT J01 (Pin 43)
→ UUT DS4(TP 7)
B) PASS-3000 DC P/S(+5V/0.5A) → UUT J01 (Pin 65)
→ UUT A2 CCA U1 (Pin 14) / U2 (Pin 14)
C) PASS-3000 DC P/S(+10V/0.5A) → UUT J01 (Pin 63)
→ UUT A2 CCA Q1 (Point E) / R27
D) Verify the "DET-HOT" message at the DS4(FCP Indicator)
E) PASS-3000 DC P/S(GND) → UUT J01 (Pin 44)
→ UUT P1(Pin 4) → UUT A2 CCA U1 (Pin 12,13)
F) Verify the "POWER-ON" message at the DS4(FCP Indicator)
G) PASS-3000 DC P/S(GND) → UUT J01 (Pin 34) → UUT P1(Pin 40)
→ UUT A2 CCA U1 (Pin 1,2)→ UUT A2 CCA U2 (Pin 5)
H) Verify the "TEST" message at the DS4(FCP Indicator)

2) Fault Symptoms

A) Expected value and different values are revelations on the FCP indicator

Figure 9. TRD Design/Implementation.

4.2 TP (Test Program)

TMS (Test Management System) 4.0 of PASS3000 is the PASS3000 operating program for Windows and a user-centered program management tool that can program to control all instruments and equipment within the system by a simple choice even if the user does not know languages such as C or C ++[10]. The contents of the program include instrument selection in PASS3000, selection of STIMULUS, setting of input signal, control of MATRIX circuit card and the internal equipment is controlled by using GPIB communication. By referring to TMS user manual and TRD, the program was created as shown in Figure 10.

4.3 ITA (Interconnect Test Adapter)

ITA design is produced based on TRD and TP created in the above. ITA is an ADAPTER connected to I/F part of PASS300 and plays a role of connecting UUT and PASS3000 and the making process of actual ITA was expressed in the figure below. First, it was connected to

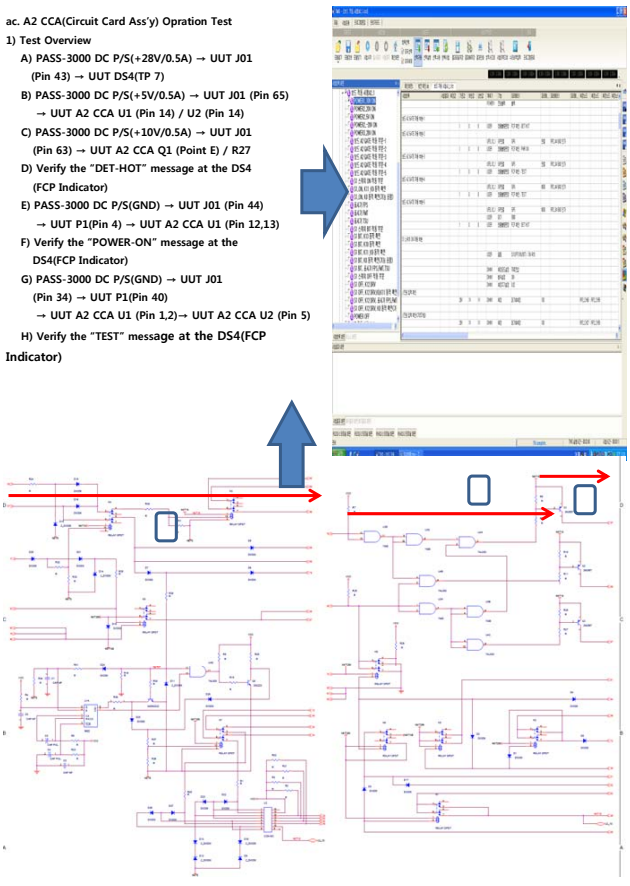

Figure 10. TP Design/Implementation.

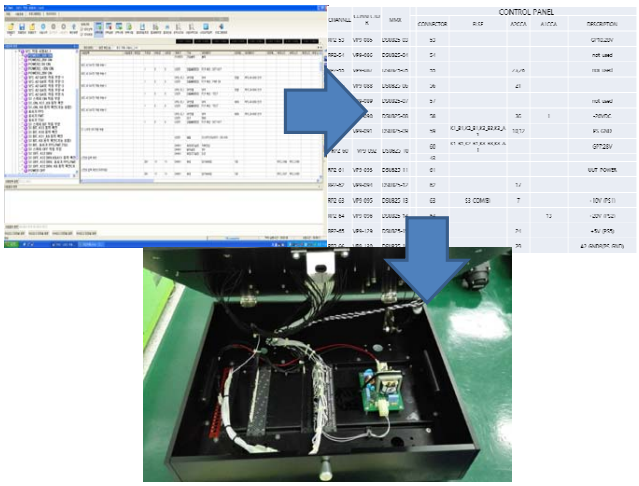

Figure 11. ITA Design/Implementation.

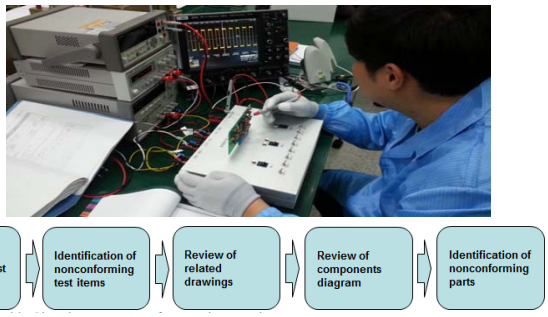

Figure 12. Trouble-Shooting Process Before Implementation.

Pin 31 of J01 of UUT with AWG 20 WIRE in MATRIX circuit connecting the output of DC power supplier inside the equipment. And likewise, it was connected to Pin 29 of J01 of UUT with AWG 20 WIRE in MATRIX circuit connecting the output of DC power supplier. And then, MATRIX circuit output lines connected with internal equipment DMM were connected to Pin 27, Pin 59 by using AWG 20 WIRE. Wire was also connected to the remaining test items according to each TPS.

5. Proposal for Maintenance Procedure Standardization

If defective test items occur while conducting a functional test in the trouble-shooting process before implementation, we first analyze the test items and refer to technical books (dash 1/dash 2) for front-line/field maintenance in order to check pin information of UUT and if checking pin information, we refer to technical books for Overhaul maintenance (dash 3) or

manufacturer drawings in order to check if the pin was connected to the connector pin of any CCA and if there is no corresponding information, we check the circuit information corresponding to test items by obtaining related information through Reverse engineering. Here,

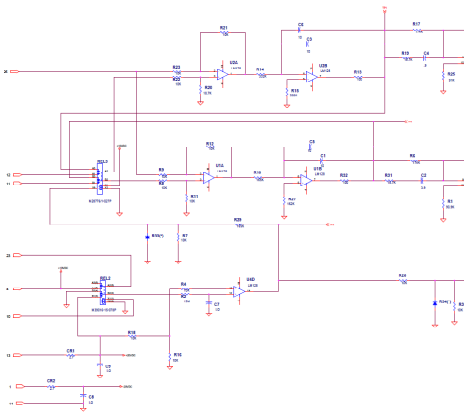

Figure 13. Review Related Drawings.

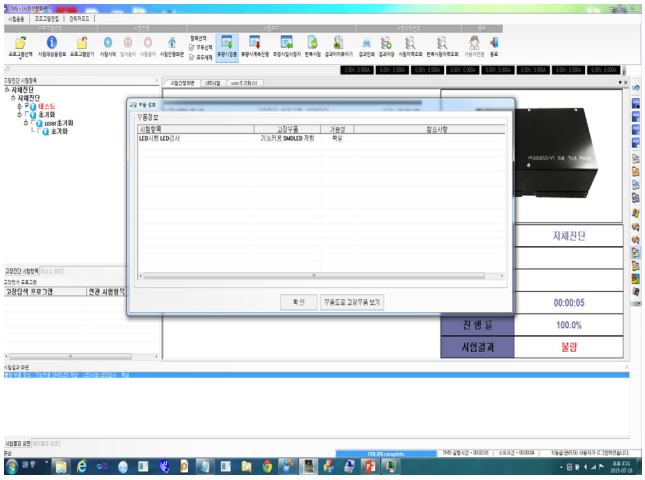

Figure 14. Nonconforming Part CALL-OUT Scene.

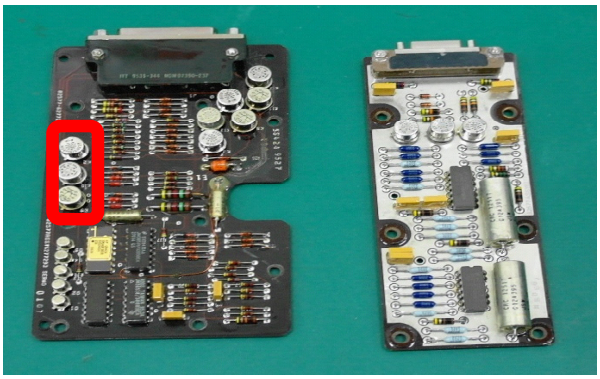

Figure 15. Identification of Called Out Parts.

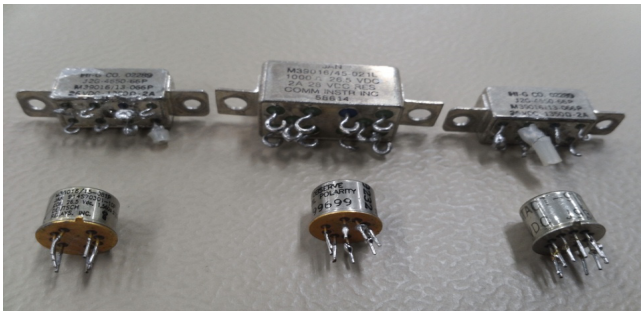

Figure 16. Replaced Nonconforming Parts.

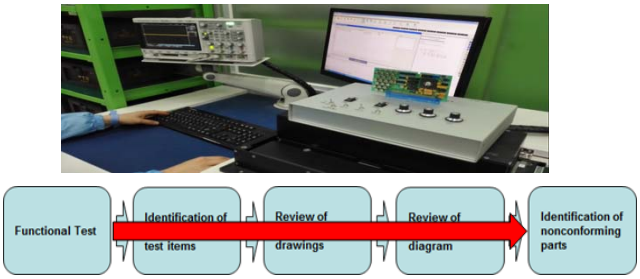

Figure 17. Improved Trouble-Shooting Procedures.

the responsible person should check each of electronic devices forming the circuit by referring to data sheet and find suspected parts and then, identify the part number of the part in IPB and then, find the part in the circuit card for inspection and replacement.

In order to perform these series of procedures, the mechanic should basically hold the English reading ability because most maintenance technical materials of UUT are written in English and search ability of technical books for maintenance, understanding of a wide range of analog/digital system circuit theories, the ability to understand data sheet by electronic device used in the circuit and instrument operation such as oscilloscope etc. All of these complex abilities cannot be developed within a short time. Also, mechanic cannot be placed only in one item because most maintenance companies carry out small quantity batch maintenance due to the product characteristics. And even if an experienced mechanic, if the item is maintained one or twice a year, even the maintenance time for the product will not be constant every year.

The standardization of the proposed trouble-shooting procedures conducts a functional test by ATE and if nonconforming occurs during the functional test, it is called out in the ATE screen and the performing mechanic checks and replaces/repairs related parts by using called out part number.

6. Conclusion

This paper proposed trouble-shooting procedure standardization during the Overhaul maintenance process of avionics equipment by using ATE. By programming related circuit and standardized failure procedures in ATE when selecting test items and creating procedures during maintenance development, English reading skills of the mechanic and depth of maintenance knowledge do not need to be considered and in the event of vacancy due to the turnover of the mechanic, the next mechanic can be also easily accessible to maintenance of the product and the problem of irregular time required caused by small quantity batch maintenance can be also solved. And it is beneficial in terms of economic feasibility because one time standardization of trouble-shooting procedures can be used even for average more than 30 years when the aircraft deteriorates. If conducting trouble-shooting in order developed by the maintenance technical engineer by using the maintenance procedure standardization technique proposed in this study, parts causing or suspected as defects can be found. Eventually, this is the case of building a system that can obtain the maximum effect by securing minimal skilled mechanics. And this study will be completed more by carrying out a comparative study on time required for maintenance in order to verify quantitative effects when standardizing and non-standardizing these trouble-shooting procedures.

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