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IMPROVEMENT IN THROUGHPUT OF RADIO SETS

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Abstract : The role of communication set is very critical for any defence forces. This equipment is only means to communicate personnel situated in the forward location of the country and base station. Thus reliability of this communication sets plays a vital role. This sets are the lifeline of many people. Equipment should work in all conditions and round the clock. Thus equipment reliability of the set should be beyond question.

Key words : PTP, ATP,TS, ATE

1. Introduction:

The equipment is a software controlled Frequency hopping radio . The design is based on Digital Signal Processing (DSP)[1]. The frequency synthesis is based on Direct Digital Synthesis (DDS)[2] technique. The radio works in Frequency Hopping (FH) and Fixed Frequency (FF)[3] modes with built -in-high-grade digital secrecy. The fixed frequency mode ensures interoperability with conventional radios. It also operates as a fixed frequency radio with speech encryption. The radio is designed as a man pack with transceiver. The major accessories for the man pack operation are battery pack, whip antenna and handset. It has extensive Built-In-Test (BITE)[4] facility. The modules are easily replaceable to facilitate for easy maintenance. The frequency-hopping mode of operation provides very good protection against intentional or unintentional jamming and interception of messages. The design is capable of full band hopping or partial band hopping. A very flexible frequency management feature is provided. The channels to be used in a particular hop set are completely user definable. Hop sets can be devised, which use or forbid any frequency or group of frequencies in the band. In addition facility exists for clear voice override in fixed frequency secure mode. photograph of radio set is shown in Fig 1.

Fig 1: Radio set

2. Research Problem:

PCBs were tested at individual test set ups as per PTPs and ATPs. After that PCBs were assembled into set and sent to Testing. Manual testing of Radio set was done as per ATP and TS of radio set. Tested OK sets were sent for ATE reading. At the manual reading it was observed that in many sets Transmit Power was not meeting the required specifications. Variation in the power was resulting in terms of Low power at initial frequencies. It resulted in failure of Radio set. The manufacturing process is shown in Fig 2.

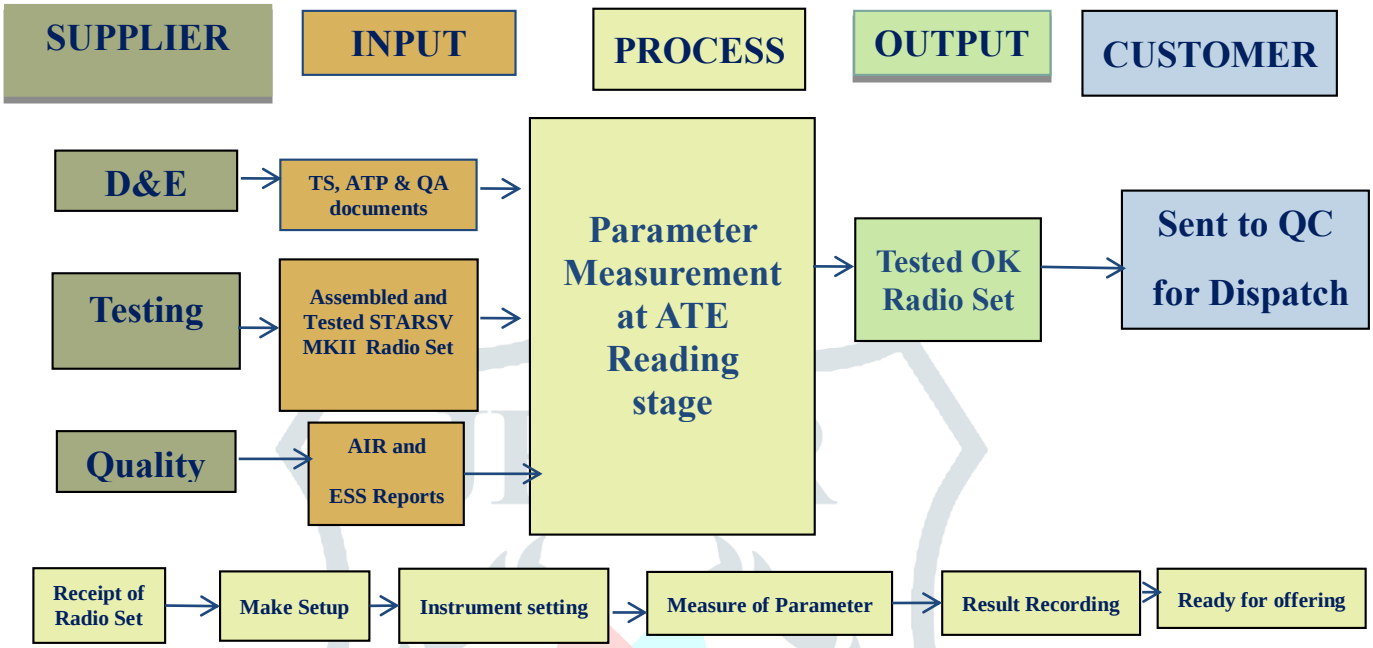

Fig 2: Manufacturing Process

Radio sets qty 200 were manufactured and tested as per specification. Result is depicted in Fig 3.

DEFECTS	UNITS	DEFECTIVES
85	200	83

Faults	Quantity
Tx Power Failure	60
High Current	7
Standby Current failure	5
Display Problem	4
FH1, FH2 modes Problem	4
Tx Switch Failure	3
Cable failure	2

Total Defects =85No.

Fig 3: Tested Data

Defect type was analysis was done and shown in Fig 4.

DEFECT Type	UNITS	DEFECTS	Total OPP0RTUNITY	Details of Opportunity
Tx Power Failure	200	60	10	A2, A8, A5,A4, A6 failure and 5 RF cable faults.
High Current	200	7	5	Relay short, 4 flexible cable faults
Standby Current failure	200	5	3	PCB failure(A2, A6, A7)
Display Problem	200	4	1	A8 faulty
FH1, FH2 modes Problem	200	4	3	A11, 2 flexible cable faulty
Tx Switch Failure	200	3	1	Relay faulty
Cable failure	200	2	9	Cables short and open

Fig 4: Defect chart

Problems noticed were mentioned below;

- 200 sets were tested in November-December 2021.
- All the sets were tested manually and the data was recorded. Data is presented in defect chart.
- 80% faults were due to Tx Power fail to meet specifications.
- So major Goal was to find a solution for Tx Power in Radio set

3. Analysis:

The failure data was collated. To have in-depth understanding of process, Cause & Effects diagram was prepared. The diagram is shown in Fig 5.

Cause and Effect diagram

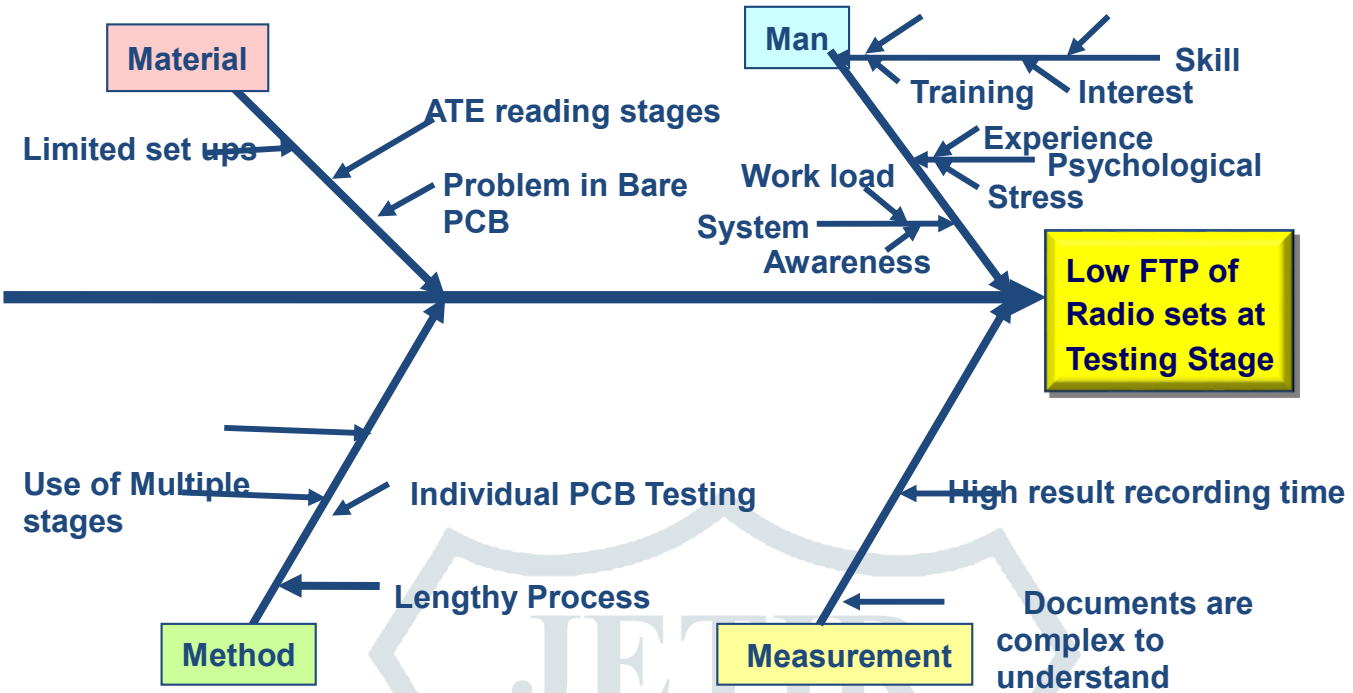

Fig 5: Cause & Effect Diagram

The causes are mentioned in a chart form in Fig 6.

CAUSES	REQUIRED	ACTUAL	RESULT
Limited Test Setups	Sufficient test setups should be available to meet target	4 test setups were used as per requirement	**Action not Required**
ATE reading stages	ATE reading stages should be calibrated in order to give correct reading	ATE stages are calibrated and are working properly	**Action not Required**
Problem in Bare PCB	There should no problem in bare PCB.	It seems that PCBs are not working as per PTP output	**Action Required.**
Cumbersome process	Process should be easy to understand and implement	Process is as per ATP and very easy to understand.	**Action not Required**
High result recording time	Result recording time should be manageable so as to meet targets	Result recording time was high at ATE stage but was managed with the use of multiple stages	**Action not Required**
Lack of Knowledge	Operator should be qualified and trained	The operators were qualified and trained in WF	**Action not Required**
Lack of Experience	Operators must have proper work experience.	The operators have a vast experience	**Action Not Required**
Change in operator	Designated operator should perform the process..	There was no change in operator	**Action not Required**

Individual PCB testing	Individual PCB testing should be as per ATP so as to meet specification	The output in PCBs is varying such that it is OK as per PTP but at system level specs are not meeting	**Action Required.**

Fig 6: Cause chart

The faulty sets were checked for module failure. 3 types of modules were identified which were responsible for generating Tx Power in radio set.

These 3 modules are :

1. A2 FH 5W (Power Amplifier)
2. A4 FH (Receiver Card)
3. A5 FH (Synthesizer Card)

All these PCBs were diagnosed individually at respective PCB testing stages and Set level stages. On detailed analysis of Tx Parameters of A2, A4 and A5 following conclusions were drawn:

1. A5 PCB gets input from A6 PCB via audio connector[6] and gives RF Output of -10 dbm.
2. This RF Output goes to A4 PCB which in turn processes and amplifies the RF signal[7] and gives output of about ≥ +8 dbm.
3. This 8 dbm RF output goes to A2 PA module which generates Tx output of +38±2 dbm.
4. It was observed that when the output of A4 exceeds +12 dbm, it saturates ALC in A2 module as a result of which the final Output from A2 PA drops below 36 dbm.
5. Hence at system level testing Tx Power test fails.

After analyzing the fault it was decided that modification to be done in either of A2 PA, A4 or A5 synthesizer module. Following solutions can be implemented. They are as follows:

1. Reducing RF input to the A2 PA so that the ALC voltage doesn't go to saturation[8] and further amplification can be done by A2 PA module.
2. Increasing RF power[9] through A2 PA .

- From analysis it was found that increasing power from PA without decreasing RF Input to PA[10] would result in high current which would again result in another failure.
- Reducing RF input[11] at PA stage seemed to be a feasible solution.
- It was proposed that modification to be done in A5 synthesizer module[12].

Following changes were observed by modifying controllable factor. It is shown in Fig 7

Controllable Factors	Present Method	Improved Method
C1 -Improvement in A2 Pcb	RF Input is >+12 dBm which saturates ALC of Power Amplifiers, Leads final output is<36 dBm	From analysis it was found that increasing power from PA without decreasing RF Input to PA would result in high current which would again result in another failure. Hence No action taken
C2-Improvement in A5Pcb	Output of A5 Pcb is high and more than required (-10 dBm)	3 dB pad introduced at output end and final output is limited to -10 dBm.
C3- Improvement in A4 Pcb	A4 PCB giving RF output >12 dBm	As there is no provision of pads for implementation of power attenuation ckt. Re layout of PCB Black is required. Hence no action taken

Fig 7: Impact of changes in controllable factors

- At the Output of A5 module R2, R3 and R4 resistances are used for 3 db pairing with A4 module. Value of these components of R2, R3 were 75 ohm and R4 was 82.5 ohm
- Values of these resistances were changed such that the output of A5 PCB should be reduced by 3 db.
- After deep analysis these resistances were changed as R2, R3 as 61.9 ohm and R4 as 200 ohm.
- After these changes the RF Output[9] at A5 synthesizer was -13db.
- When this output goes to A4 module as input, the output at RF out of A4 was +6 db at set level which in turn goes to A2 PA.
- It has removed the problem of saturation at ALC of A2 PA and the module was giving exact output as needed.

4. Result:

Above changes were done in 800 radio sets and their test results were analyzed. The result is mentioned in Fig 8

DEFECT Type	UNITS	DEFECTS	Total OPP0RTUNITY	Details of Opportunity
Tx Power Failure	800	0	10	A2, A8, A5,A4, A6 failure RF cable faults etc
High Current	800	15	5	Relay short, flexible cable faults
Standby Current failure	800	9	3	PCB failure
Display Problem	800	7	1	A8 faulty
FH1, FH2 modes Problem	800	21	3	A11, flexible cable faulty
Tx Switch Failure	800	16	1	Relay faulty
Cable failure	800	13	9	Cables short and open

Fig 8: Total defect spectrum

DEFECTS	UNITS	DEFECTIVES
81	800	64

Faults	Quantity
Tx Power Failure	0
High Current	15
Standby Current failure	9
Display Problem	7
FH1, FH2 modes Problem	21
Tx Switch Failure	16
Cable failure	13

Total Defects =81No.

Fig 9: Defect analysis

All defective radio was analysed. Out of 800 radio sets, defective radio sets were 64 sets and out of that total defects were 81 no. Pass percentage was increased from 58.5% to 92.2%, it is shown in Fig 10.

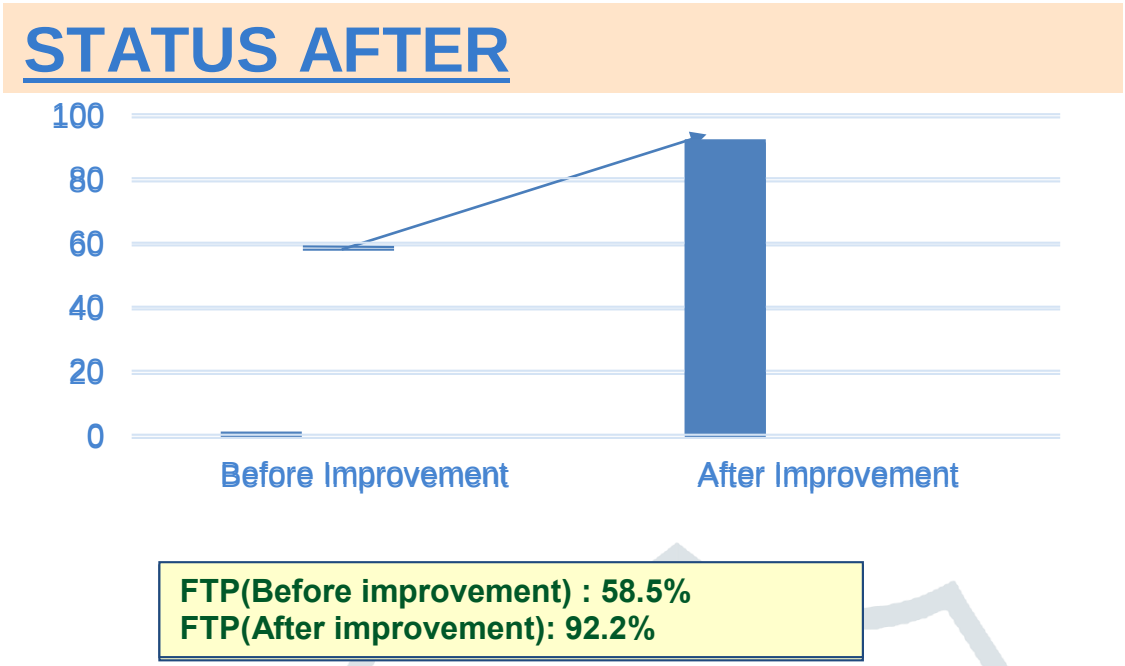

Fig 10: FTP before and after.

5. **Conclsion**.

By doing all changes following improvement was observed ;

- ❖ Power of the module matches as per ATP.
- ❖ FTP of main set was improved drastically.
- ❖ Rework time was reduced as the proposed change was easy to implement.
- ❖ The solution is cost effective as only resistances are needed to be changed.

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