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MANET Design improvement using Six sigma technique

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Abstract: *Optimization of design parameter is one of the key aspect in Electronics equipment. Performance of the equipment is entirely depends upon it. So before a product is launched, it is necessary to check each and every parameter for its desired functionability. There are various methods available by which it can be achieved. Six sigma technique is one amongst them.*

Key Words: *PLL, MANET, TDMA.*

1. INTRODUCTION:

Radio communication sets are designed and manufactured based on their frequency ranges like VLF, HF, VHF etc. Due to technological advancement, currently it is possible to same hardware architecture to have multiple frequency ranges for communication[1][2]. Having same hardware with help of software it is possible. Apart from that to improve the communication in a group of user using MANET, communication can be established among group member, selective call between members or group call etc[3][4]. However in this type of design architecture, there should not no loss of communication packets. So the equipment should have rugged architecture to fulfill these requirements. Radio communication is shown in Fig 1.

Fig 1: Radio Communication set

2. **Problem:** Radio set was taken for design for frequency range 30Mhz to 512 Mhz. RF card (Trans receiver module) used in radio set which was under development and to be made trial ready. During integration of Baseband and RF modules, network stability and data transfer between two radios found intermittent with multiple boots. Radio should have feature of high network stability and high speed data transfer capability[5]. During initial trial, it was observed that data transfer feature was not working as per expectation. There was loss of packets during communication[6]. The system was not showing network stability during MANET operation. Observation during testing is shown in Fig 2.

Observation During Testing

- Total no. of Radios tested 5
- Booting operation on 5 radios 50
  (10 Times per radio)
- Network stability and data transfer OK 28 Times
- Network stability and file transfer not OK 15 times
- Waveform loading failure 2 times
- Joining mode hanging 5 times

Fig 2: Testing Observation

Observation during testing is also shown in Pareto chart for in Fig 3.

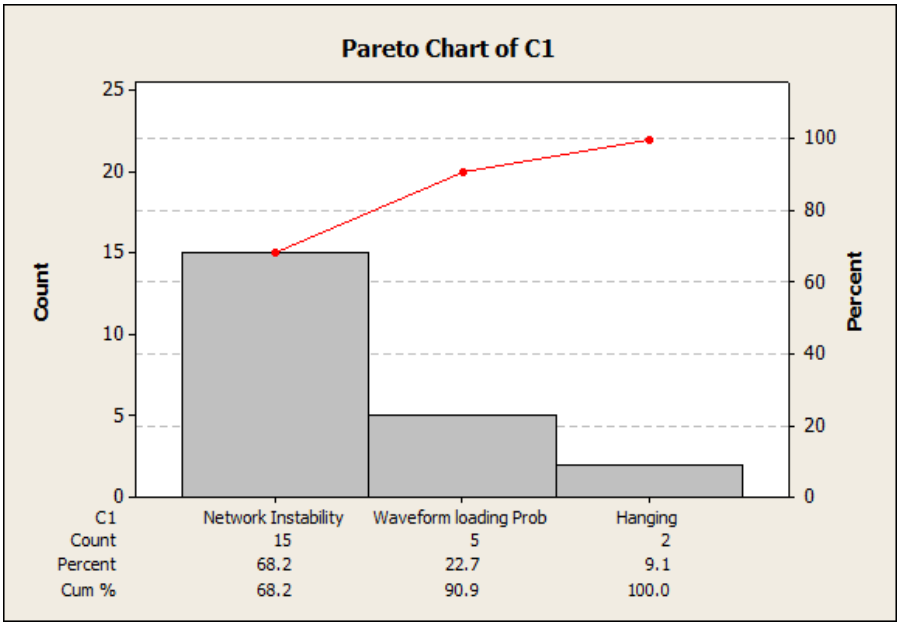

Fig 3: Pareto Chart

Pareto charts shows that major problem was observed for net work stability and data transfer. System level showed intermittent Network stability and reduced data transfer.

3. Analysis:

An analysis was done to find out the causes. A brainstorming season was conducted to find out the reasons. A list of probable reasons are depicted in Fig 4.

IDENTIFICATION OF PROBABLE CAUSES OF POOR SENSITIVITY

Tax /Rx RF connection	PLL stability over the time	Flat cable from mother board to RF card not OK

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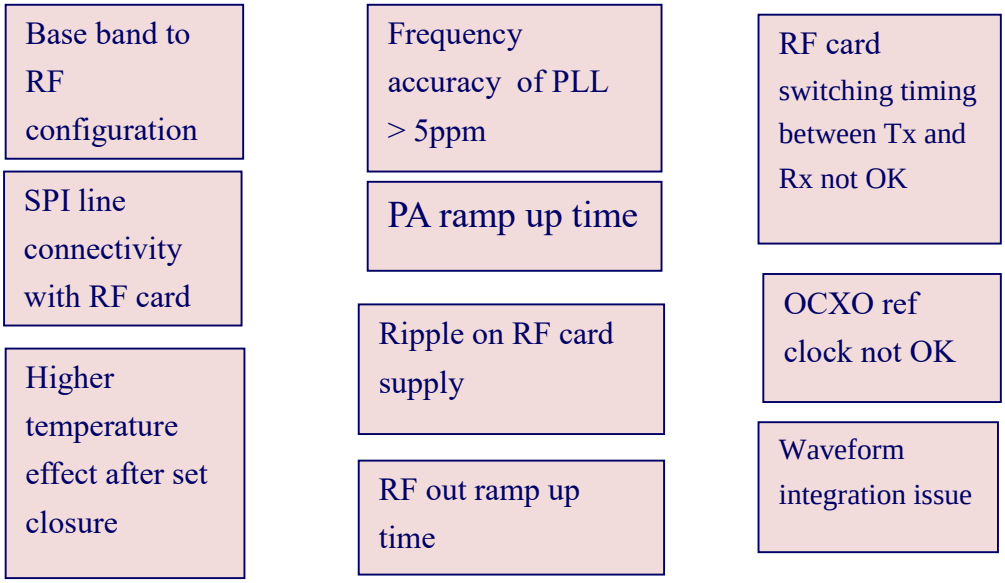

Fig 4: Probable causes

Using Pugh matrix options were evaluated and among that best option obtained as optimization of existing PLL design. It is shown in Fig 5.

Following factors were to be studied through design of experiments;

1. Frequency stability and accuracy.
2. Analysis of locking time and SPI line monitoring during PLL programming.
3. Tuning PLL locking time Vs network stability.
4. RF card ramp up time and PA ramp up time.

As no of levels for above factors were high, so it was decided to conduct experiment with one factor at a time.

PUGH MATRIX Criteria	DDFS based new hardware design	Existing PLL design optimization	Waveform modification
Hardware optimization	+	-	-
Layout size	+	-	-
Tuning speed	+	-	+
Power consumption	-	+	-
Programming complexity	-	+	-
Heat dissipation	-	+	+
Cost	-	+	-
	3	4	2

Fig 5: Pugh Matrix.

Analysis of design of experiment:

a) Analysis of Frequency accuracy and stability over time:
   1. The experiment was conducted for observing frequency stability and accuracy over the time and effect of the same on network stability.

2. The specification of frequency stability and level were as per specification and no deviation observed over the time of approx 5 – 10 mins.
3. During testing Spur was observed and 200Khz on both side of center frequency.
4. The Spur observed was -50 dBc down to carrier, as per PLL data sheet spur level should be -80dBc.
5. To rule out possibility of network stability due to PLL spurious, external frequency source using evaluation board used and SFDR observed better than -80dBc[7].
6. With external frequency source the network performance of two nodes at RF level was not improved.
7. Experiment was repeated with PLL2.

b) Effect on loading time on network stability:

1. The experiment was conducted for observing effect of Locking time on network stability.
2. As per waveform requirement the locking time should be < 116 micro sec. LD status was coming OK with in 116 micro sec[8].
3. The cross check the effect of PLL locking time, loop filter component tuned for 120 micro sec.
4. As radio connected in back to back testing network found in joining mode i.e. control packet lost for 120 micro sec PLL lock time.

c) Analysis of locking time reduction Vs network stability:

1. Locking time reduced by tuning loop filter components.
2. Variation over packet loss observed for different time constant.
3. Best result observed for reduced locking time of 106 micro sec.
4. However still packet losses observed in some cases.
5. Significant improvement observed with reduced locking time.
6. Actual locking time measured around 86 micro sec, the additional time of 20 micro sec is taken for Lock detected confirmation[9]. Further reduction in PLL locking is not possible.
7. In this Design PLL 1 is used for both Tx and Rx chain, so being TDMA radio PLL is required to switch Tx LO and Rx LO[10].
8. For Tx LO and Rx LO, PLL section is turned ON and OFF every time.
9. MOS switches are used for switching supply for Tx and Rx.

Based on these observation design improvement was done, following were the improvements;

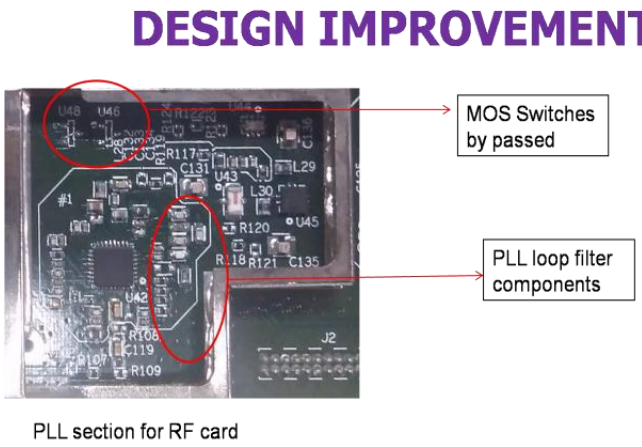

Fig 6: Design improvement

DESIGN IMPROVEMENT

TYPICAL CHARACTERSTIC OF PLL AFTER OPTIMIZATION

Description	Specification	Remarks
Reference frequency	20MHz	High stability OCXO used
RF power Out	-5dBm to 0 dBm	Programmed for high level
IInd Harmonic	18dBc	
Spurious	50dBc	At 200Khz
Phase noise	110dBc/Hz	At 100KHz offset
Locking time	85 µ sec	With new loop filter components

Fig 7: Design improvement

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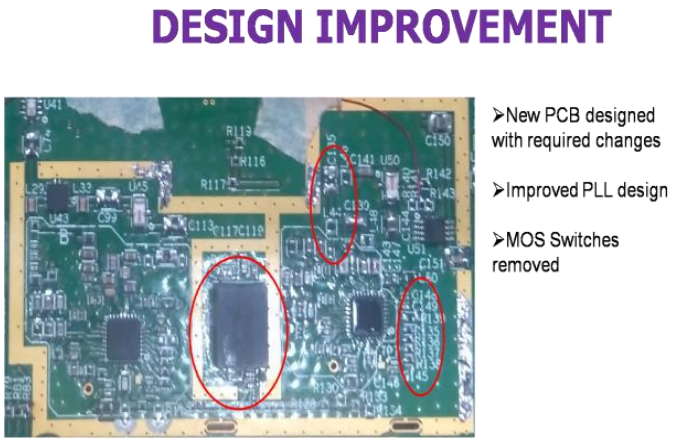
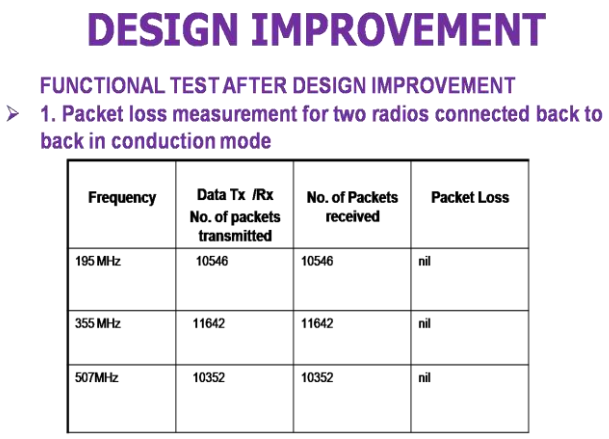


Fig 8: Design improvement



Frequency	Data Tx /Rx No. of packets transmitted	No. of Packets received	Packet Loss
195 MHz	10546	10546	nil
355 MHz	11642	11642	nil
507MHz	10352	10352	nil

Fig 9: Design improvement

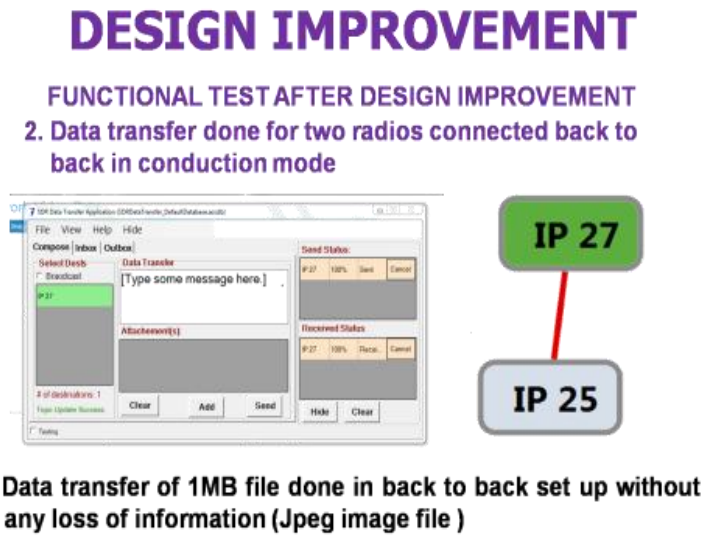


Fig 10: Design improvement

Design improvements are shown in Fig 6, Fig 7, Fig8, Fig 9 and Fig 10. After incorporating all changes following were the observations.

1. Result shows after optimizing PLL timing and modified hardware, problem of network stability and data transfer was resolved.
2. Radios were booked multiple times to verify the repeatability.
3. Implementing the above changes ensured reliable data transfer capability of radio.
4. The above design changes were easy to implement and cost effective.

4. Result:

Modified Hardware:

1. After design modification Tx and Rx charaterstics of RF module tested as per laid specification and found satisfactory.
2. ESS testing was also done on two radios and performance found satisfactory.

5 radios were taken for design optimization were modified by changing the chip components and hard ware modification by By-passing switches. All parametric measurements were done after modifications. After modifications back to back testing were carried and found satisfactory and it is shown in Fig 11.

5 radios connected in mesh network in CLR MANT mode and each radio booted 5 times repetitively to observe the network stability and data transfer

SR.Nos. (IP) of RADIOS	Network stability and data transfer in 5 nodes
25	OK
27	OK
28	OK
31	OK
33	OK

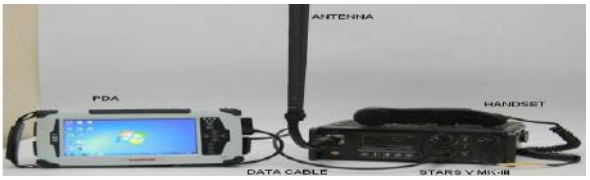


Fig 11 : Modified radio set result

5. Conclusion :

- New technology (TDMA/MANET) is proved in this project and can be used in future project.
- All above results were validated for stable network in MANET mode and reliable data transfer between radio nodes.
- With this new change in radios, there is high probability for new business.

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