Quality Control Study Using Six Sigma DMAIC To Minimize Defects In The Soldering Process

Final Project

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2026

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I, the undersigned, certify that the contents of part or all of my Final Project entitled: "Quality Control Study Using Six Sigma DMAIC To Minimize Defect In The Soldering Process" is my **own work, completed without the use of materials that are not permitted**, and **is not the work of other parties which I acknowledge as my own work.** All references cited or referred to have been written in full in the bibliography. If it turns out that my statement is not true, I am willing to accept sanctions in accordance with applicable regulations.

Batam, 31 August 2026

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APPROVAL

The Final Project is structured to fulfill one of the requirements for obtaining a degree
Bachelor of Associate Engineer (AMd.T.)
in
Batam State Polytechnic

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Session Date: 9 July 2026

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Abstract

Quality control is an important aspect in the manufacturing industry to ensure that the products produced meet quality standards and minimize the occurrence of defect during the production process. The problem faced in the soldering system process at Infineon Technologies AG Cegléd, Hungary is the high number of defective products that impact the effectiveness of the production process and the achievement of company targets. This study aims to identify the most dominant types of defect, analyze the stability of the production process, and determine the main causes of defects as a basis for preparing improvement recommendations. The method used is Six Sigma with a DMAIC approach limited to the Define, Measure, and Analyze stages. The Define stage uses Pareto Diagrams and Quick Wins to determine defect priorities and improvement opportunities, the Measure stage uses a P-Chart to evaluate process stability, while the Analyze stage uses Failure Mode and Effect Analysis (FMEA) to determine the priority of failure causes based on Severity, Occurrence, Detection, and Risk Priority Number (RPN) values. The results of the study indicate that Not Complete Soldering defects are the most dominant type of defect with 889 occurrences or 41.26% of the total defects during the period August-November 2023. P-Chart analysis shows a pattern of eight consecutive points experiencing a decrease, which indicates that the production process is not yet in a statistically controlled condition so that corrective actions are still needed. The results of the FMEA analysis show the highest RPN value of 240, which is caused by incorrect placement of DCB on the JIG due to excessive pressure during the production process.

Keywords: Six Sigma, DMAIC, FMEA

Foreword

I would like to express my gratitude to Infineon Technologies AG Cegléd, Hungary, for granting me permission to conduct research and collect data at the company, thereby enabling me to complete my research.

Batam, 31 August 2026

Meilan Novayanti
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Quality Control Study Using Six Sigma DMAIC To Minimize Defects In The Soldering Process

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Abstract— **Quality control is an important aspect in the manufacturing industry to ensure that the products produced meet quality standards and minimize the occurrence of defect during the production process. The problem faced in the soldering system process at Infineon Technologies AG Cegléd, Hungary is the high number of defective products that impact the effectiveness of the production process and the achievement of company targets. This study aims to identify the most dominant types of defect, analyze the stability of the production process, and determine the main causes of defects as a basis for preparing improvement recommendations. The method used is Six Sigma with a DMAIC approach limited to the Define, Measure, and Analyze stages. The Define stage uses Pareto Diagrams and Quick Wins to determine defect priorities and improvement opportunities, the Measure stage uses a P-Chart to evaluate process stability, while the Analyze stage uses Failure Mode and Effect Analysis (FMEA) to determine the priority of failure causes based on Severity, Occurrence, Detection, and Risk Priority Number (RPN) values. The results of the study indicate that Not Complete Soldering defects are the most dominant type of defect with 889 occurrences or 41.26% of the total defects during the period August-November 2023. P-Chart analysis shows a pattern of eight consecutive points experiencing a decrease, which indicates that the production process is not yet in a statistically controlled condition so that corrective actions are still needed. The results of the FMEA analysis show the highest RPN value of 240, which is caused by incorrect placement of DCB on the JIG due to excessive pressure during the production process.**

Keyword: Six Sigma, DMAIC, FMEA

I. Introduction

Manufacturing companies constantly strive to deliver top quality products to their customers therefore, maintaining a focus on quality throughout the production process is essential. This attention to quality enables the rapid detection of defects or faults thay may arise during production, allowing corrective actions to be implemented immediately before the products reach the final stage of the process.[1]

Companies must maintain continuous quality control throughout the production process , this applies to Infineon Technologies AG Cegléd, Hungaria, which focuses on the manufacturing and development of various semiconductor products, including microcontrollers, sensors, power components, and IC.[2] During productions the company faces the challenge of a high number of defective products arising from the soldering process. These defects include in Not Complete Soldering, Solder Spatter, and Broken DCB.

Recurring malfunctions have caused the company to face obstacles in the soldering system production process in meeting production targets, thereby necessitating quality control with in the production process. Consequently, this study employs the Six Sigma method to assist the company in implementing improvements.

The Six Sigma method is a continuous improvement method that functions to reduce defects by minimizing variations that occur in the production process through th DMAIC stages. The steps to reduce defects are carried out systematically by define, measure, analyze, improve, dan control.[3] But in this study the researcher will focus only on the defects that occur most frequently during the production process.

II. Method

This research process is limited to the first three stages only Define, Measure, and Analyze. The following is the flowchart to be used for the project's final outcome.

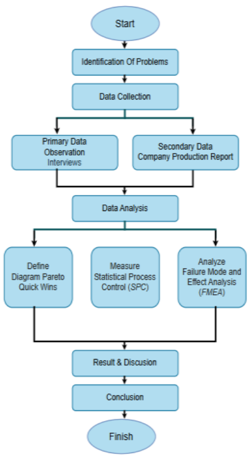

Figure 1. Research Flowcharokt

The data analysis method employed in this research is Six Sigma. The primary objective of the study is to focus on reducing the defect rates frequently encountered in the system soldering process. The approach adopted for this research is DMAIC (*Define, Measure, Analyze*). The analysis will not extend to the control phase, as the researcher intends to utilize rapid changes to accelerate the improvement process. The data analysis stages using the DMAIC, approach are as follows :

1. Define

This stage involves identifying the defects that have arisen and outlining the research objectives regarding the production process of the active system soldering. The data for this stage covers the production period from August to November 2023.

No	Month	Production Volume	Defect		
			Not Complete Soldering	Solder Spatter	Broken DCB
1	August	20500	223	175	145
2	September	23000	235	189	167
3	October	21000	210	180	135
4	November	20500	221	165	110
Total		85000	889	709	557

Figure 2. Product Defect Data

The quality measurement tool that will be used in this identification stage uses a Pareto Diagram to determine which defects occur most frequently during the system soldering process as well as Quick Wins to quickly find opportunities for improvement.

2. *Measure*

This stage aims to assess or measure the issue at hand. During this "Measure" phase, a P-chart control chart is utilized to evaluate the severity of defects and determine whether they remain within normal limits during the soldering process. The control chart also serves to detect deviations by establishing control limits, namely ;

- *Upper Control Limit* (UCL), for a permissible devation.

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1+\bar{p})}{N}}$$

Ket:
$\bar{p}$ = Rata-rata proporsi defect
N = Jumlah produk yang diperiksa/diproduksi

- *Central Line* (CL), indicating the absence of deviation from the sample.

$$CL = \bar{p} = \frac{\Sigma np}{\Sigma N}$$

Keterangan:
$\bar{p}$ = Rata-rata proporsi *defect*
Σnp = Jumlah total *defect*
ΣN = Jumlah produk yang diperiksa/diproduksi

- *Lower Control Limit* (LCL), for a sample deviation.

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{N}}$$

Ket:
$\bar{p}$ = Rata-rata proporsi *defect*
N = Jumlah produk yang diperiksa/diproduksi

3. Analyze

This stage aims to analyze and identify potential causes of problems occuring whit in a process or issues currently taking place. It employs *Failure Mode and Effect Analysis* (FMEA) a structured top down approach designed to identify and prevent risks contributing to failure, as well as to eliminate defects and issues in the production process, addressing both known problems and those currently arising.[4]

III. Result and Discusion

This section covers data processing and the analysis of the obtained results :

A. Define

To identify the most dominant types of failures or defects occuring during the system soldering process, data analysis was conducted using a Pareto Diagram consequently the most dominant failures or defects identified were prioritized for rapid remediation through "Quick Wins". The data used was derived from production reports covering the period from August 2023 to November 2023.

Before the data is visualized in a Pareto Chart the defect percentages and cumulative defect values will be calculated the corresponding table is provided below;

Type of Damage	Frequency	Presentation %	Cumulative %
Not Complete Soldering	889	41%	41%
Solder Spatter	709	33%	74%
Broken DCB	557	26%	100%
Total	2155	100%	

Figure 3. Percentage of Defective Product

Based on the calculation results shown in Figure 3, the data was converted in to a Pareto Chart to identify the most dominant type of defect. The analysis is presented below in the form of a Pareto Chart ;

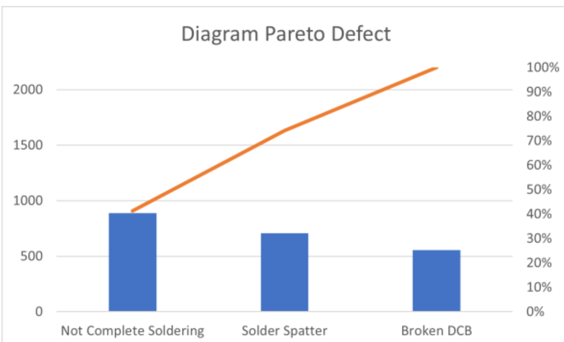

Figure 4. Diagram Pareto Defect

Figure 4 shows that incomplete soldering is the most dominant defect occuring during the system soldering process at Infineon Technologies AG Cegléd, Hungaria consequently this defect will be the primary focus of rapid improvement efforts using Quick Wins.

To achieve rapid improvements Quick Wins measures will be implemented the following are the quick fixes being carried out to help reduce the recurrence of Not Complete Soldering defects ;

No	Causes of The Problem	Quick Wins
1	Vibrations occuring while the jig moves along the conveyor cause the DCB to move position	Check the tightness of the bolts and mounts on the JIG
2	Applying excessive pressure to the DCB when inserting it in to the JIG	Operators need to evaluate and receive a refresher briefing on the correct soldering method
3	Fluctuating reflow machine temperature during operation	The machine requires maintenance once a week

Figure 5. Table of Quick Wins

B. *Measure*

Measure is the second stage of the Six Sigma DMAIC process. During this stages, measurements are taken using control charts. Testing using 1 σ, 2 σ, and 3 σ will also be conducted to compare the three standard deviations. The following describes the control chart process for identifying deviations ;

Periode	Week	Production Volume	Defect	Propotion	CL	UCL 1σ	LCL 1σ	UCL 2σ	LCL 2σ	UCL 3σ	LCL 3σ	STD
August	1	5100	52	0,010	0,010	0,011	0,010	0,011	0,010	0,012	0,009	0,000
August	2	5200	56	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
August	3	5000	54	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
August	4	5200	61	0,012	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
September	1	5700	58	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
September	2	5800	61	0,012	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
September	3	5700	59	0,012	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
September	4	5800	57	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
October	1	5200	50	0,010	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
October	2	5300	52	0,010	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
October	3	5200	54	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
October	4	5300	54	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
November	1	5100	54	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
November	2	5100	55	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
November	3	5200	56	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
November	4	5100	56	0,011	0,010	0,011	0,010	0,011	0,010	0,012	0,009	
Total		85000	889									

Figure 6. Defect Control Chart Calculation For 1 σ

The data in Figure 6, presents the production period, defect types, total production, number of defect, defect propotion, central limit, upper control limit, and lower control limit for the soldering system production at Infineon Technologies AG Cegléd, Hungaria. Consequently this data can be represented as a P-Chart control shown in Figure 7 using Minitab Software .

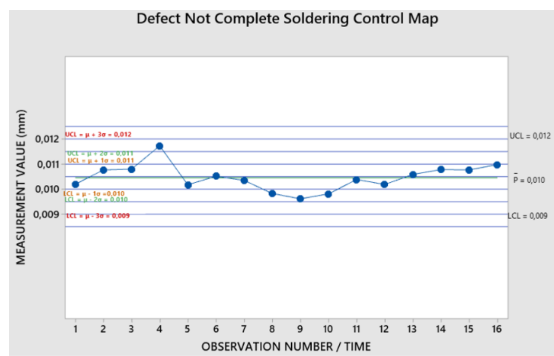

Figure 7. Control Map Defect

The results of the P-chart analysis show that the variation of defects in the soldering process is still with in the 3σ control limit. The absence of points that exceed this limit indicates that during the observation period there were no variations that statistically indicate a special cause. However, the use of the 1σ and 2σ limits indicates that changes in the defect level continue to occur throughout the process.

This condition indicates that the process is still under control, but does not mean that the process is in optimal conditions.Therefore, process control needs to be carried out continuously by paying attention to changes in defects that approach the warning limit and analyzing the factors causing defects so that the number of defects can be reduced.

C. *Analysis*

Analysis of product defects in the soldering process using the FMEA (*Failure Mode and Effect Analysis*). Shown below is the FMEA figure for the Not Complete Soldering defect type:

Problem	*Failure Mode*	*Cause Of Failure*	*Effect Of Failure*	*Severity*	*Occurence*	*Detection*	*RPN*
Not Complete Soldering	Applying too much pressure to the DCB during the bonding process in the JIG	The DCB is not precisely positioned with in the JIG	DCB is not evenly soldered	8	10	3	240
	Temperature does not comply with the SOP	Uneven heating	Formation of voids	6	8	4	192
	Failure to perform periodic maintenance	The JIG becomes loose, causing the pin position to changed	DCB moved when the jig is placed into the conveyor	7	5	3	105

Figure 8. Tabel of FMEA

The RPN (Risk Priority Number) value is obtained by multiplying the Severity (S), Occurrence (O), and Detection (D). The assignment of these values follows the FMEA assessment guidelines, namely ;

1. Severity level is an estimate of the seriousness of the impact should a failure occur. Severity levels range from 1 -10, the greater the resulting effect the higher the severity level.

2. The Occurance level serves to assign a rating to the likelihood of an event occurring for the each resulting effect. Occurrence levels range from 10 – 1, the more frequently a failure occurs the higher the level.

3. The Detection level serves to determine the likelihood of a failure being detected before the product reaches the customer. Detection levels range from 1-10, the higher the detection value, the greater the resulting risk as the defect is difficult to detect.

The figure above shows that the highest RPN (Risk Priority Number) specifically 240 results, from the action of placing the DCB in to the JIG while applying excessive pressure during the production process.

IV. CONCLUSION

Based on the results of the FMEA analysis obtained, the main cause of the high RPN value reaching 240 is the Human Error factor, where the operator applies pressure that exceeds the standard during the assembly process. There for, to reduce the high RPN value, improvements can be made, where the corrective actions are focused on increasing operator competence and compliance through retraining, SOP socialization, implementation of process checklists, stricter supervision by supervisors, and the provision of visual standards in the work area. So that these actions are expected to reduce the frequency of errors (Occurrence) and increase detection capabilities (Detection), so that the RPN value can be reduced significantly.

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