Understanding Digital Clock through Reverse Engineering

Mayank Yadav[1], Medaboina Preetham[2]

[1]Electrical Engineering IIT Mandi, India

[2]Electrical Engineering IIT Mandi, India

b22221@students.iitmandi.ac.in ; b22222@students.iitmandi.ac.in

***Abstract*— This Digital Alarm Clock is an environmentally friendly, multipurpose device built for modern life. Its sleek, modern form matches a variety of decors. The key features are an automated sensor, date display, and temperature indicator. Its automated sensor adjusts to ambient light settings, making it appropriate for heavy sleepers and a variety of locations. The device has a progressive alarm that progressively raises loudness and is simple to set and regulate.**

***Keywords*— Digital Clock, Alarm clock, Clock, Analysis of Clock, Kadio, Sustanability, HouseOfQuality**

I. INTRODUCTION

A. *Basic Background*

A digital clock is an electrical device which displays the time in numerical digits on LCD. It was first appeared in the mid of the twentieth century and originally was used for scientific and industrial applications before becoming more popular in normal homes and different businesses. Digital clocks then immediately became popular for their readability and convenience because of their small and compact size, as they provide exact timekeeping as well as functions such as alarms, timers and also other features such as calendar and temperature measurement in various models. As technology was improved, digital clocks got increasingly tiny, fitting into a variety of gadgets such as small cellphones and other appliances. Today, they are ubiquitous and accessible in a variety of styles and functionality. They also serve as critical time management aids in modern life. Reverse engineering helps in improving digital clock design, and to increase performance, and satisfy the changing customer needs.

B. *Importance*

Digital clocks are must for time management, delivering very precise timing in a variety of scenarios and at different climates. They improve the efficiency and order in everyday activities with features like as alarms and timers. Their combination with current technologies is used to enable cross-device synchronization and coordination among them. Digital clocks are essential in homes, companies, and other public areas because they assure timeliness and efficiency when performing jobs which are time-sensitive. Overall, they play an important role in order preserving and productivity in today's fast-paced environment.

C. *Market Size*

The market for digital clocks is sizable, which indicates their extensive use across the varied populations and other businesses worldwide. Digital clocks are used to meet a wide range of purposes and tastes, from consumer-grade to different industrial versions. The market continues to grow as the technology advances thus introducing new features and different and eye loving designs. The increased need for the smart home devices drives the market growth, and digital clocks are an essential component of this ecosystem. Overall, the digital clock industry is much vibrant and healthy, with prospects for continuous growth in the foreseeable future.

D. *Need of Reverse Engineering*

Reverse engineering is critical aspect for digital clocks and every other item to understand rivals' in the technology and to uncover the areas for innovation, and to improve performance. It allows firms to improve manufacturing processes, streamline various workflows, and locate low-cost components. By analyzing current models existing already in market, manufacturers may upgrade legacy designs with some new functionality so as to match changing market desires. Reverse engineering also assures of product compatibility and security, which increases competitiveness in the market. Overall, it helps to advance the technology of digital clock, to stimulate innovation, and to drive the expansion of market.

II. Analysis of the Product using Black box

A. *Product Photograph*

Fig. 1 Isometric view of clock

B. *Product Design Specifications*

Table 1
Specifications of Clock

Function	To show Time and Alarm (also Temperature in some models)
Power Source	Operates on DC Supply
Voltage	4.5V (3*AAA type batteries)
Colour	Solid Black
Material	Plastic (Acrylonitrile Butadiene Styrene)
Height	7.6 cm / 2.92 in
Width	4.5 cm
Breadth	13.6 cm /5.34 in
Weight	153gm
Display Type	Digital LCD display Multisegment
Backlight	Automatic environment Detection and Respondece
Performance and UI	Responds quickly to the input commands and Nice user Interface which can be understood easliy

C. *Black Box Model*

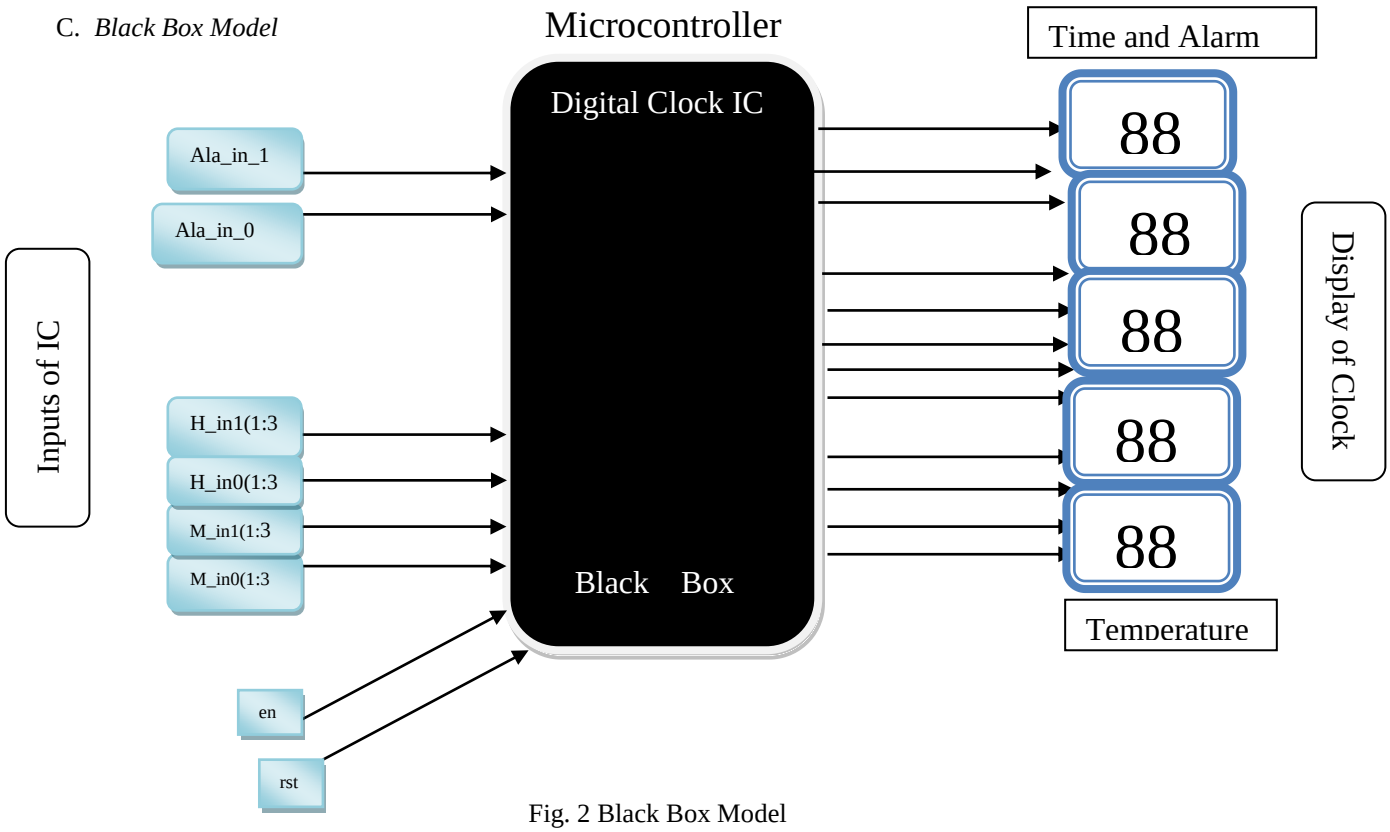


Fig. 2 Black Box Model

D. *Manufacturing Process of different parts With Justification*

1. *Circuit Board (PCB)*
   It's Manufacturing Process involves various steps such as Designing, Etching, Lamination, Drilling, Plating, etc.
   While Making PCB copper is firstly etched with a specific pattern which is pre designed, after this the layers that are made on copper are piled off and they are connected by the mechanism of drilling holes in the board. The board is then covered with a layer made of specific material which is conductive in Nature. Then the remaining traces are etched off and then it is checked to make sure that the PCB is fabricated correctly and it is not Malfunctioning.
   - *Justification:*
     PCB's are manufactured using this process because it is cost effective in bulk manufacturing, provide reliable electrical connections and are very compact so consume less space. They are also customizable for various functionalities

2. *Microcontroller Unit(MCU)*
   It is made by a process called Semiconductor device fabrication. It uses the concept of Analog circuit design at micro level that is also called as VLSI.
   Firstly microcircuits are constricted on the wafers of silicon be the semiconductor manufacturing machines. Then transistors and connections are made at microscopic level by using some specialized layering techniques like etching and deposition. They add and remove material respectively. The finished devices are subsequently formed by cutting and by packing of these wafers
   - *Justification:*
     The semiconductor fabrication techniques provide incredibly complex circuits. They can also onboard the microscopic transistors. As it is not possible to achieve miniaturization and density needed for powerful and efficient MCU so this plays an important role in the industry.

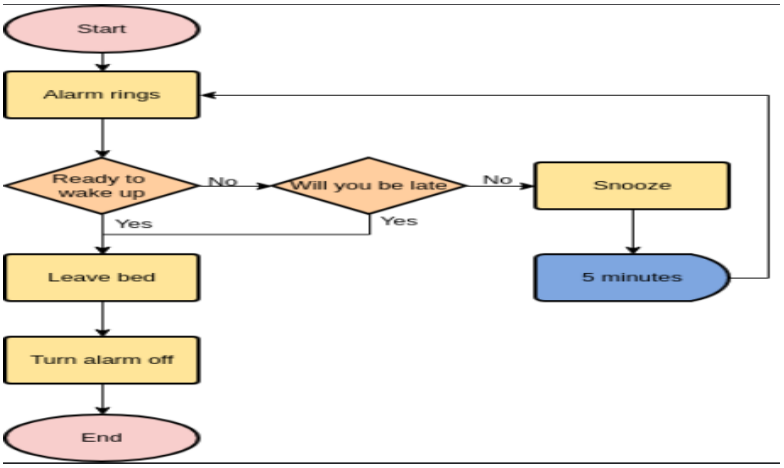
3. *LED (Backlight)*
   Manufacturing of LED's take place by the technique of phosphor deposition and Photolithography.
   In this technique firstly the semiconductor wafers are grown and then etched to form tiny-tiny LED chips that can emit the blue light usually only. Then the blue LED chips are then coated with phosphor

material that absorb blue light and then re-emit it as white light. Finally techniques like die bonding and encapsulation are used for packaging and assembly.

- *Justification:*
  This method is used because it involve the precision and controllable light spectrum. Also it offers the Scalability and efficiency and can be packed durably and that prevent it from other environmental factors.

4. *LCD display*
   While making an Led the technique of TFT fabrication and Liquid Crystal injection is used.
   In this technique firstly a thin film transistor is fabricated on the board which is specific process of creating the transistors on the glass substrate using the techniques like Photolithography and the Deposition techniques. Then the precise alignment of the TFT and color filter substrates is done and after all this process finally the liquid Crystal is injected between the Glass substrates.
   - *Justification:*
     Because of its tiny and energy-efficient design, this technology is extensively utilized and may be used to a broad range of products, including digital clocks. Clear displays with minimal power consumption are guaranteed by the exact alignment of TFT substrates and carefully regulated liquid crystal activation.

E. *Flow Chart for the Clock*



Flow Chart of The working of functions

F. *Some Specific Terms Which are Important To Discuss*

1. Function

The clock has features like time, date, and temperature measurement capabilities, along combined with automatic night light sensor which adjusts brightness based on the ambient light

2. *Performance:*

It offers accurate timekeeping and negligible error of less than 0.5 percent, and also accurate temperature measurement which ensure reliability and convenience for users of this clock. A high performance quartz is also used which generate only reliable frequencies.

3. *Safety:*

The clock is designed with eco-friendly materials and adheres to sustainable standards which are set globally, contributing to environmental conservation.

4. *Material:*

Constructed from durable plastic, the clock is lightweight and suitable for various places, including home, office, and corporate environments.

5. *Dimensions*:
The product dimensions are nearly14W x 8H centimeters which provide a compact and space-efficient design which make it easy to put anywhere and easy to carry.

6. *Energy Saving:*
The design of the alarm clock focuses on consumption of low power along with a battery-powered power source which make it energy-efficient.

G. *3D scanned Model of the Product*

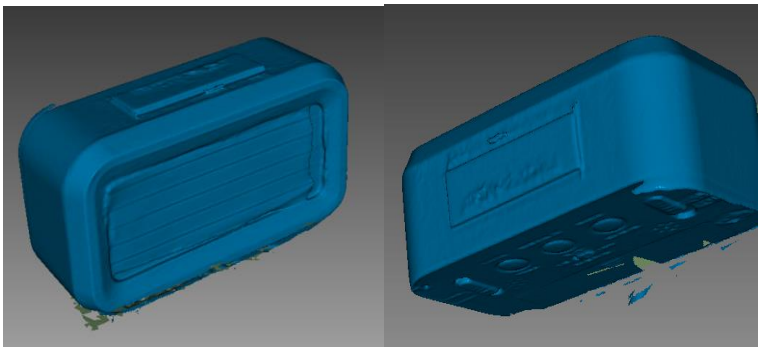


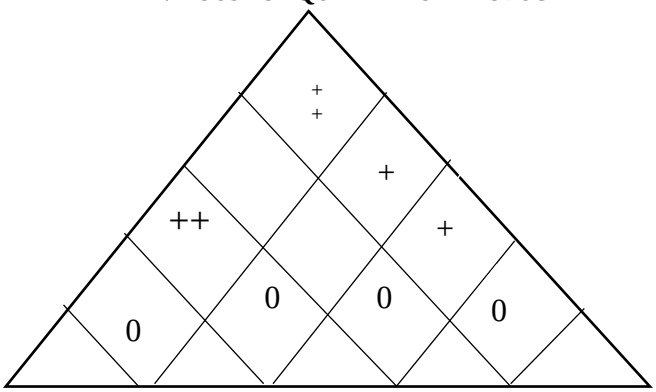
Fig. 3D scanned Model

H. *Standards associated with different Parts*

Standard Aspect	Standard Name	Standard Number	Description
Safety	International Electro technical Commission	IEC 60950-1	This standard is for pertaining to information technology equipment, such as our field i.e digital alarm clocks, and it also ensures electrical safety standards. To ensure that electrical components, insulation, and heat resistance meet safety standards, the technique includes rigorous testing. It involves tests such as dielectric strength, temperature, and mechanical stress resistance to assure the product's safety under normal and expected abnormal situations.
Environment	International Organization for Standardization	ISO 14062	ISO14062 is a standard which specifies about how to include different environmental considerations into the design of the product and its development, such as digital clocks, in order to reduce the effect on environment. This technique entails doing life cycle assessments (LCAs) for identifying the environmental hotspots and different opportunities for improvement throughout the lifespan of product. Material selection, energy efficiency optimization, trash reduction, and end-of-life management are all actions that can help to reduce environmental impact and to promote sustainability.
Performance Testing	International Electro technical Commission	IEC 60051-1	IEC 60051-1 defines general criteria for direct-acting and indicating analog electrical measuring instruments and their accessories, which include those which are used to evaluate the functioning of digital clocks. This technique entails the

			calibrating of measuring devices to certain tolerances and then verifying their accuracy with standardized test signals. It also involves testing for accuracy, reaction time, and stability to guarantee that the measuring equipment function consistently and that digital clock characteristics are measured accurately.
Energy Saving	ENERGY STAR	----------	Although not a standard in itself, ENERGY STAR certification assures that digital clocks satisfy energy efficiency standards, which helps in saving energy and also in decreasing environmental impact. This technique entails measuring the alarm clock's energy usage in different working modes and different features and then comparing it to ENERGY STAR standards. Products that satisfy the requirements are eligible for certification, which indicates their energy efficiency and environmental friendliness.
Commercialization	International Organization for Standardization	ISO 9001	ISO 9001 provides the standards for a quality management system when a company must demonstrate its capacity to consistently supply products and services that fulfill customer, statutory, and regulatory requirements, including digital alarm clocks. The technique entails creating quality targets, implementing quality management systems, and evaluating performance through periodical audits and reviews. Document control, corrective action, and continuous improvement are all activities used to assure product quality and customer satisfaction throughout the commercialization process.

III. HOUSE OF QUALITY FOR PRODUCT



WHATS	Weightage	HOWS					Competition		
		Quartz Replace	Packaging	Accuracy Of Time	Size	Quality Of Material	Our Product	Kadio	Ajanta
Good Display	01	00	03	00	00	09	02	03	05
Water proof	05	00	08	00	04	02	00	00	02
Low cost	03	02	06	00	05	03	05	04	02
Multiple Functions	02	01	00	02	06	00	04	04	03
Measurement Unit		_		n	In cal				
Target Value		-	04	100%	12	08			
Actual Value		-	02	95%	15	06			
Kadio clocks		-	03	94%	15	06			
Ajanta clocks		-	03	98%	18	07			

Everything in the table is scaled on a factor of 10; 0—lowest , 1—Hightst

The House of Quality (HOQ) is a process which provides a complete framework which can be used to analyze product features and to compare them to rivals' offers. This paper provides comprehensive examination of digital clocks made of quartz components using the HOQ approach. The goal is to discover the essential features that influence customer preferences and strategic areas for development.

A. *Weightage Assignment*

The first stage in our study is to give weight to the various features on the basis of their relative value to the potential customers. This prioritizing aids for directing attention towards factors that have substantial influence on the purchase decisions. For example, the criteria such as "accuracy of time" and "low cost" are given increased weightage because of their importance in satisfaction of the customer.

B. *How's Analysis*

The "How's" section is there to provide a comparative assessment of each attribute for "Our Product" and its competitors like Kadio and Ajanta clocks. By comparing the strengths and weaknesses across different factors like the packaging, display quality, and waterproofing, we gain some insights into areas where our product is already excels and where some improvements are needed to remain competitive in the market.

C. *Competition Comparison*

In the Competition section, we directly compare the performance of "Our Product" against other brands such as Kadio and Ajanta across a variety of metrics. This research on this identifies areas where our product surpasses the competitors, as well as some of the opportunities for improvement. For example, while our device may have a greater waterproofing rating than Kadio, it may fall short of Ajanta in terms of display quality.

IV. LIST OF PATENTS

Patent number	*Year*		*Country*	*claims*
	filed	*published*		
EP0664496 B1	*1995*	*2002*	*Germany*	*Clock with Radio-Controlled Alarm and Digital Display*: The clock has an inbuilt display controlled by a display register and two push-button type switches which help to set values. The simultaneous pressing out of these switches changes the mode from clock operation to SET mode, where pulses are then added to the display register for setting the alarm time. After setting, the clock reverts to operating mode and the alarm is set to stand-by mode *Additional Function Changeover:* An extra push-button switch is provided to change the functions along with the different operating mode changeover into the SET mode.. *Alarm On/Off Switching:* A prolonged press of one of the two push-button switches toggles the alarm clock's operation on or off. *Printed Circuit Board Design*: The push-button switches are part of a printed circuit board within the clock movement, which is properly designed to accommodate both the display and also facilitate the mode changeover and make it easier. *Snooze Function*: The additional push-button switch is identified as the SNOOZE button for the alarm clock and the biggest one applied at the top.
US3924399 A	*1974*	*1975*	*United states*	*Hour Wheel and Alarm Set Wheel*: An hour wheel linked to the minute drum works with an alarm set wheel, controlled by a function lever, to activate a switch. This switch turns on a radio and subsequently sounds an alarm. *Digital Time Indication:* The invention features a digital alarm clock with the endless loops of tape which display time digitally, and is driven by drums connected through the mechanism of Geneva-type *Independent Alarm Mechanism*: The alarm mechanism operates completely independently of the hour drum present and is

				advanced through a different and seperate drive train. *Sleep Lever Functionality*: A settable sleep lever which interacts with timing train to allow the radio to play until automatic turn-off, and also provides am additional sleep time when the alarm sounds when the associated drowse button is pressed. *Cross-Shafts and Mechanism Layout*: Parts of the driving and different control mechanisms are placed on the opposite sides of the digital which indicate assembly and is interconnected by cross-shafts.
US5487053 A	*1994*	*1996*	*United sates*	*Digital Display*: This invention includes a digital alarm clock with an electronic control system and a digital display for time indication. *Optical Switching:* It utilizes an optically switched electronic control to facilitate user interaction with the clock's functions. *Control Mechanism:* The clock features an unique control mechanism which allows for setting and adjusting the time. *User Interface*: The clock is designed with user-friendly input methods for ease of setting and controlling various clock features.

B. Component Wise Patent

Patent number	Year		Country	Claims
	filed	published		
US20090244102A1 (Liquid crystal Display)	2002	2006	United states	*LCD with Frame Memory:* The invention includes an LCD with a liquid crystal panel for purpose of displaying video images and a frame memory which is installed on outside of the LCD. *Lookup Table for Overshoot Drive*: It features a lookup table that computes 3rd gray scale data for overshoot drive based on 1st and 2nd gray scale data from consecutive frames. *Optimized Image Display*: This method optimizes the display of images on the LCD by using the adjustment of gray scale data to improve the quality of the displayed video images.
US4023162A (electronic buzzer)	1975	1977	United states	*Electronic Buzzer Structure:* The invention of this relates to an electronic buzzer with specific structure that includes a plate of metal and an acoustic vibrator layer by layer placed. *Vibrator and Inductor*: It details the relationship between the acoustic vibrator and an inductor that is used in the design of Burzzer.

V. Challenges In Existing Design

A. *Display Visibility*:
Use high-contrast screens with the feature of adjustable brightness settings to increase vision in a variety of lighting situations. Also consider using auto-dimming to alter the display brightness based on ambient light levels and also we can add a feature that the clock become dim automatically at some hours at which it generally kept unused.

B. *Complex UI*
The user interface design of the clocks existing in the market is very complex. We need to change so many buttons to change a single thing. This can be made easy using the Touch panel or the single set button, which can be used to set the time and another set button, which can be used to set other functions

C. *Single Alarm Sound*
The buzzer that is available in the clock is only set to produce a single beep sound. We can also change the tunes by doing some coding in the buzzer controller. This can also be implemented to provide melodious tones. One additional feature that can be added is the addition of intensifying sound if we do not turn off the alarm; we can change the sound linearly with increasing time.

D. *Multiple PCB boards*
There are 2 PCB boards which are generally present in a digital clock. If we replace them with a single PCB board, then the cost and the manufacturing and assembly time will both reduce to a great extent, and the use of wires can be minimized, which leads to increased efficiency and no fear of cutting wires.

E. *Not water Resistant*
We can make it water-resistant just by adding rubber seals in the joints or by using TPE plastic, which does not allow water and is not much costlier than PVC. This can be very useful as the clock can also be used outside, and no such similar model clock is available in the market.

F. *Not Rechargeable Batteries*
We can replace the standard AAA type cells with rechargeable batteries. One single charging point can be provided, and a non-removable battery can be installed so that the design can be clearer. Additionally, if we do this, we can easily make the model waterproof.

G. *Lack of Wireless Connectivity*
Optimize wireless connectivity modules, such as Bluetooth or Wi-Fi, to reduce power consumption while ensuring consistent contact with external devices or networks, allowing for features like smartphone app integration or synchronization with online services.

VI. Conclusions

The initiative emphasizes how crucial reverse engineering is to comprehending and advancing current technologies. It offers a path forward for upcoming improvements, such adding intelligent networking or creating user interfaces that are easier to use.

All things considered, the Digital Alarm Clock is a great example of how practical design, user convenience, and environmental conscience can be combined. The knowledge acquired opens up new possibilities and establishes standards for the creation of new products in the digital timekeeping sector. This study demonstrates the possibility for ongoing consumer electronics innovation in addition to highlighting the importance of reverse engineering.

Acknowledgement

The completion of the report of Reverse Engineering successfully on the topic of Digital Alarm Clock. It would have not be possible without the support and contribution of each individual and resources. We would also like to express our sincere thanks and gratitude to Dr. Srikanth Sugavanam whose expertise and guidance in the research process were invaluable. Their constructive and personalized feedback helped us maintain the focus and to endure the quality of the report.

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[7] History of the Digital clock available on WIKIPAEDIA also helped a lot while performing analysis.

[8] Some suggestions are also taken from the comment box of products of different companies available on different e-commerce sights.

[9] The list of patents registered for Digital clock in different countries, Sourced From Google Patents official Website.