P2

Smart electrical switch interface

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Guide
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Introduction

Electricity and lighting have played a tremendous role in the progress of the world. Most of us are completely dependent on these and cannot think of living without them. We can control them by the click of buttons, yet we take these controls for granted.

By definition, a switch/button is a device that lets us switch between 2 or more choices. The switches represent how we interact with our creations. Before switches, there were levers that scaled our motion. Then switches came and they abstracted our motion. Our experience was augmented. But in present age, they are no more seen in awe, rather they seem cumbersome.
So how can we augment this experience of controlling home electricity.

Presently many companies are working in the field of domotics(home automation) and are striving to augment the user experience by providing new ways of controlling home appliances. In the Indian subcontinent, domotics is catching speed and we are witnessing many IOT devices coming in the market. But are these devices really addresisng what a user wants or the user is just adjusting to these devices.

My interest in understanding IOT systems and reimagining a ubiquitous product like an electrical switch has motivated me to initiate the project and study the existing usage of electricity controls in urban Indian houses and can there be a better solution to what is available in the market.

Methodology

Project 2 at IDC, IIT Bombay focusses on Redesigning existing products. The idea of project 2 is generally to implement critically the design thinking gathered over previous year in a real life setting. The focus is more on design and design process rather than just extensive in-depth research, due to the time constraints.

The methodology would be to critically analyse the issue by applying design research methods, leading to a project brief and a set of design directives. This will be followed by an iterative process of design and testing, concluding in the form of a design as per the directives and brief.

On a broader note, the objective of the project can be described as follows:

1. Look for problems and issues in real life scenarios and products.
2. Understand issues critically with the help of user studies and site visits.
3. Literature study on the respective area of work, looking for clues and approach for similar projects
4. Selection of design directives critical for the project and finalizing design brief
5. Design interventions in form of ideations catering to the design directives and evaluation
6. Concept generation on the basis of ideations.
7. Evaluation of concepts
8. Prototyping and user testing

Discover

1. Diachronic and synchronic study
2. Market study
3. Technology
4. User interviews
5. Surveys
6. Role-playing

Diachronic - synchronic study

Electric switches were invented in late 19th C soon after the invention of light bulb. The need for a switch arrived to provide a functional solution to the arcing caused when the electric connection was made.

John Henry Holmes invented a quick break switch in 1884 and the technology is still used in almost all electromechanical switches. As the usage of electricity grew, the demand for safer controls also grew. Therefore we see the introduction of various innovations that improved the switch functionally and increase its usability.

Various materials like mercury were also being used to make soundless switches but could not achieve the popullarity due to the toxic nature of these materials. New technological developments led to the miniaturization of dimmers and there introduction in home electricty comtrols.

Further down the line, usage of remote controls, touch switches, network connected systems has become common.

In the current age, with cutting edge technology developments, diverse lighting control systems exist parallelly. As there are multitude of consumer segments. Following pages will showcase infographics of the study.

Figure:2 .

1890s

Pull switch

By Harvey Hubbell
Provided isolation from electricity

Figure:5 .

1930s

Tamper resistant switch

Can take greater abuse
Reduce accidental switching of functions.

1880s

First light switch

with "quick break technology"
John Henry Holmes
Prevented arcing.

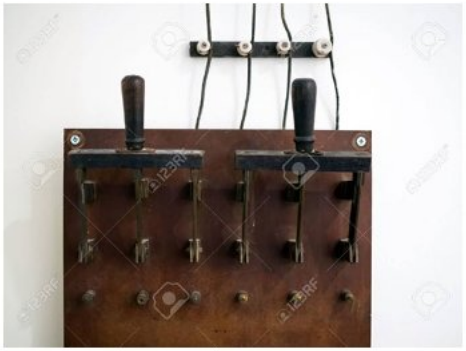


Figure:1 .

1910s

Mercury switch

Invented by L.A.M. Phelan
Completely silent
Toxic metal reduced its further development.

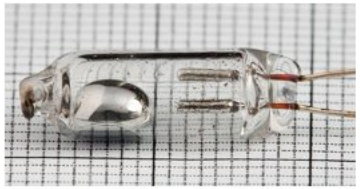


Figure:3 .

Toggle light switch

William J. Newton
Produced a loud snap or click

Figure:4 .

1950s

Glowing switch

Easy visibility in dark

Figure:6 .

Figure:7 .

Figure:8 .

Figure:12 .

1959-71

Home light dimmer switch

1st home dimmer switch(1959)
1st linear slide dimmer switch(1971)
Provided greater control to users.

2000s

Voice activated controls

Work in smart ecosystems
Generates new ways
of interactions.

1980s

Wireless light control

Used IR for controlling the switch functions.
Augmented the control by making it wireless.

Figure:9 .

Touch plate switches

Includes soft touch, Interactive, pressure based etc.
Provided flexibility of interfaces like; pressure based, soft touch etc.

Figure:10 .

Smart lighting controls

Network based control solution.Use sensors, electronics to trigger functions.
Energy efficiency
Support user actions

Figure:11 .

Synchronic study of electrical controls

Presently home electrical controls fall under these 4 categories based on the types of technology used:
Basic controls
Dimmers and regulators
Sensor controls
Smart lighting controls

Basic controls are standard wall switches which rely on mechanical stress in a spring and helps in switching the state of the appliance on and off.

Dimmers are more advanced switches which provide greater control by varying the voltage supplied to the lights. Whereas regulators control the speed of fan by controlling the current supplied to the motor.

Figure:13 Basic wall switches

Figure:14 Dimmers

Sensor controls can be independent or connected controls for different lightings and other appliances like fans, alarms, etc. These make use of IR, Microwave technology to name a few. They are used to detect presence of the occupants, motion activity etc. based on the space these sensors are applied.

Smart controls are part of an IOT system of connected devices that provide greater controls of home electricity with benefits of energy savings, safety, user comfort etc. They come in myriad of options ranging from complete system kits or open hardware/software devices which can be connected together.

Figure:15 Sensor controls

Figure:16 Smart controls

Market study

There are various products available in the market with more starups germinating with some or the other unique attributes.

For the purpose of the project, I tried to study the most common type of switches used, most popular IOT electricity control systems and few of the new startup products in the Indian market.

Figure:17

Generic controls

Strengths
Very cheap
Universal
Direct action

Weaknesses
Confusing
Limited control
Users improvise

Figure:18

Philips hue light system

Strengths
Different control options
Sticks anywhere/remote
Works without Internet

Weaknesses
Works with hue hub
Only controls light
Expensive (INR 11k for 1 bridge and 3 lights)

Figure:19

Brilliant Smart Home Control

Strengths

Replaces wall switch panel
Slider and touch panel.
Connects to other SDevices
Multiple presence detection sensors.

Weaknesses

One for each room.
Very expensive
(INR 30k for 3 switches)

Figure:20

Per Node

Strengths

Transforms existing switches
No hub required
Concealed

Weaknesses

Only provides Application control
No remote

Price INR 65k for 3bhk residence

Figure:21

Nuos switches

Strengths

Indian Switchboard compatible
Replaces old switches

Weaknesses

Requires hub
No remote

INR 1-15 Lakh for a 3bhk residence

Technology

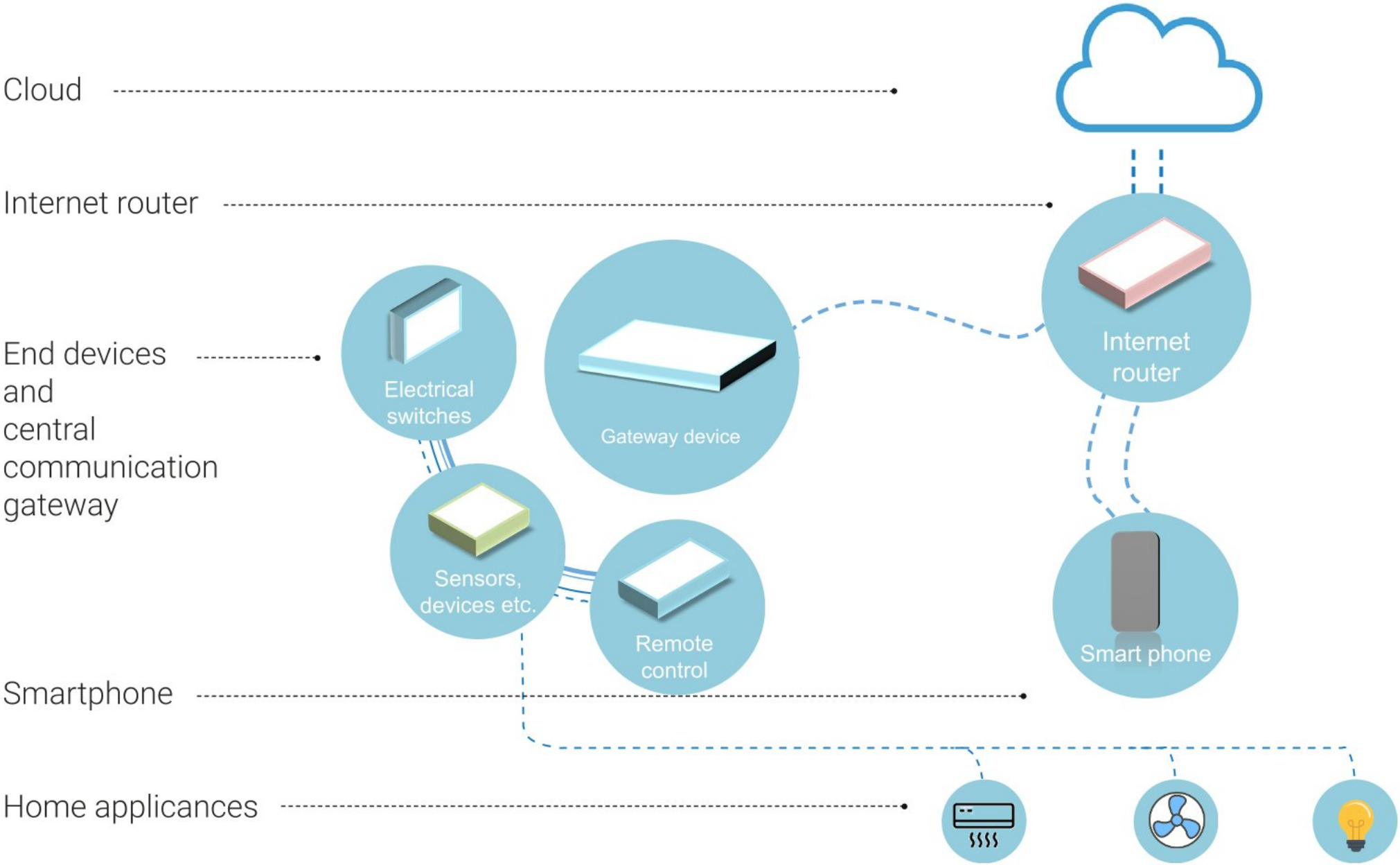
We are already surrounded by many smart devices like phones, smart-watches, smart TVs etc.. These are able to function in higher capacity than their primal functions. They connect to the internet and with each other and perform tasks without the human intervention. Yet we have the control of these devices.

Smart switches and electricity controls are an important part of Domotics (home automation). They make use of the wireless communi-cations and provide greater controls and convenience. These devices use wireless protocols like WiFi, Bluetooth, Zigbee etc..

Most of the devices in the market rely on internet connectivity although few work without internet with reduced smart functionality.

But there are also devices which are bypassing the cloud and reliance on internet and are being locally controlled by getting connected to the local devices.

A basic schematic diagram of an IOT home system is provided on the adjacent page.



Schematic diagram of a typical IOT setup

User interviews

Being such a ubiquitous part of our lives, most of the issues with current switches are well known and helped me in empathizing with the users I interviewed. Limited user interview were conducted mostly in the user context and 1 was telephonic.

User 1 is a Captain in Merchant Navy and stays 4-5 mnths/yr at his home usually. He lives with his wife, 2 children and mother. This user can be considered an expert user as he has been incorporating smart devices for the past 3.5 years. His provided some invaluable insights into the field as I personally havent been a user of smart home devices. He also mentioned about his stay in the Nordic regions and how informed the people are about light health and its usage.

User 2 is a housewife in Mumbai and lives with her husband, son and daughter. She is in her 50s and is not much aware of the IOT systems. She provided a typical scenario of electricity usage in an Urban indian home. Important conversation and insights form the interview are presented.

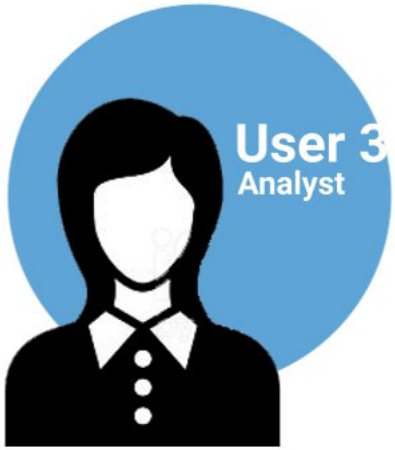
User 3 is a younf financial analyst working in Mumbai and living as a tenant in a flat shared with 2 more working women. She spends most of the time in her room and kitchen when in flat and occasionally uses the living room.

User 4 is an architect and provides her observation of how electricity is used or perhaps wasted at her home and also some other useful insights.

These interviews provide limited insights about home electricity controls but are relevant as all the users live in Indian metro cities and reflect the ethos of the metro demography.

- Started using smart switches and devices for energy savigns and convenience.
- Setting them up is stressful and almost gave up on it.
- I did not sign up for the frustration.
- Sometimes dont work as expected, have to use wall switches.
- Voice commands not really used. My wife always go to the switches.
- Lot of devices and wires dont look pleasing.
- Should have better control over their usability.

- Feels content with wall switches Has double switches at visible location.
- Difficulty in recognizing bed side light switch.
- Interiors renovated 10 years ago.
- House layout has remained same since then
- Electrical works costed a lot.
- Finds the controls sufficient.
- Says her nephew is bed ridden and might have good use of smart controls.
- Acknowledges that smart devices can help in safety and energy savings.



- Doesn't rememer somtimes if she tuned off the lights before leaving.
- Appealing experiences will motivate me to embrace the technology.
- Has a fairy light with battery because it is portable.
- But more controls could be misused by children.
- Lazy! People get lazy anyway. A switch alone wont make them lazy. I will go for it if it helps me.
- It could be nice if I controlled it with my AC remote.

- Seen her uncle get a door security system. Better coz no worry of key but his parents cant operate the interface.
- Feels it is very expensive.
- Energy saving will be her biggest priority.
- Her parents have room heaters. Sometimes they keep them on even when out. So that they find the house warm when they arrive
- Too much energy wastage. Smart controls can help them schedule and remotely control these heaters.

Try it yourself

It was felt relevant to get a hands on experience of installing an affordable smart switch device to better understand the kind of experience a customer goes through.

For the purpose of this experiment, I purchased a concealed smart module which can be installed with the existing wiring setup without disturbing the layout of wall switches. I bought a rather affordable device from a local brand named Katkum. The device is a 4 switch module and has a wifi module for internet connectivity and operability.

Figure:22 Katkum 4 switch module

Step1

Purchase the device (INR 3k-3.5k for 4 switch module)

Understand the electric connections

Read the Manual

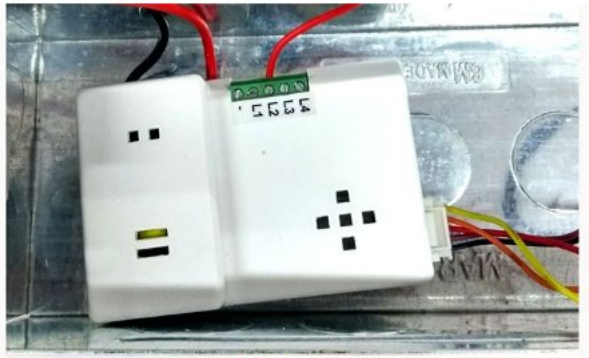
Figure:23

Step 2

Removing the existing wall switch panel.

Making the new connections

Ensuring proper connections



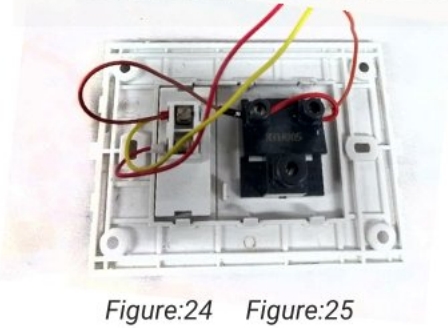


Figure:24 *Figure:25*

Step 3

Connecting the device to the application.

Testing the working before fixing.

Inserting the device in the junction box.

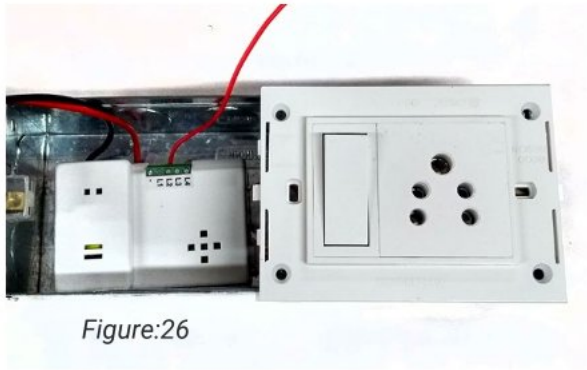


Figure:26

Step 4

Using the device.

Device hides easily inside the box. Simple to understand.

Changing the connections or switches require opening the panel and connecting again.

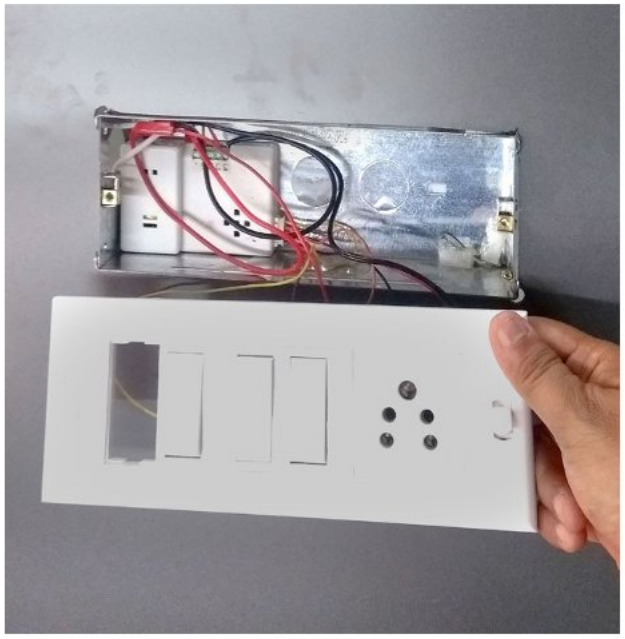


Figure:27

Insights

Installation took about an hour to connect 2 light and a socket switch.

Connecting with the applcation took another half an hour.

Installation felt simple enough due to working with a demonstration switch panel and box.

It felt irritating while connecting to the internet.

Define

1. Issues and needs
2. Scope and limitations
3. Design brief

Issues and needs

After finishing the limited research in alignment to the project, I was able to come up with the major issues faced by the customers with existing electrical switches and new smart solutions. These have been mentioned here.

Issues

Poor Interface: Lack of switches with clear interface causes minor frustrations

Fixed switch location: Since switches are fixed on walls, people have to arrange theirinterior layout around them.

Complicated wiring: Complicated wiring arrangments make the users call electricians for every small changes.

Expensive rewiring: Rewiring of houses causes mess and remains an expensive affair.

Smart device installation: Installation of such devices creates annoyance when the syncing gets delayed.

Poor home automation experience: Initial experiences with smart devices can make or break the user appreciation.

Inefficient application: Smartphones provide greater control of the devices but they are not always the best controls.

Needs

Intuitive switch interfaces

Easy installation

Greater degree of control

User safety

Convenient domotics experience

Energy savings

Affordability

Scope and limitations

Scope of the project

The project tries to understand the features of existing ways of interaction with home electricity and find out various pain points in them. I will be working on addressing these issues and try to come up with solutions which claim to improve the user interaction with smart electricity control interfaces. And how these interactions can be made convenient.

Limitations of the project

Considering the length of the academic project and my limitation in the area of IOT electronics, I will mostly be looking at the interface level interactions and not the actual working of the devices.

Working on the mockups and test rigs can be a constraint in understanding various ways in which users could potentially interact with the product and in what capacity can these interventions actually resolve the existing issues.

Design brief

Statement

Design of smart electrical switch interfaces to provide convenient and intuitive ways of controlling home electricity.

The design outcome would be a system of multiple products like core gateway hub, switches, portable switches, remotes, sensors applications etc..

Users

Primary users are the urban mid-high income individuals. They are aware of global advancements in tech and culture and are adapting to the global lifestyles.

They have a DIY ethos and are likely to get involved in setting up their domotics with the help of **Secondary users** like local electricians and company representatives.

Features and Benefits

Easy installation
Gets easily installed in existing infrastructure by electricians or primary users

Usage
Instant usage after the installation with reduced frustrations. Users can later proceed with application sync.

Intuitive interface
Users adapt to it mostly naturally without any manuals or learning.

Modular
Users get greater control of the system as they can easily replace modular switches and sensor modules.

Future ready
The device becomes a bridge and allows for more smart devices to intergrate.

Develop

Ideations
Idea evaluation
Results

Ideations

With initial sketches, I explored various switch arrangement and interfaces. Further in the ideation process, wiring connections and forms were explored. Quick mockups also made for 3dimensional visualization.

With the progress of research, concepts developed as well, and this progress can be seen in the proceeding pages.

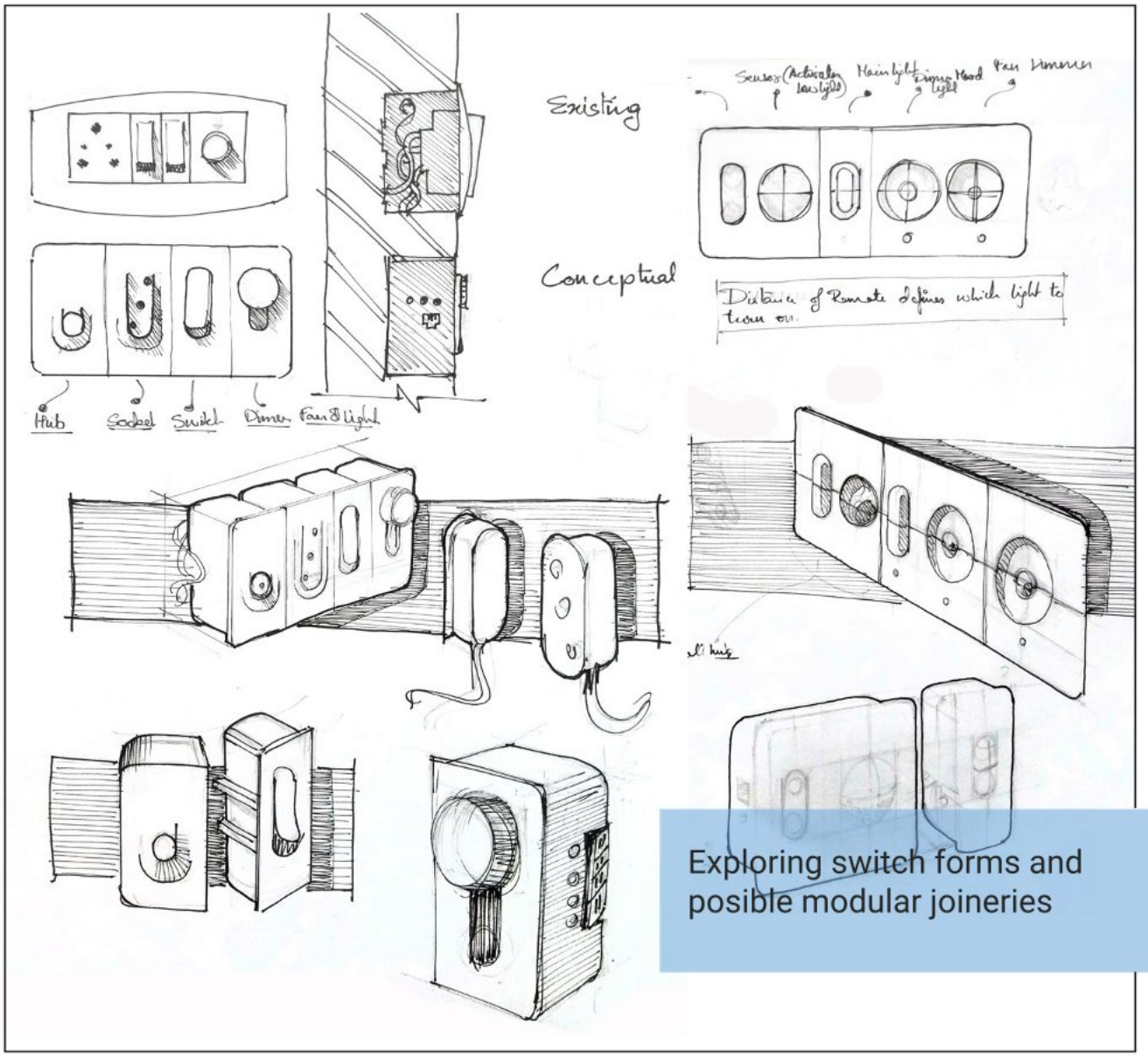
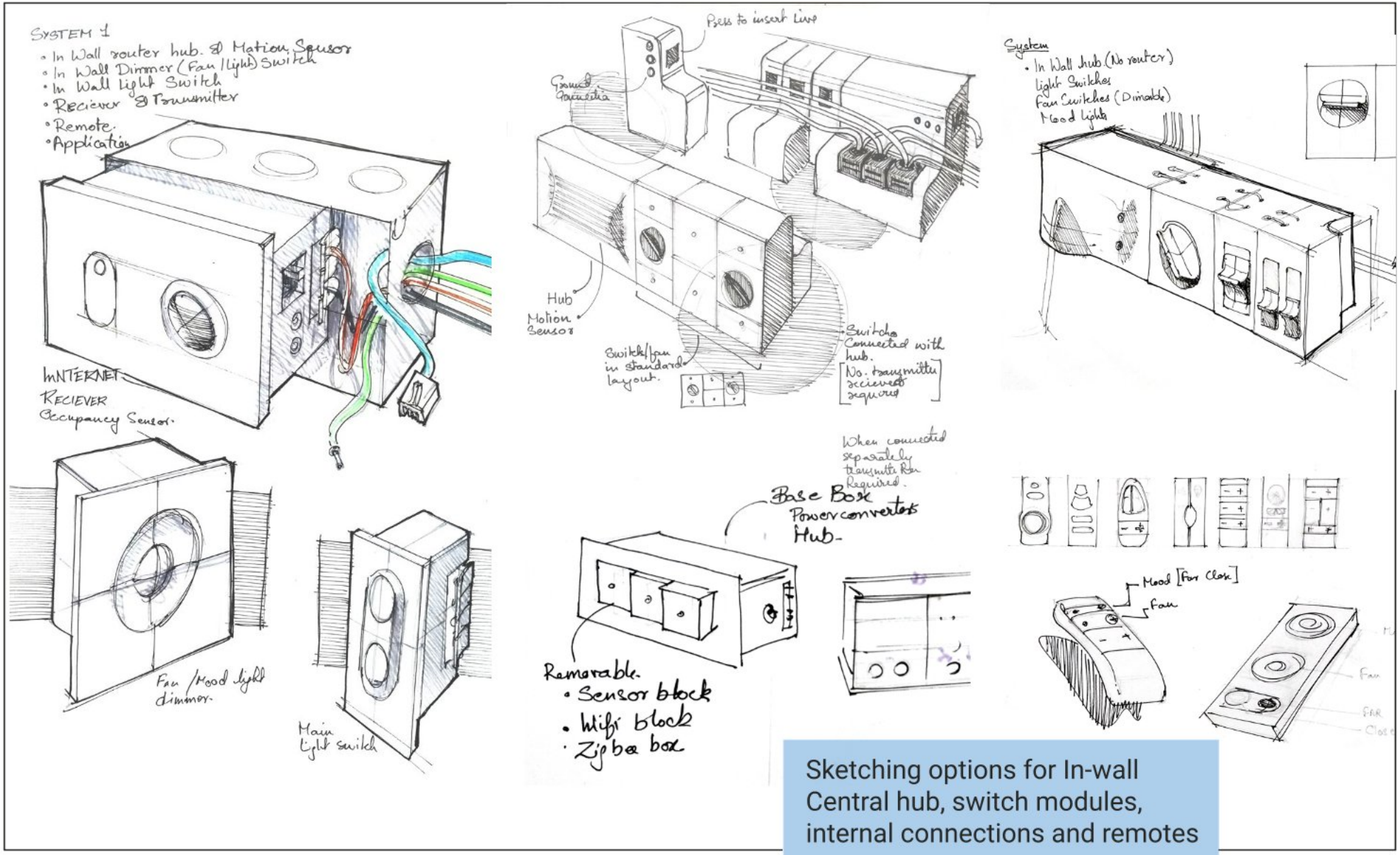


Figure:28

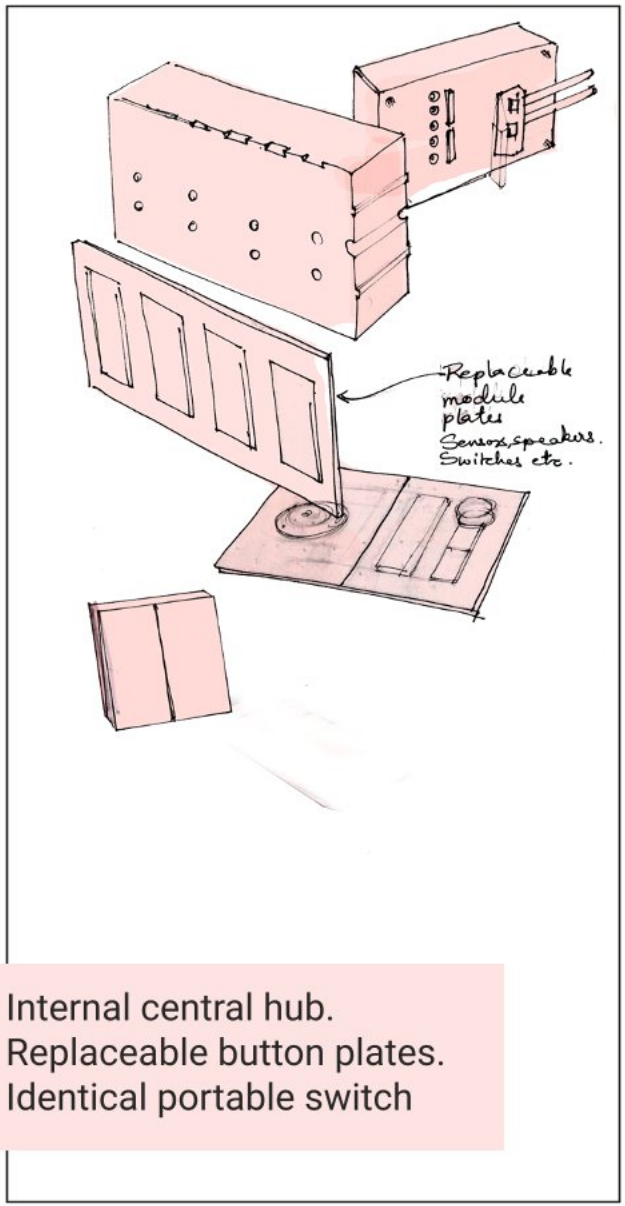


Sketching options for In-wall Central hub, switch modules, internal connections and remotes

Figure:29

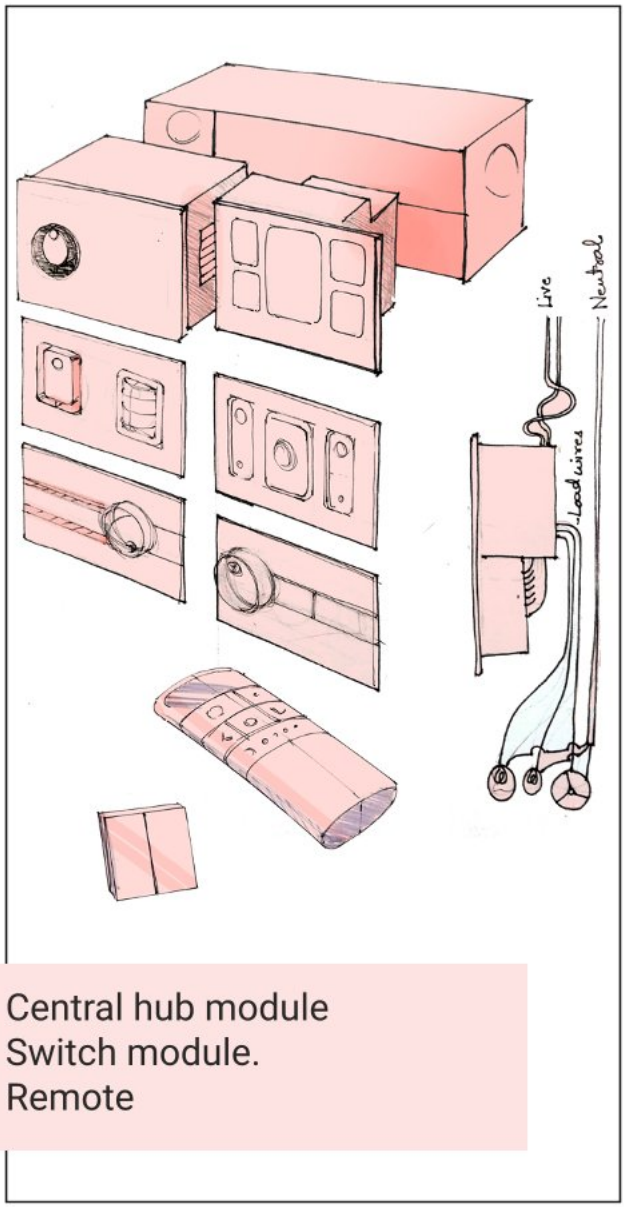
Ideations

Initial sketches paved way for detailed components and product forms. Here are a few ideas which developed as a result of sketching and mindmapping of wireless switch systems.



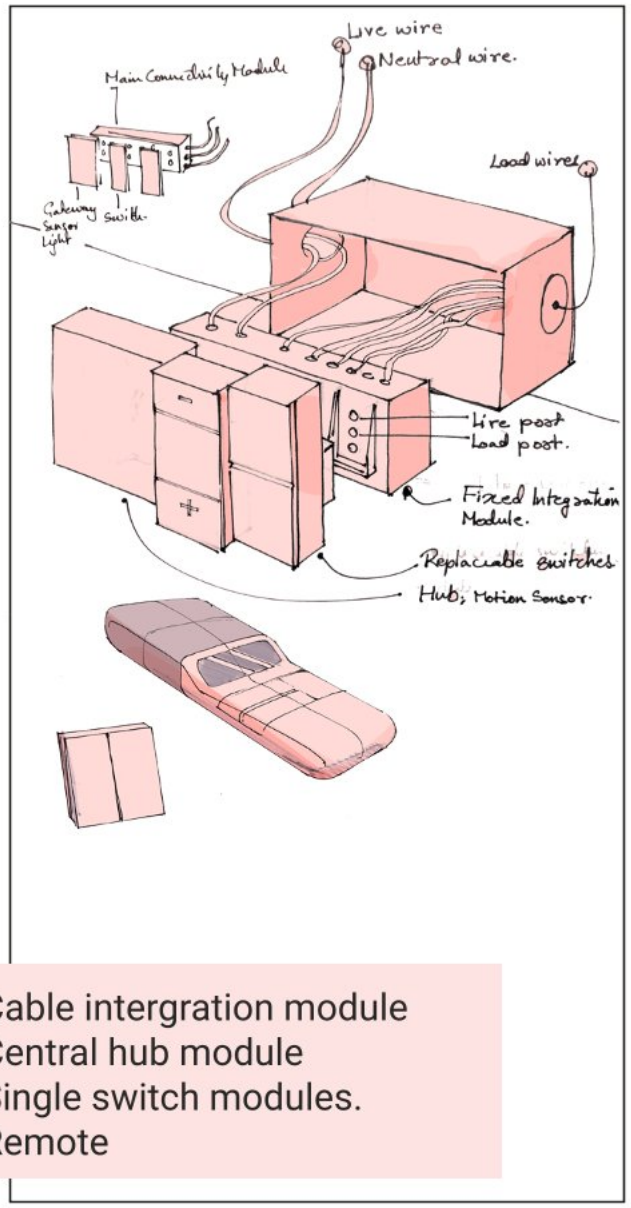
Internal central hub.
Replaceable button plates.
Identical portable switch

Figure:30



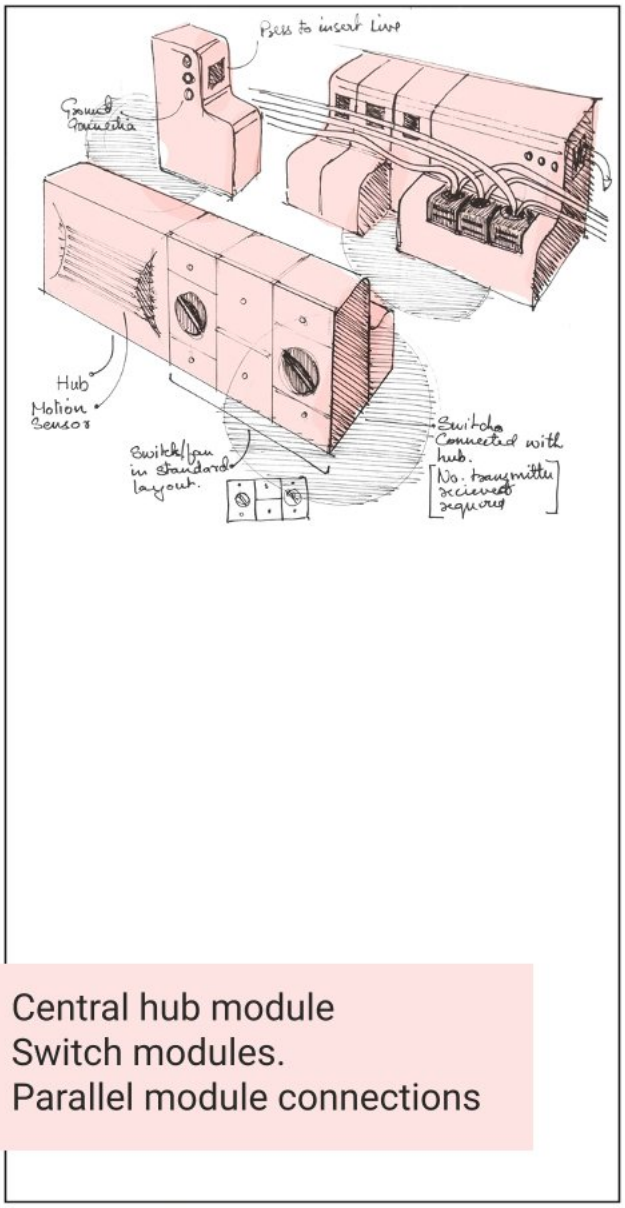
Central hub module
Switch module.
Remote

Figure:31



Cable intergration module
Central hub module
Single switch modules.
Remote

Figure:32

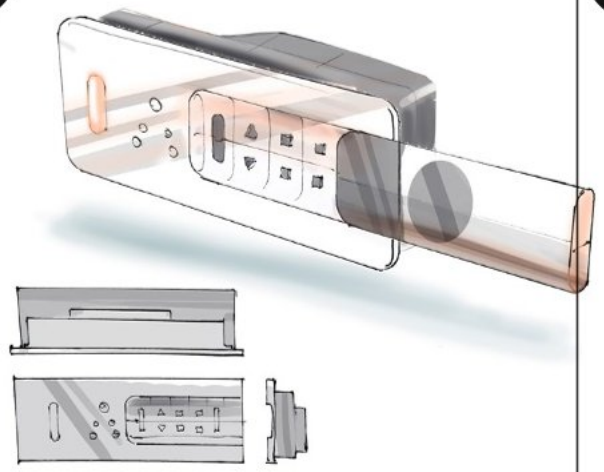


Central hub module
Switch modules.
Parallel module connections

Figure:33

Ideations

C1

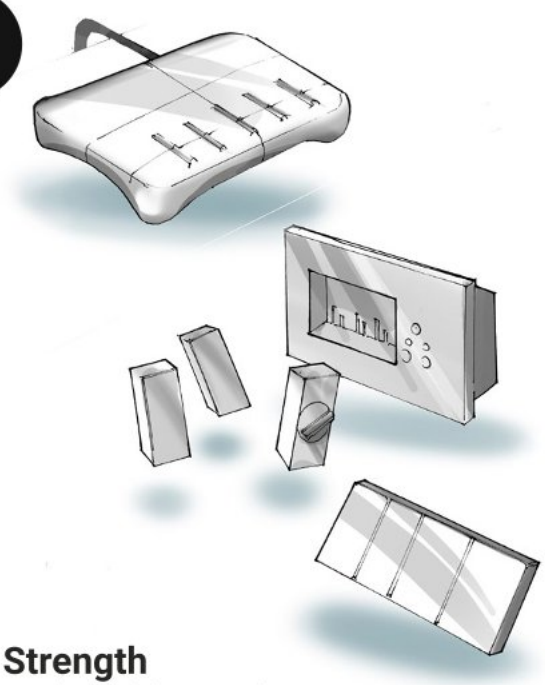


Strength
Embedded gateway hub
Clean form
Navigation wheel button
IR blaster in remote

Weakness
Non replaceable switches
Basic wiring mechanism
Limited sensor provision
Bulky remote form

Figure:34

C2

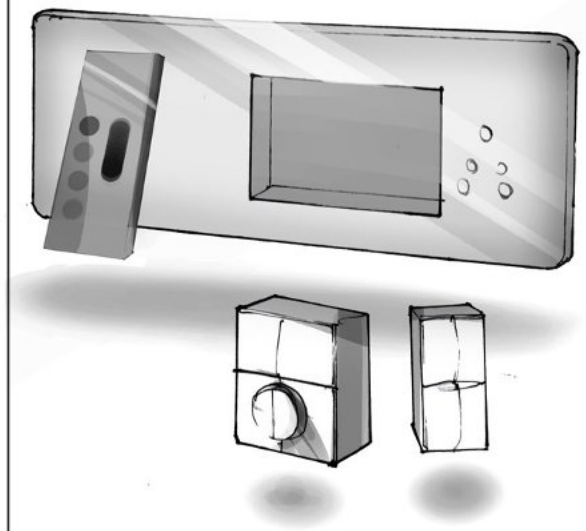


Strength
Replaceable switches
Sleek form
Separate switch and gateway module
Easy sensor provision

Weakness
Multiple components
Conventional switch button remote
No IR capability

Figure:35

C3



Strength
Embedded gateway hub
Minimal form
Magnetic remote
IR blaster in remote
Replaceable switches and sensors
Push mechanism wiring

Weakness
Protruding remote
Confusing remote buttons

Figure:36

Concept testing

Figure:37

Figure:38

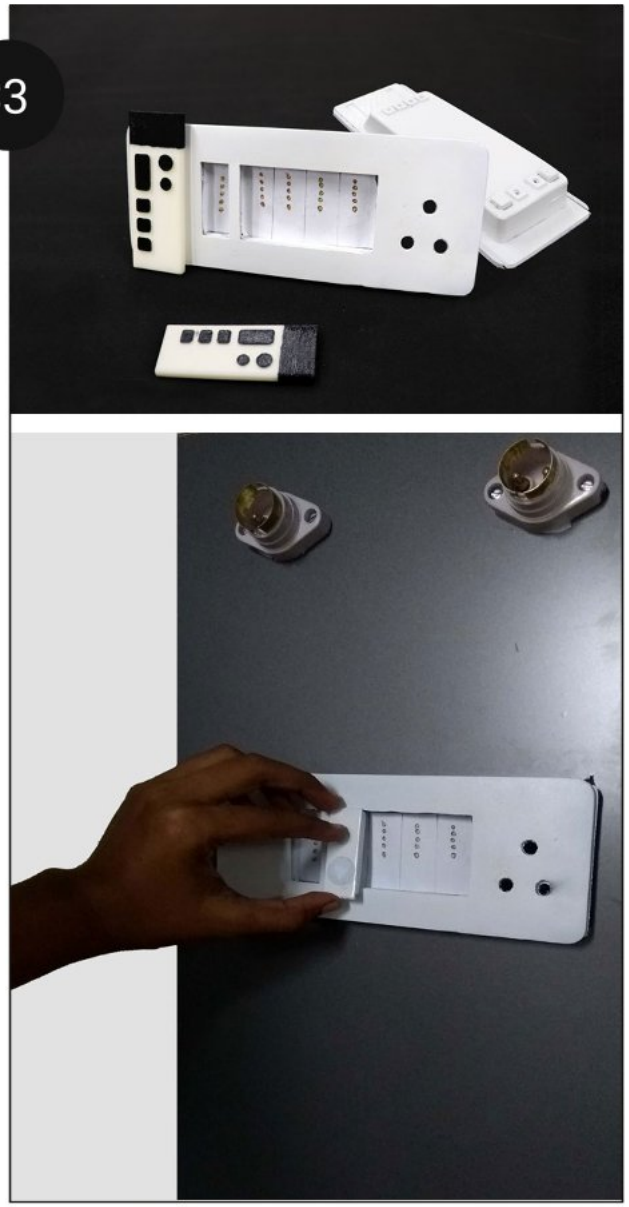


Figure:39

Remote form evaluation

Various forms for a remote were designed with various button con-binations. These were made into mockups to understand the look and feel of each of these and provide a better evaluation opportunity.

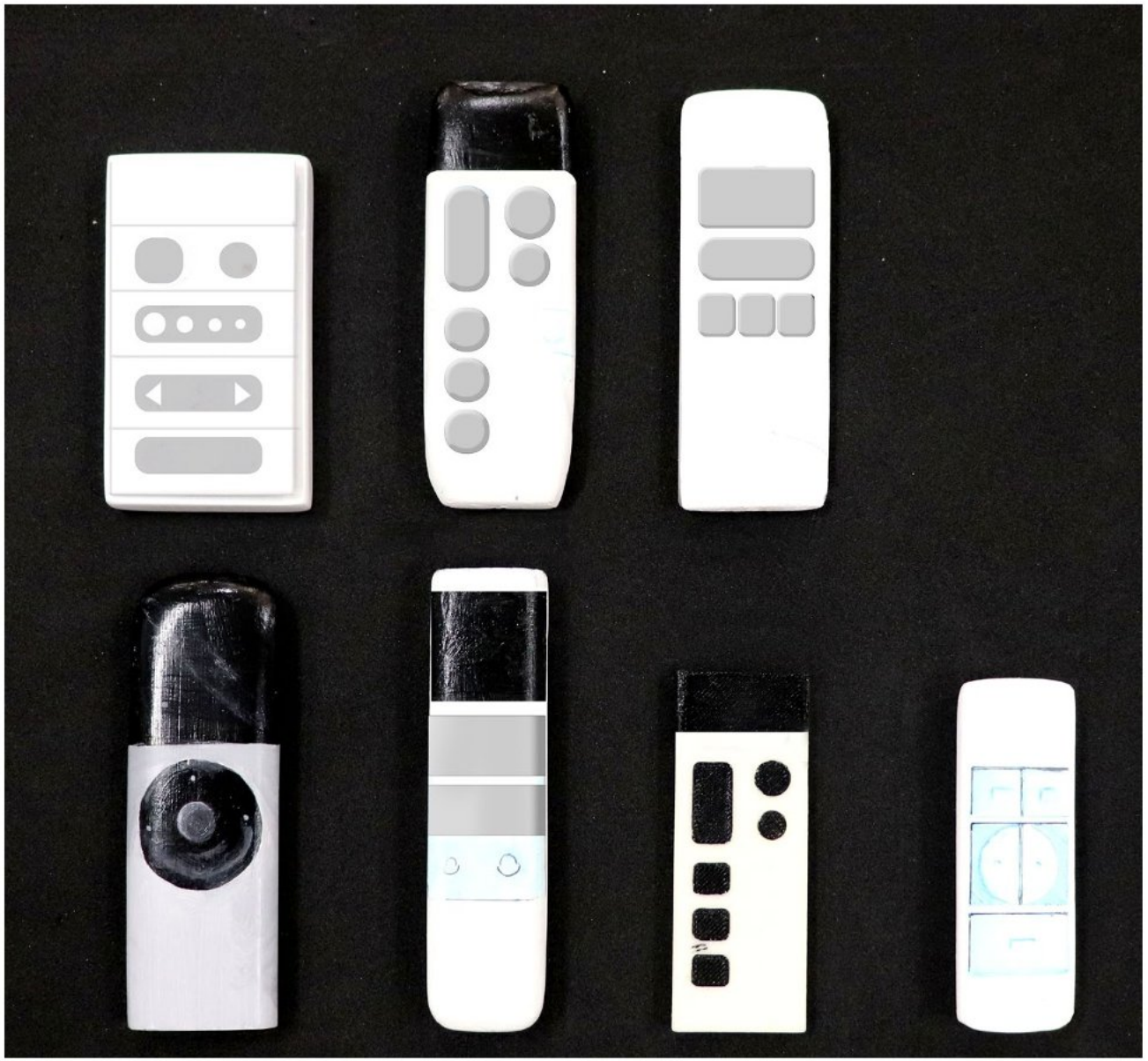


Figure:40

Participants were asked to hold each remote in a natural way and give their feedback on elements like bbutton placement, looks, holding comfort, intuitiveness etc.. The navigation wheel was easy of understand. Participants spoke out their perception about different button forms and what each of those meant.

Participants were then asked to place the remotes in the order of their preference. Some of these arrangements have been showcased on the far right

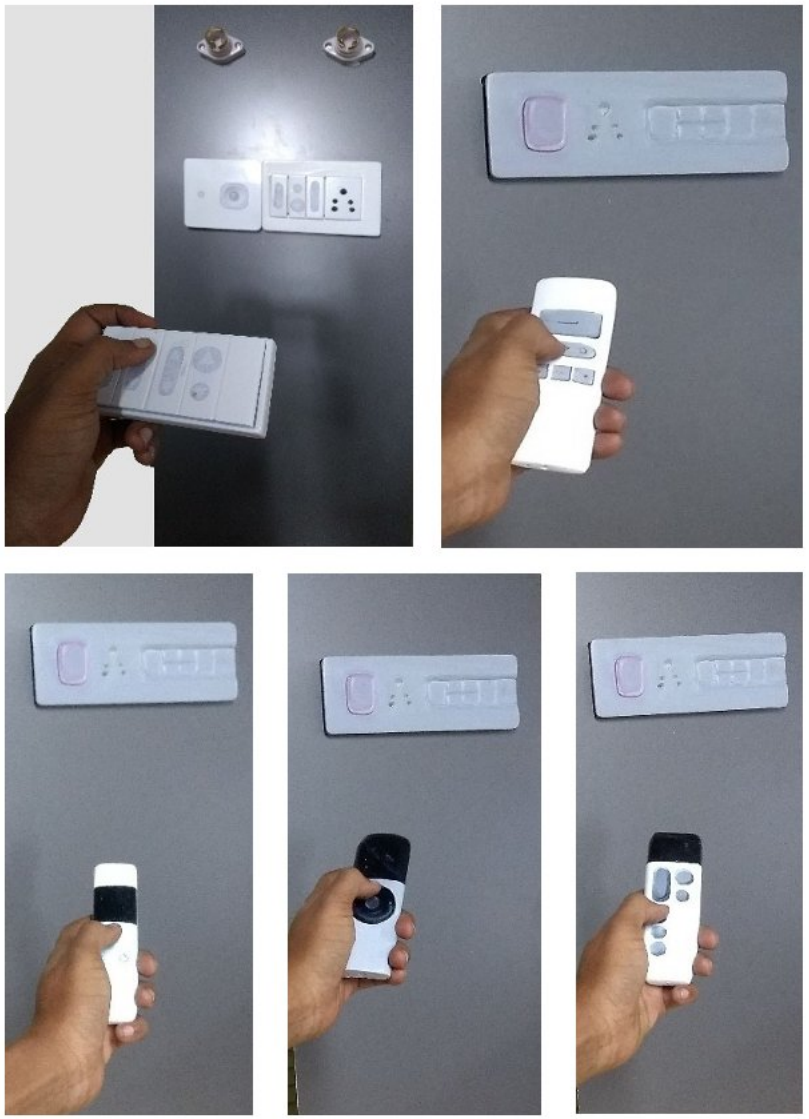


Figure:41

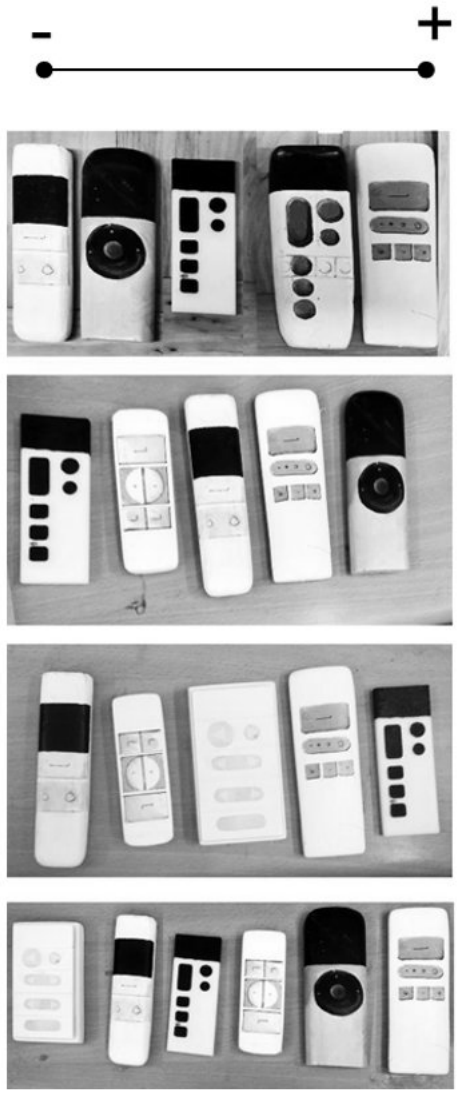


Figure:42

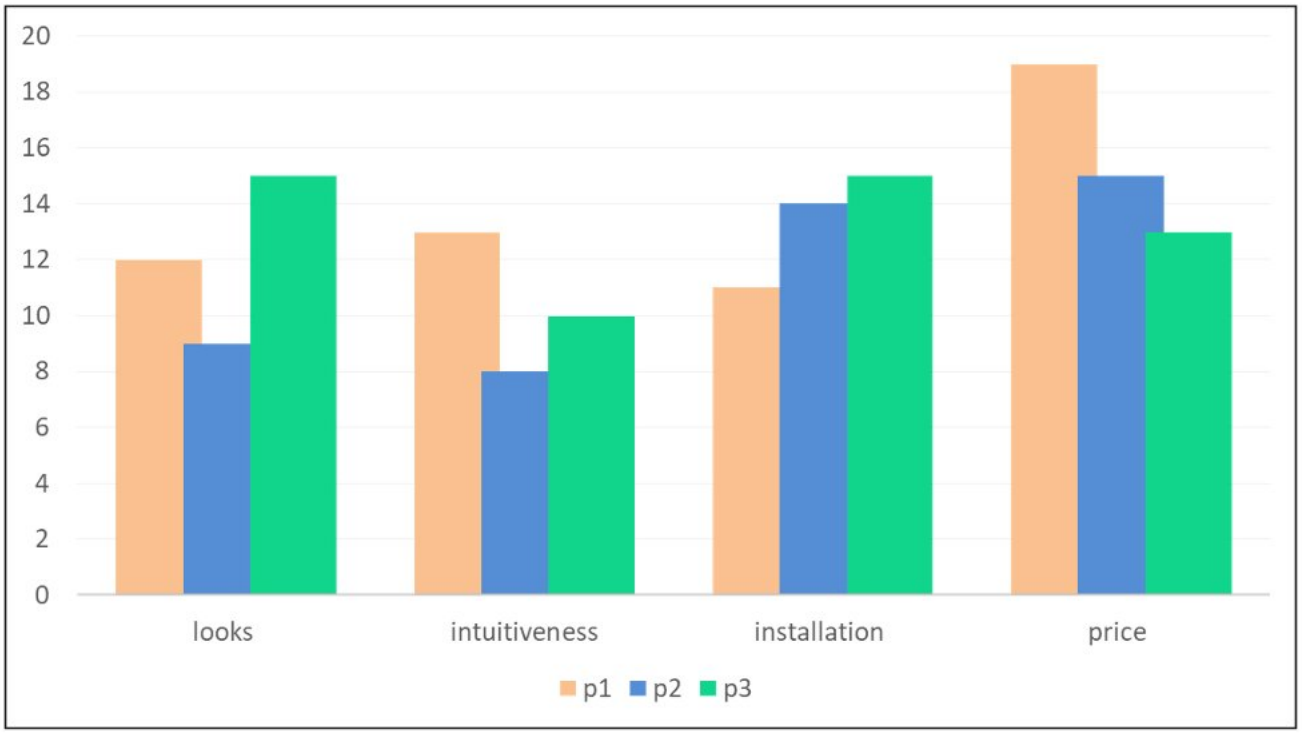
Concept evaluation

3 concepts explained above were evalutated by asking people to rate each one of them on the below mentioned criterias:

Looks
Intuitiveness
Installation
Price perception

These criterias were used in limited definitions and the evaluation lacks the rigor due to academic constraints and experience. Each participant was explained the features of each concept and was asked to rate them by giving values 1, 2 and 3. Where 3 was considered the highest score. Based on the results of the evaluation and my personal critique, I developed a design concept

The graph on the side shows the critierias used on x axis and the points scored on the y axis.



Concept ranking graph

- P3 concept was overall preferred by most participants for its minimal form, modularity and push mechanism cable connections.
- Participants also liked the easy plug n play of switches and sensor module inclusion.
- Participants liked the depressed P1 form for remote placement.
- Simple button remote of concept P2 was seen as a wall switch and not preferred for its lack of usability as a remote.
- All 3 design were still seen as simple and did not actively provoked the smart nature of the device.

Final Concept

Smart Switch-B

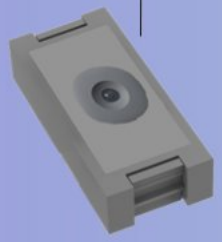
Product components

Switch-B

Core module

EASY SNAP FIT

for customizability & easy replacement..



SCALABILITY

Multiple sensors can be swapped with switches

REMOTE

Gives flexible controls.
Can connect to two switch panels & AC.
IR and RF

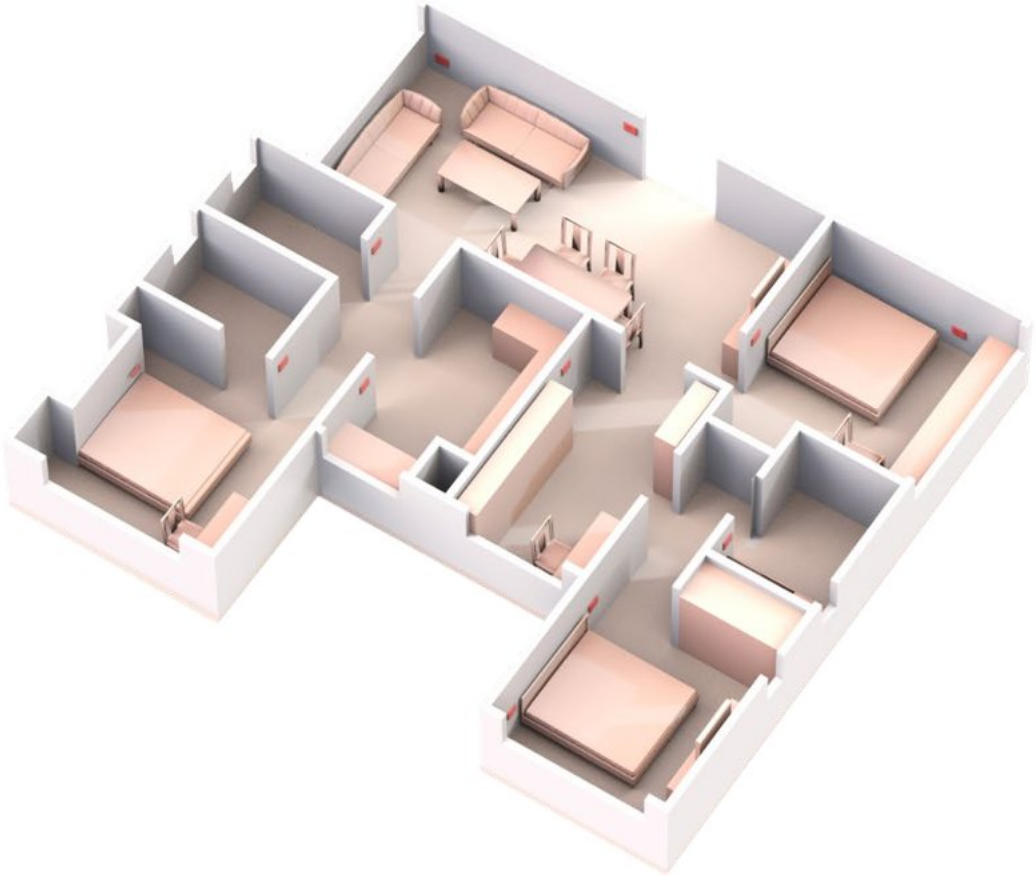
APPLICATION

Provides greater control
Remote access
Energy usage diagnostics
Safety

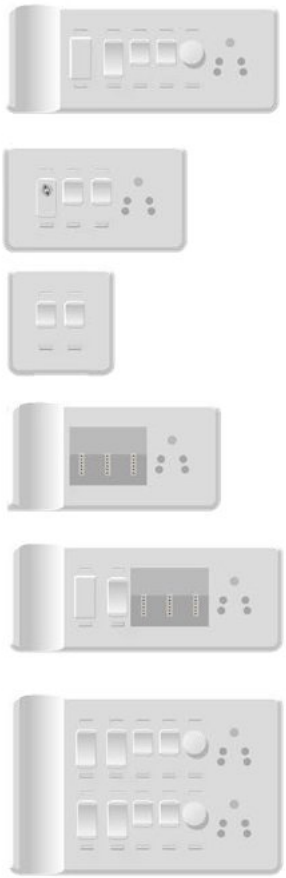
Scenario

A 3bhk+study apartment has around 22+ switchboards and powersockets.
We can see the reduction in wall switch boards if we replace them with Switch-Bs.

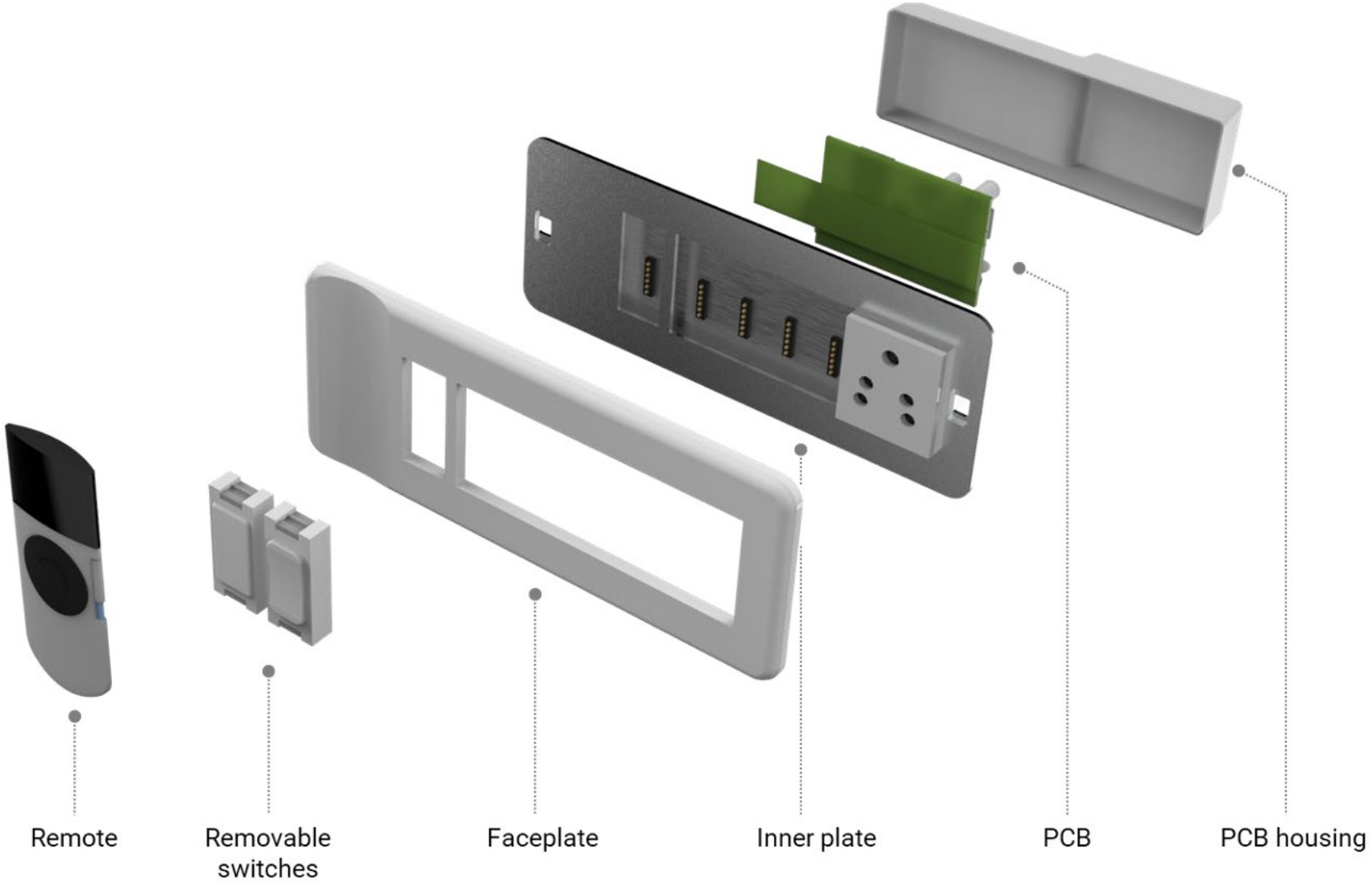
22
Switch boards +



10-11 + **5**
Switch-Bs Remotes



Component features



Component features

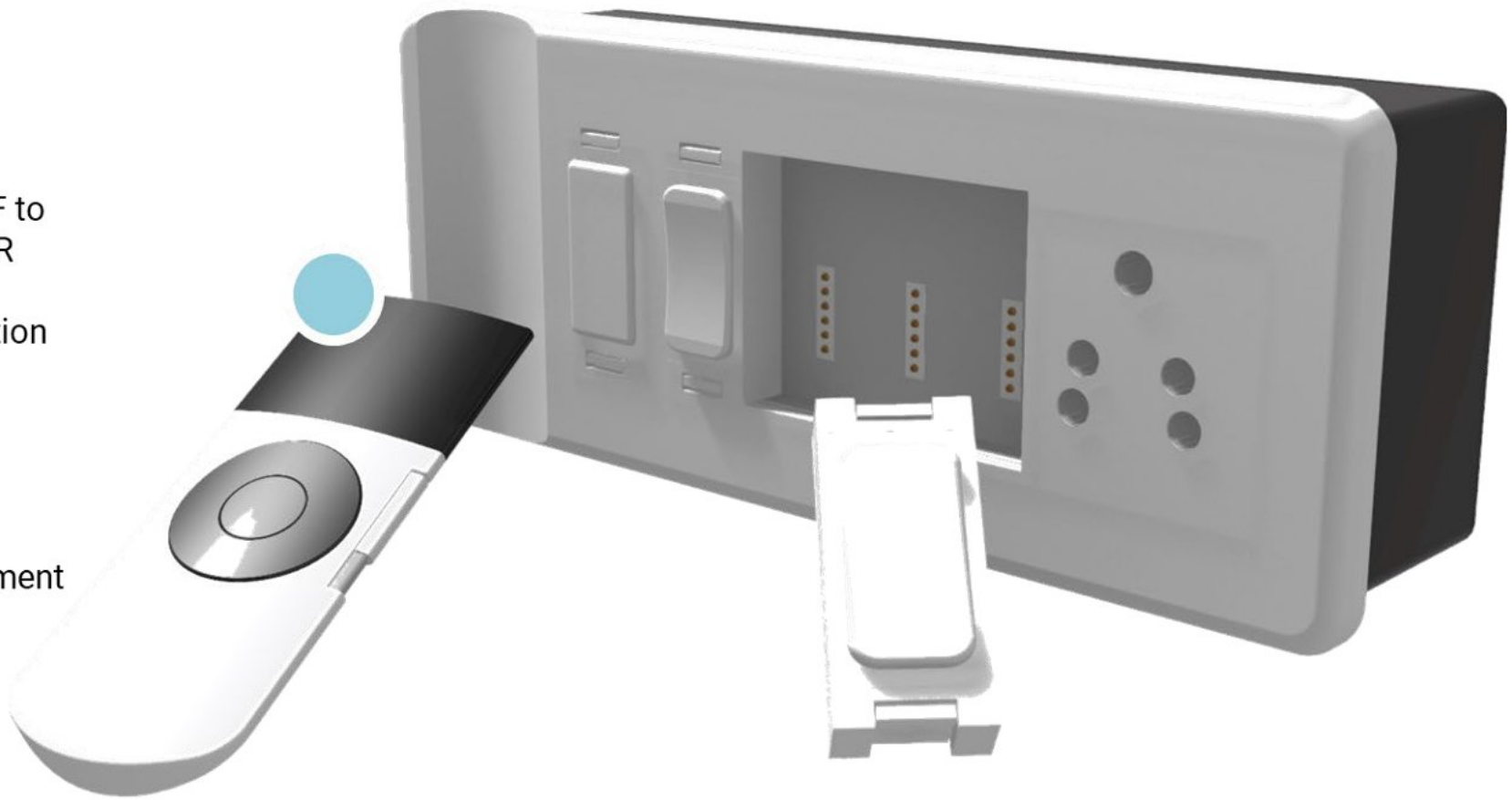
Remote

Connected via RF to the device. Has IR

Universal navigation wheel +

Multi device connectivity.

Magnetic attachment



Component features

Remote

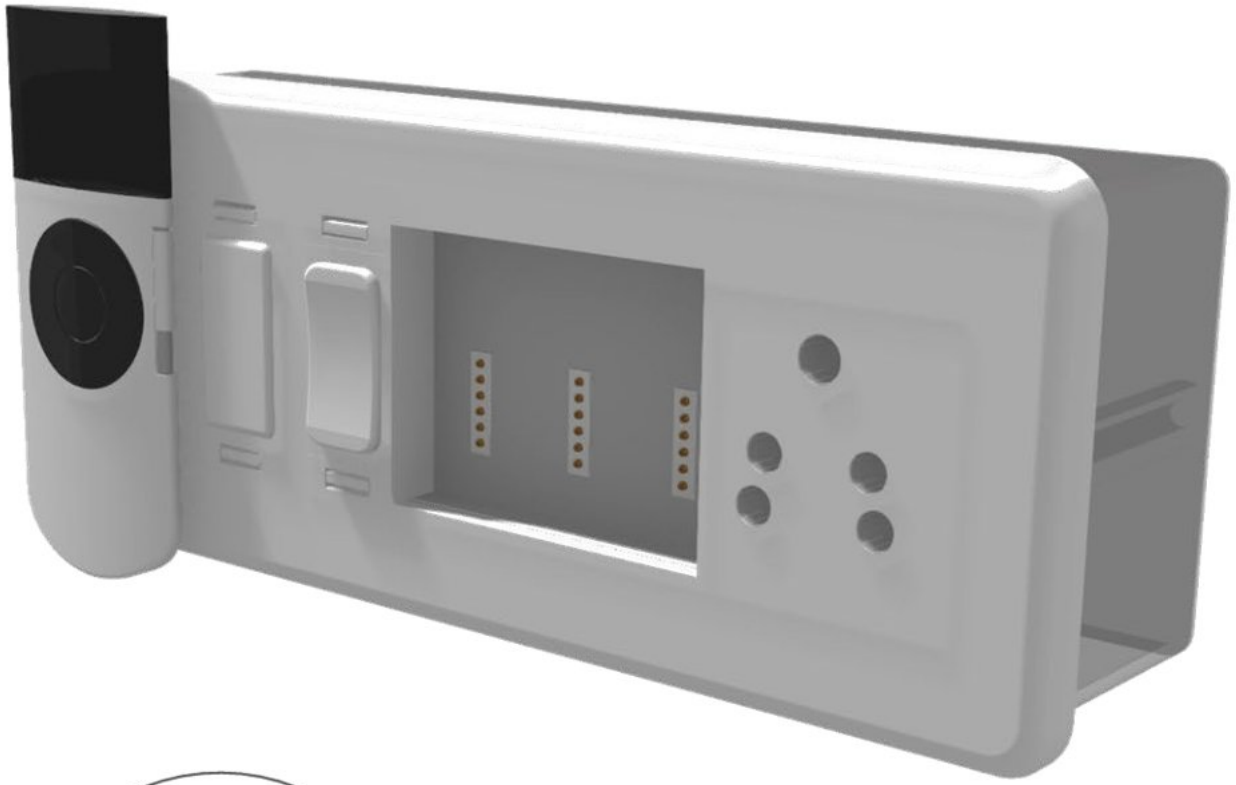
Connected via RF to the device. + Has IR

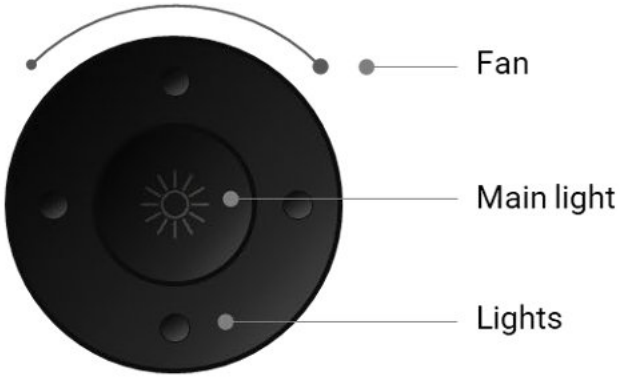
Universal navigation wheel +

Multi device connectivity.

LCD screen

Magnetic attachment





Component features

Faceplate

Various shape & sizes

Easy snap fit

Polycarbonate material
*V0- UL 94 standard

*V0- burning stops within 10 seconds

Component features

Switches

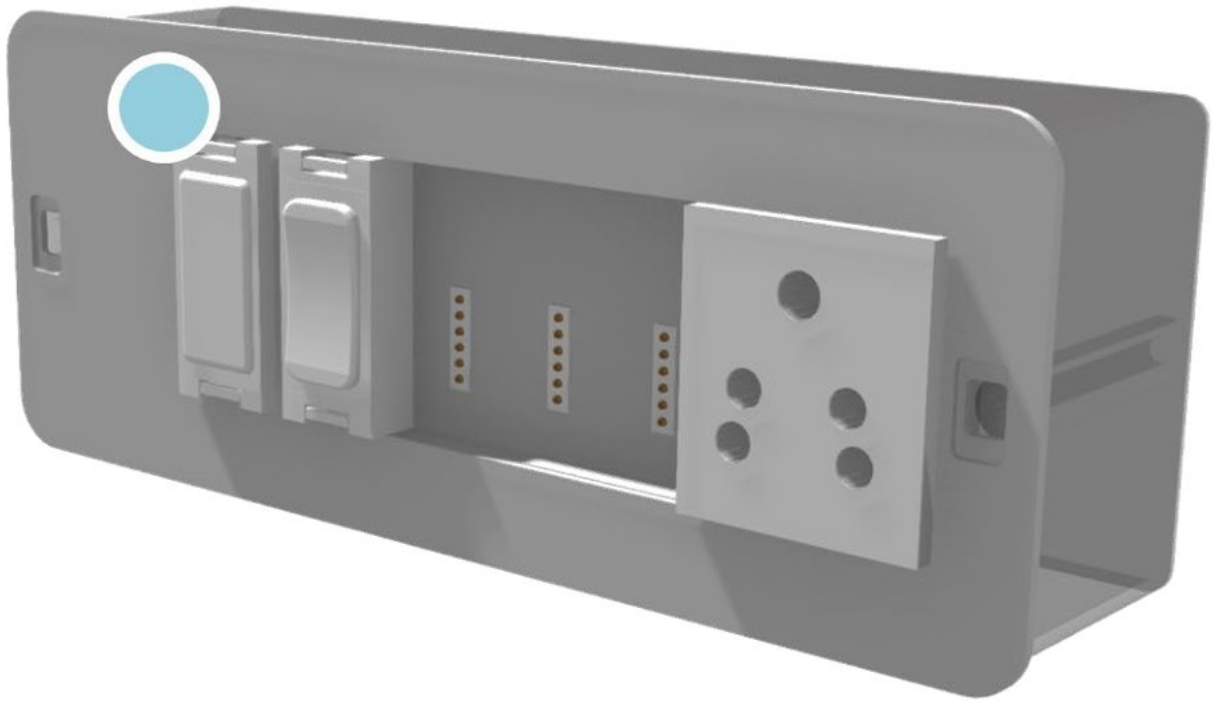
Easy snap locking

Capacitive touch interface

Conventional size

Polycarbonate material *V0- UL 94 standard

One module size for various sensors (gas, motion etc.)



Component features

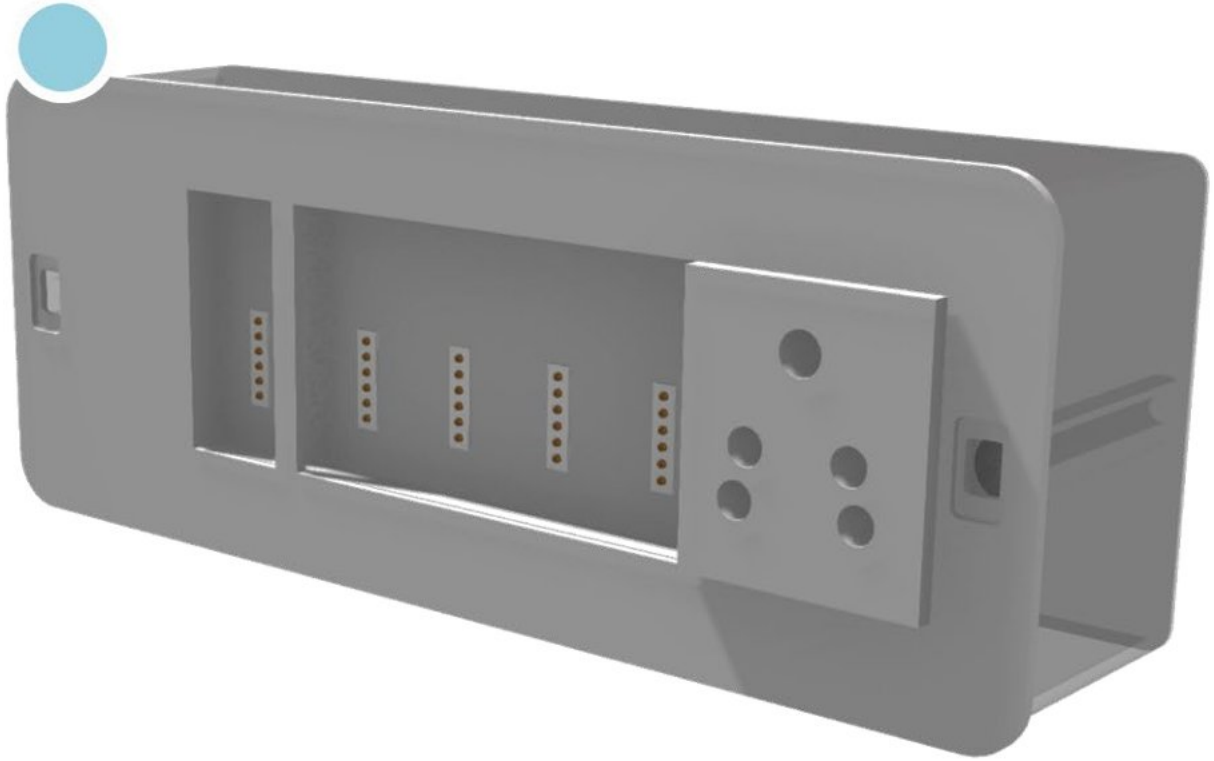
Inner plate

Provides space for snapping switches

Acts as the base for the internal PCB

Polycarbonate material
*V0- UL 94 standard

Various shape & sizes



Component features

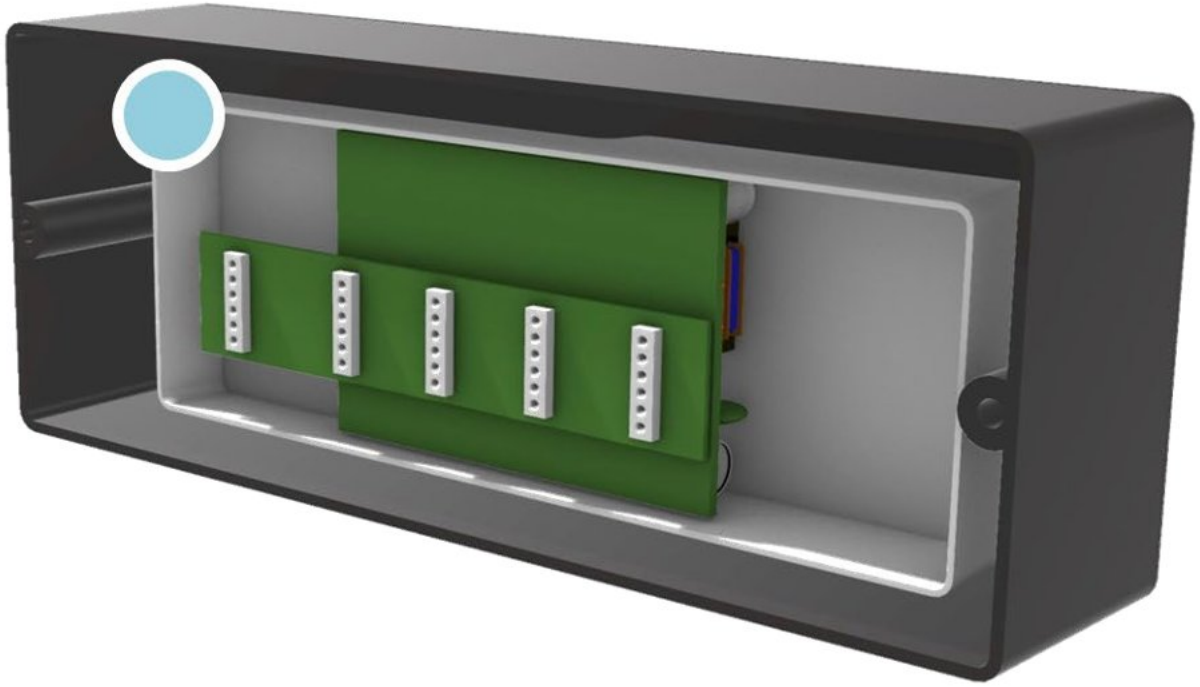
PCB housing

Fits inside standard junction box

Uses volume equivalent to existing switches and regulators

Easy terminal wire connection. (push button style)

Polycarbonate material *V0- UL 94 standard



Component features

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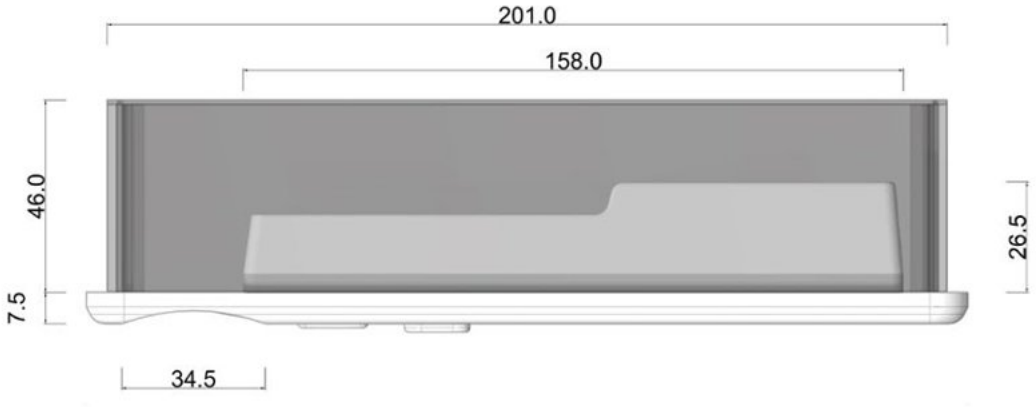
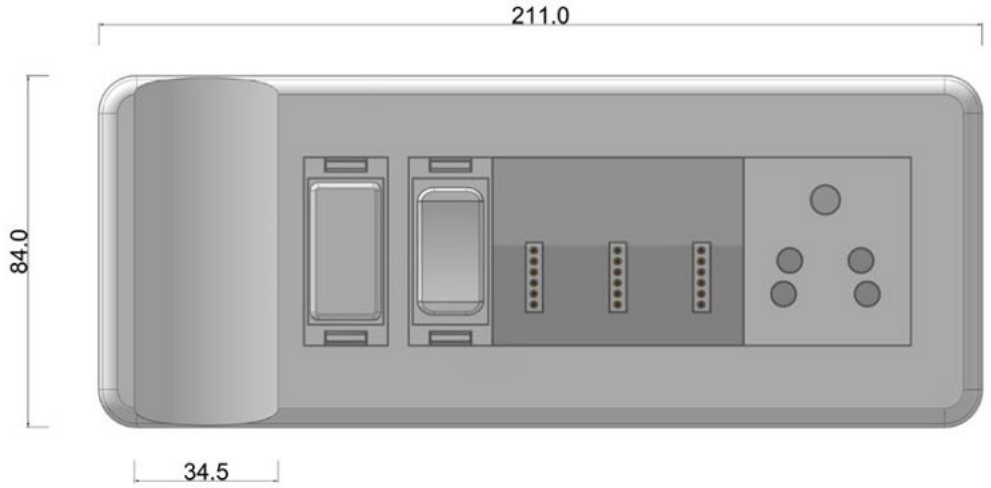
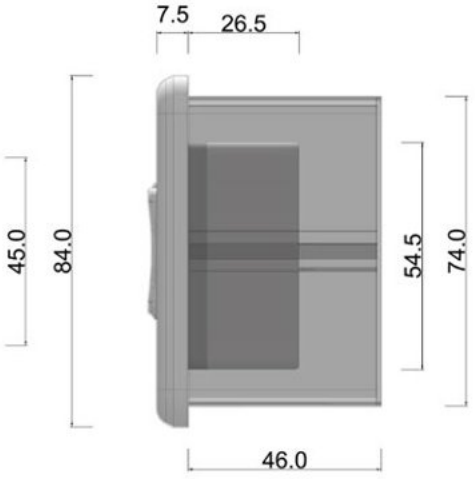
Measure drawings



Top view

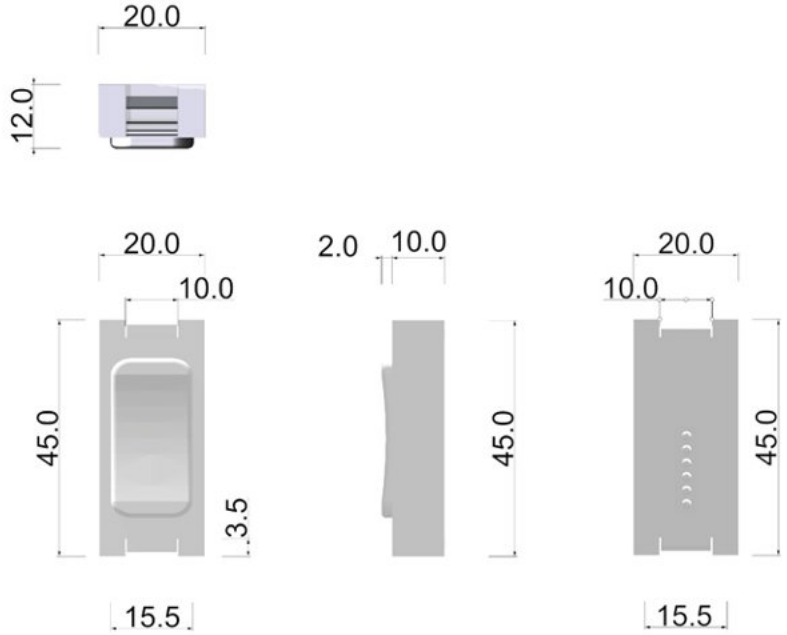


Front view

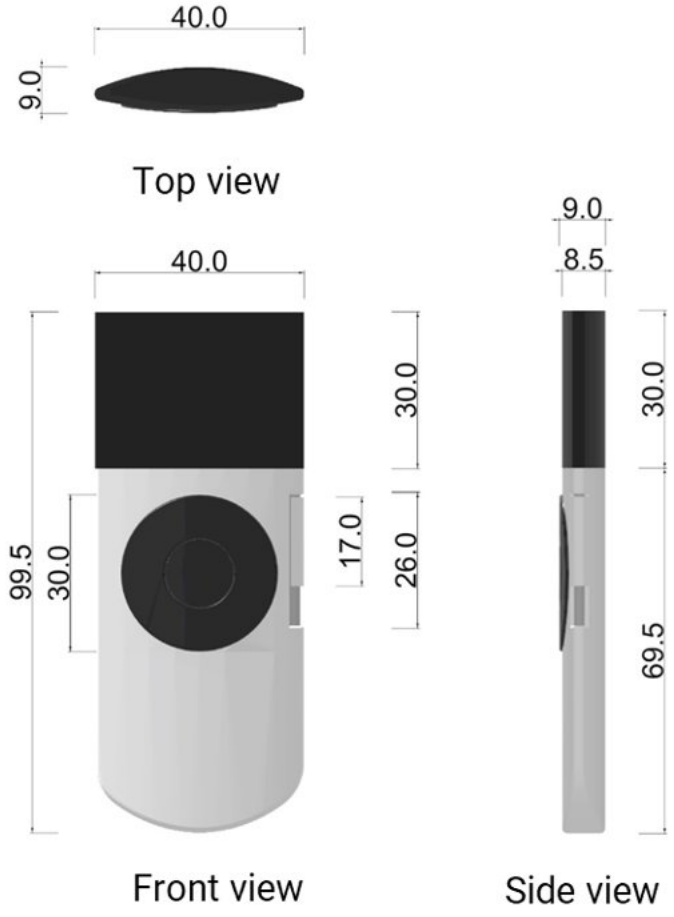


Side view

Measure drawings



Switch dimensions



Remote dimensions

Image references

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Figure:2 https://deskgram.net/p/1843037405869004178_176935959
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Figure:5 https://commons.wikimedia.org/wiki/File:Locking_switch.jpg
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Figure:24 author
Figure:25 author
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Figure:29 author
Figure:30 author
Figure:31 author
Figure:32 author
Figure:33 author
Figure:34 author
Figure:35 author
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Figure:39 author
Figure:40 author
Figure:41 author
Figure:42 author

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