TITLE: PCB BOARD DESIGN

Design Objective:
- Cicada GSM module connection to PCB (Printed Circuit Board).
- RTC (Real Time Clock) board connection to PCB. RTC will be a different board connected to PCB of the meter.
- 16x2 LCD (Liquid Crystal Display) connection to PCB.
- Power board design on same PCB.
- Variable resistor for Vrms calibration purpose
- Hall effect current sensor.
- Electromagnetic relay.
- RS232 port.
- STM32 based design.
- 2-layer PCB CAD design on Kicad
- Circuit layout design.
- Gerber production file.

DESIGN RATIONALE

1. **Cicada GSM module connection to PCB**

In the design of the GSM based energy meter, Cicada 2G/3G GSM was selected as the GSM communication module to be used send and receive information from the web application due to its reliability/stability as needed for communication purpose in this prepaid energy meter design. The cicada pin-out connection also features cicada WIFI module to be connected to same pin-out on the PCB to remove network barrier and limitation in areas with poor GSM connection.

2. **RTC**

RTC(Real Time Clock) module is needed in this design to keep track of time, also it helps in timing the uploading of energy and credit information from the hardware to the things-board web application, also the RTC module serves as a stable time base to keep track of all time based operation in the meter, operations such as STS Top-up validation, energy tracking and more, an RTC module was used as opposed to using an RTC chip, to reduce manufacturing error due to closeness of crystal oscillator to the chip and other minor RTC manufacturing error, which pose accuracy threat to the design, also to ease the process of manufacturing and aid compactness. The RTC

module also has an EEPROM chip named AT24C32, this chip will help save all metering information such as STS token, tariff and much more as needed.

3. 16x2 LCD

A 16x2 LCD from Hitachi is proposed and used in this design to display all necessary parameters such as RMS voltage, current, power, energy, Top-up balance and visually see STS token number inputted for manual Top-up in event of network failure, this LCD serve as physical interactive medium between electrical parameter measured and user readable and understandable information.

4. Power board design

The power board design for the energy meter is a SMPS (Switch Mode Power Supply) based design with a fly back forward switching topology using UC3843 current controller IC and ferrite core transformer, this topology was selected as opposed to using transformer based design due to its reliability, weight, cost, sophistication and performance under low voltage/high voltage conditions without failure, also voltage regulator IC(Integrated Circuit) were used to regulate voltage as needed for the GSM module, micro-controller and other module needing regulated voltage, voltage regulator IC such as (L7805, LM350) were used in regulation, data-sheet to each IC is available on the data-sheet section of the deliverable set1.

5. Variable resistor calibration for V_{Rms}

Variable resistor is incorporated into this design to enable calibration the AC voltage as required.

6. Electrically isolated hall effect sensor

The current sensing method used here had to be changed from hall effect current sensor to current transformer measuring method, this method is used to increase efficiency. An accuracy test between hall effect current sensor and current transformer was performed and it was discovered that current transformer provides better accuracy and stability when measuring AC current as compared to hall effect current sensor. In addition, hall effect current sensors accuracy is affected by heat and more susceptible to electromagnetic interference due to the sensors electromagnetic die sensing method used as proposed by "**Edwin Hall**".

7. Electromagnetic relay to turn users on/off

Magnetic latching relay is used in place of electromagnetic relay due to cost,

reliability, power consumption, size. Comparison table is highlighted below.

Electromagnetic relay	Magnetic latching relay
Terminal is susceptible to arching and carbon which eventually lead to relay failure.	Terminal is less susceptible to arching and carbon which eventually lead to relay.
High cost in comparison to current handling capability.	Low cost in comparison to current handling capability.
Takes a lot of space.	Takes a very small considerable space.
Continuous supply power is needed to keep relay active.	A single pulse of power is only needed to trigger the relay on or off.

The above advantage of magnetic latching relay as compared to electromagnetic relay in terms of **cost, size, terminal carbonizing, power consumption and current handling capability** is why we opted for a magnetic latching relay as opposed to using an electromagnetic relay.

8. STM32 based design

Stm32f401cc was the first chip proposed to be used in the design of the energy meter due to its speed, cortex-M4 architecture and other feature, however the chip has internal oscillator regulator issue during upload, which makes upload a little bit tasky, in view of that, we had to switch to a more stable chip **STM32f103C8T6.**

STM32 based chip was used in the control of all operations in the meter, the STM32 micro-controller used in the energy meter design is **STM32f103C8T6**, this chip was selected due to its ease of use, firmware upload to the chip is not affected by heat, stability, 32bit processing speed, arm cortex M3 incorporation, ART accelerator, FPU(floating point unit calculation), zero wait state, available break out board for easy manufacturing called "**blue pill**", add-on feature to use the popular Arduino-uno IDE to write, compile and upload code to the micro-controller via USB and STM32-Cube-MX. More information about the feature of the chip is available in the data-sheet available on the En-Access energy meter Github page.

Deliverables

Deliverables such as 2-layer PCB board, circuit design layout, Gerber production files are available on the Github folder named **Deliverable Set 2.**