CS 684 - Embedded Systems
Spring 2018

Smart Fault Monitoring Device

Guide
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Problem Statement

Objective

- A Smart Fault Monitoring Device can be used for monitoring the trip/fault status across MCB in domestic and industrial safety application.
- This will log trip information and intimate to user using IoT device.

Product Impact

- All residential and commercial establishments.
- Be a part of **Smart City initiative**.

Scheme

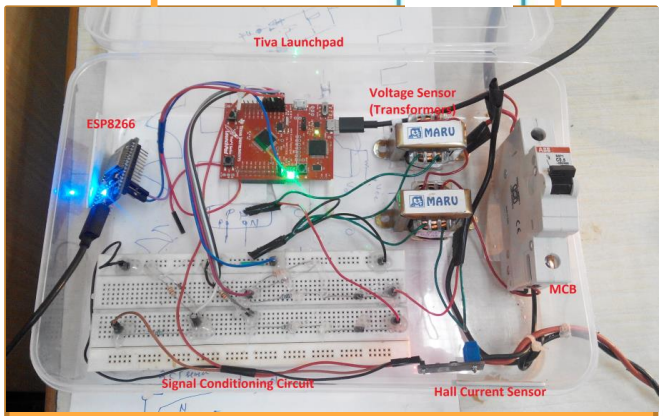
Signal Conditioning Circuit

Launchpad
MCU + ADC

NodeMCU
ESP8266

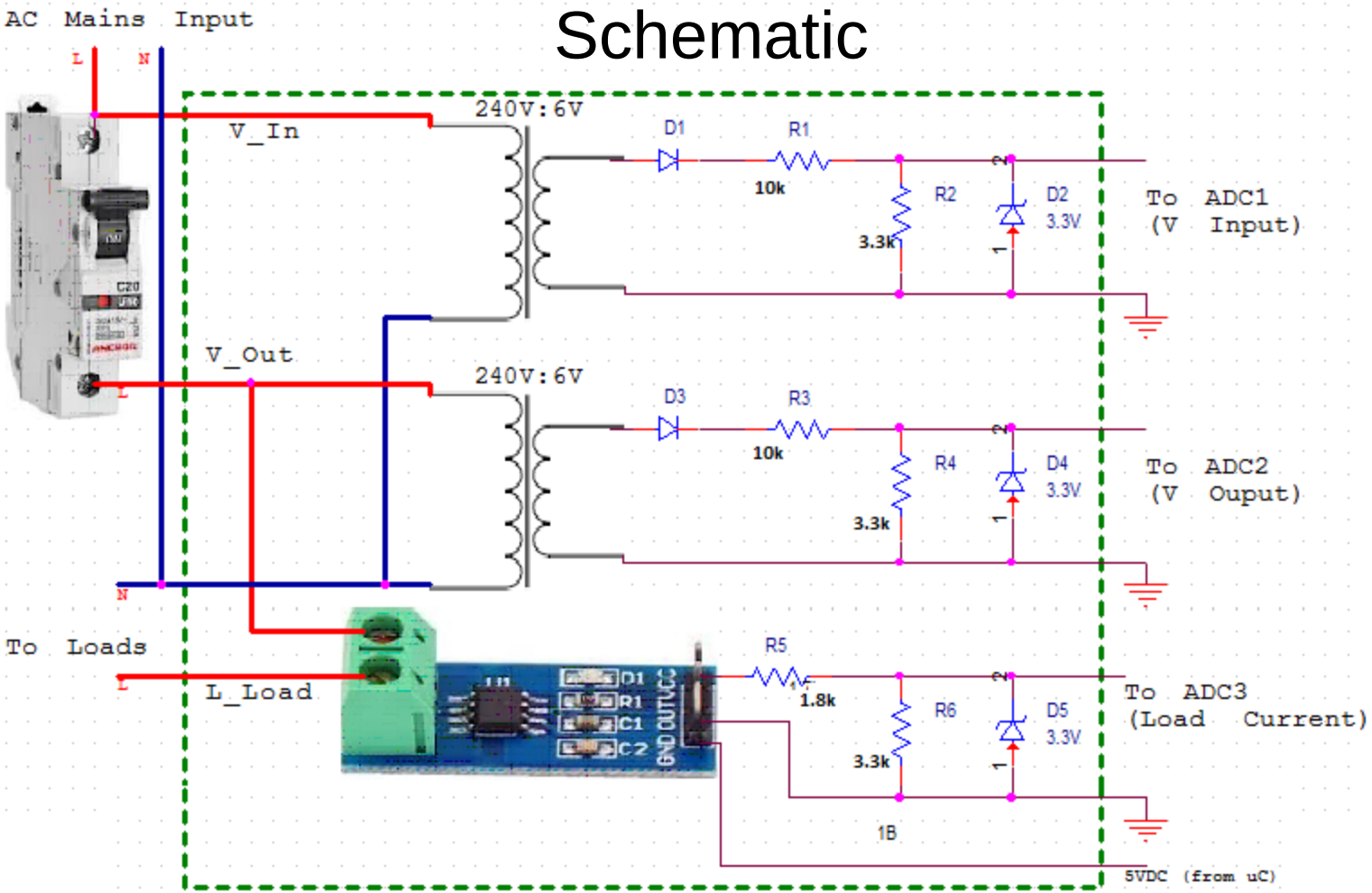
Smart Fault Monitoring Device

Actual Product Realized



Smart Fault Monitoring Device

Schematic


AC Mains Input
L
N
V_In
240V:6V
D1
R1
10k
R2
3.3k
D2
3.3V
To ADC1
(V Input)
V_Out
240V:6V
D3
R3
10k
R4
3.3k
D4
3.3V
To ADC2
(V Ouput)
To Loads
L_Load
R5
1.8k
R6
3.3k
D5
3.3V
To ADC3
(Load Current)
1B
5VDC (from uC)

Power Status Monitoring

- **Power OK** : Voltages on Primary & Secondary side of MCB are OK.
- **No Power**: Mains supply is not coming.
- **MCB Tripped**: MCB got tripped due to overcurrent, short circuit etc.

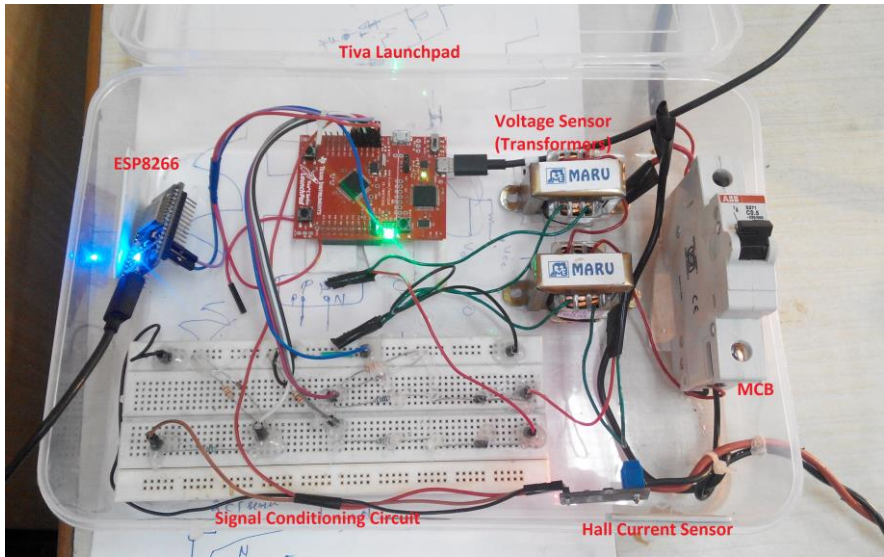
Requirements

Hardware

- ESP8266 NodeMCU
- Tiva Series Launchpad
- AC Voltage Sensor (Step down Transformer)
- AC Current Sensor (ACS712)
- Signal Conditioning Board
- 5VDC Supply

Software

- CCS 6.1.2
- MOS (for IoT Device)
- AWS Platform (e-yantra)
- Serial Console



Challenges

Challenges

- Safety precaution to be followed, while working with live voltages.
- Hardware selection for Wireless communication.
- Sensor selection for AC current and voltage.
- Sensor calibration
- Real time DC offset calibration.
- Exploring web/email interface for user notification
- Acquiring the skills for the IoT device programming (MOS/mJS)

Deliverables

- Smart Fault Monitoring Unit
  - Microcontroller board with ADC/sensors
  - IoT device
  - Analog signal conditioning hardware

- Front-end interface(IoT platform)

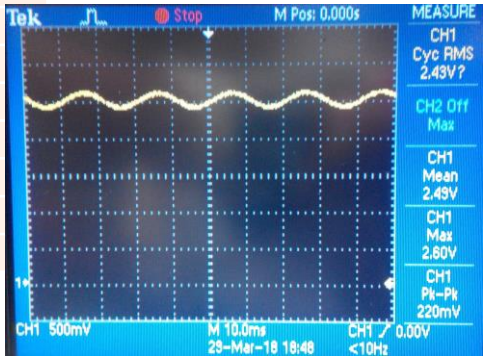
Test Strategies

- Measurement Tests : To verify measured input current and voltage values
- Fault Monitoring and Test : To verify the detection of MCB trip contact status
- Communication Test: Send the fault/trip alert to the user via internet/AWS
- Front-end testing

Test Results ..1

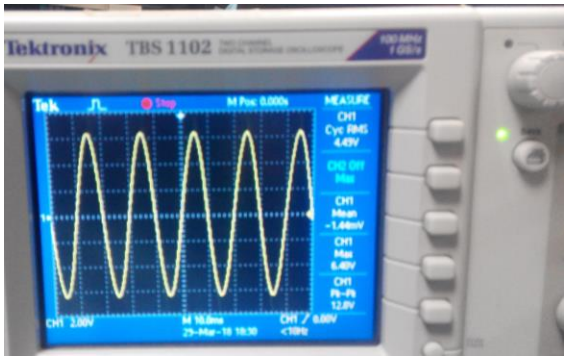
- ACS712 - 30A Current Sensor

Ip (Input), Amp (rms)	Sensor O/P Volt (Vpp)
0.25	56.8mV
0.5	101mV
1	220 mV
2	420 mV
3	620 mV
4	820 mV
5	980 mV
6	1.18 V
7	1.38 V
8	1.58 V
9	1.76 V
10	1.94 V



- Voltage Sensor

Primary Volt	Secondary Volt
240 Vrms	+/-10.6 V



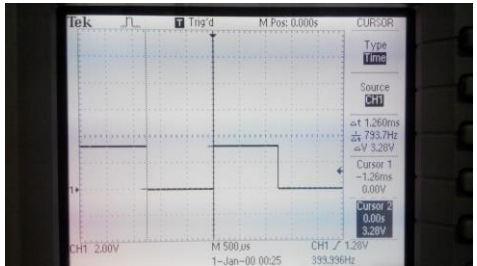
Test Results ..2

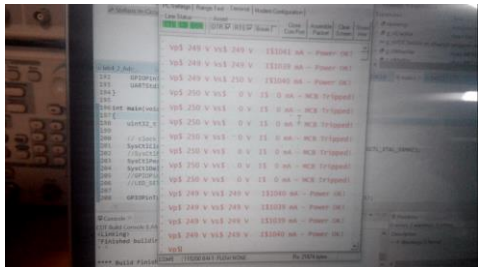
- Tiva

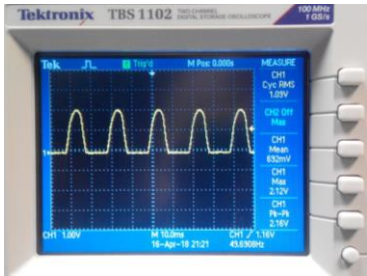
Timer Interrupt Generation & Verification	Done
ADC SoC Generation & Data read Verify	Done
Volt/Current RMS calculation logic	Done
Fault status decoding logic	Done
Fault intimation on UART	Done

- ESP

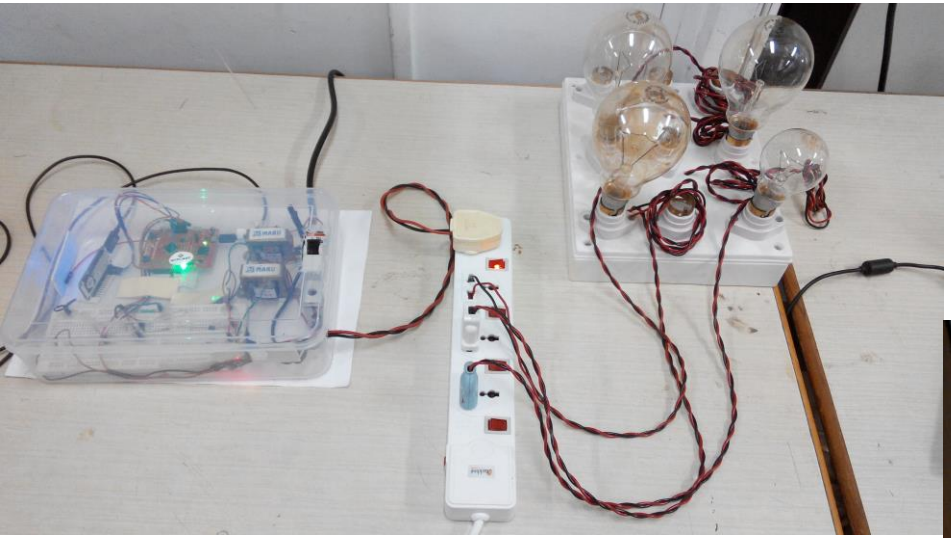
ESP8266	
Arduino IDE & library installation	Done
ESP programming procedure	Done
ESP UART communication with Tiva	Done
ESP Wifi Comm.	Done
ESP Notification Sending	Done
Web/Email	Done
IoT Platform (AWS) Interface	Done

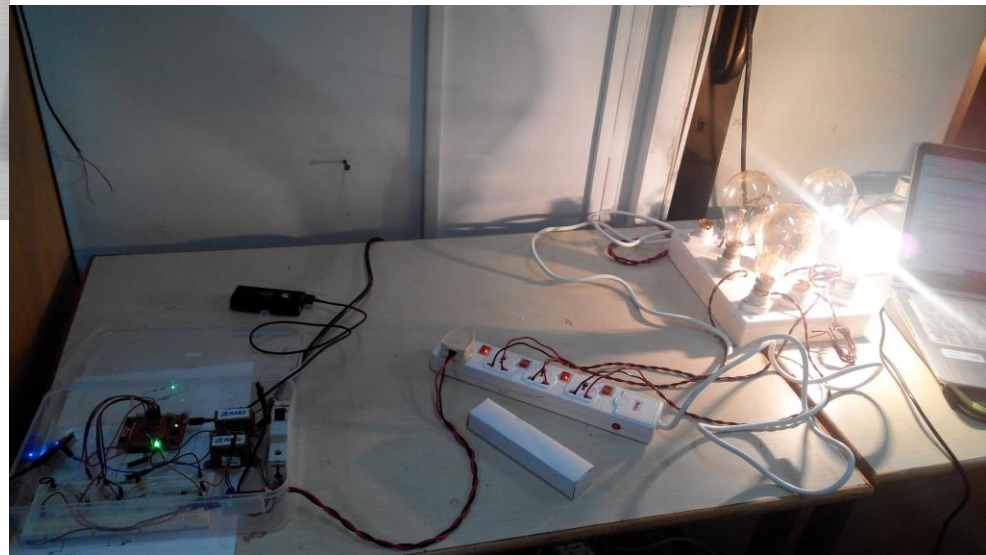




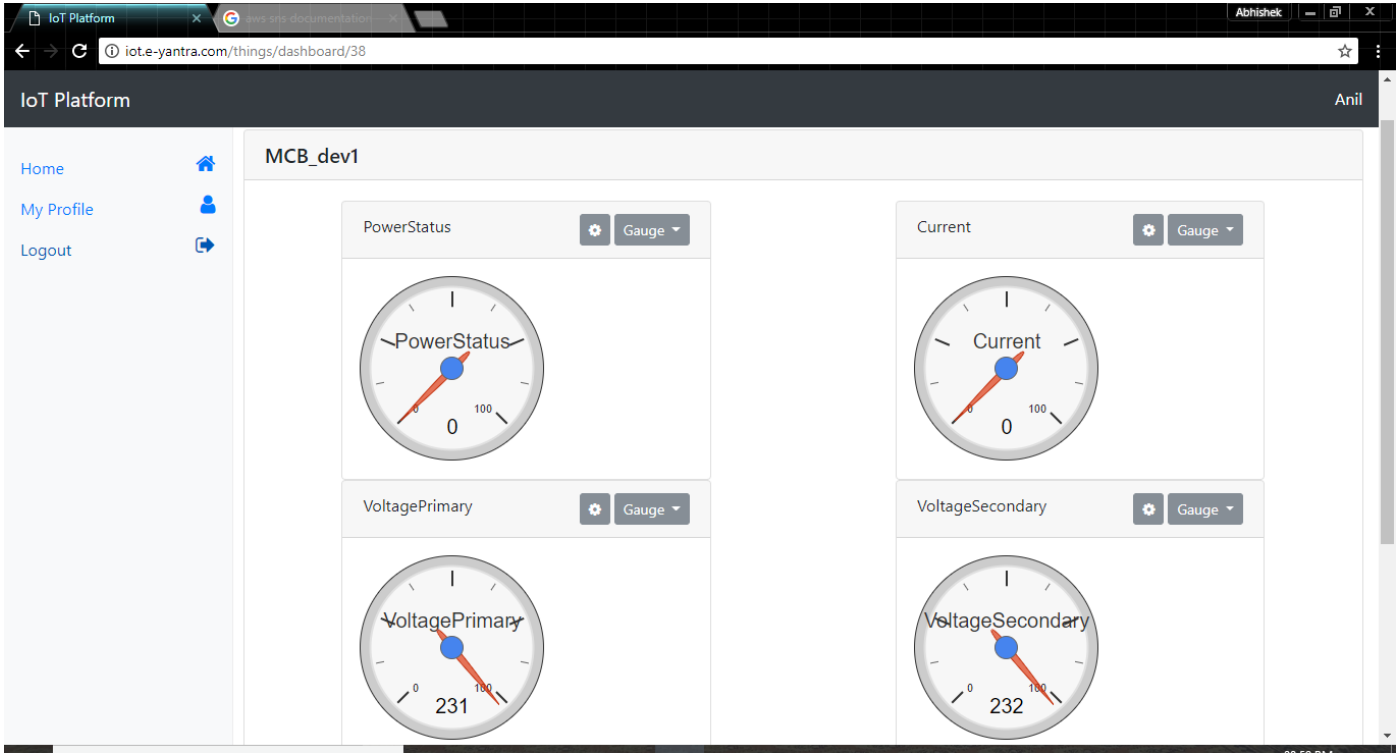


Integrated Test Setup

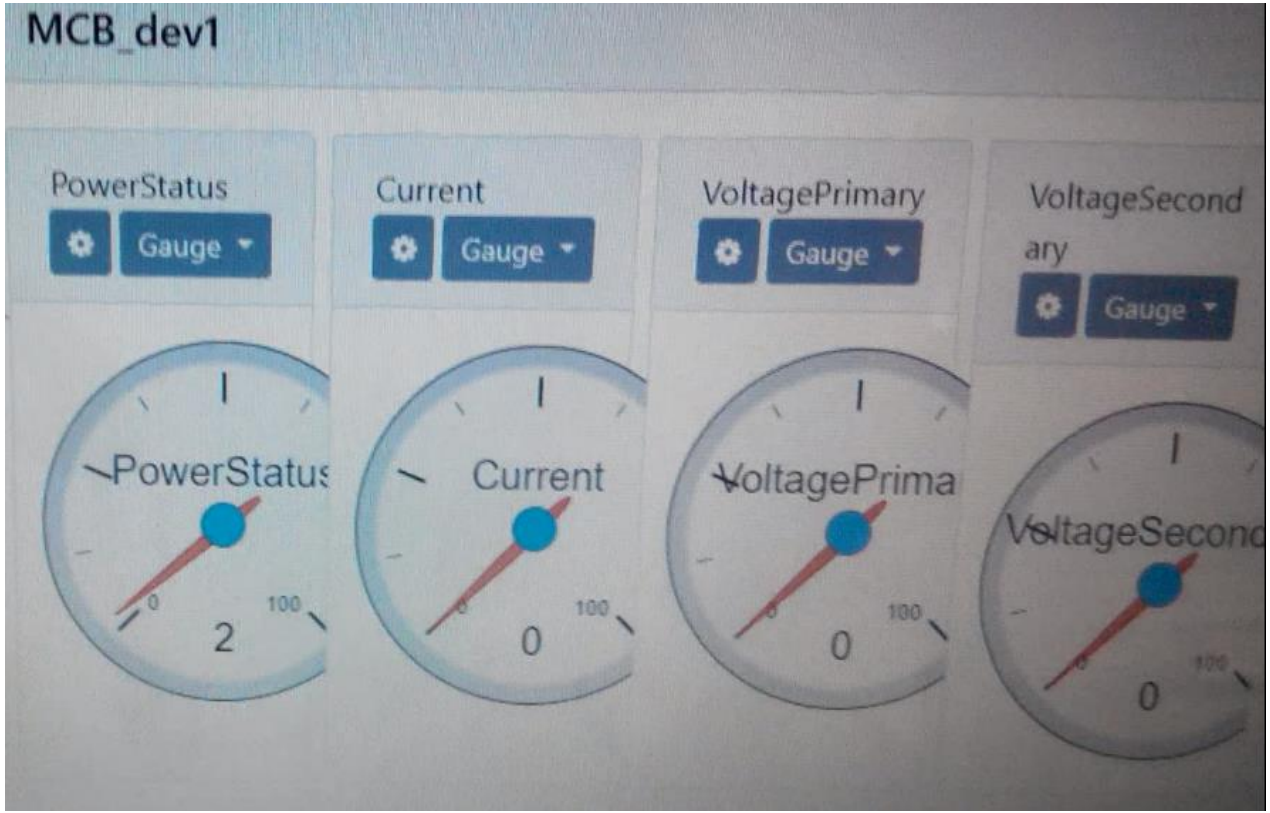




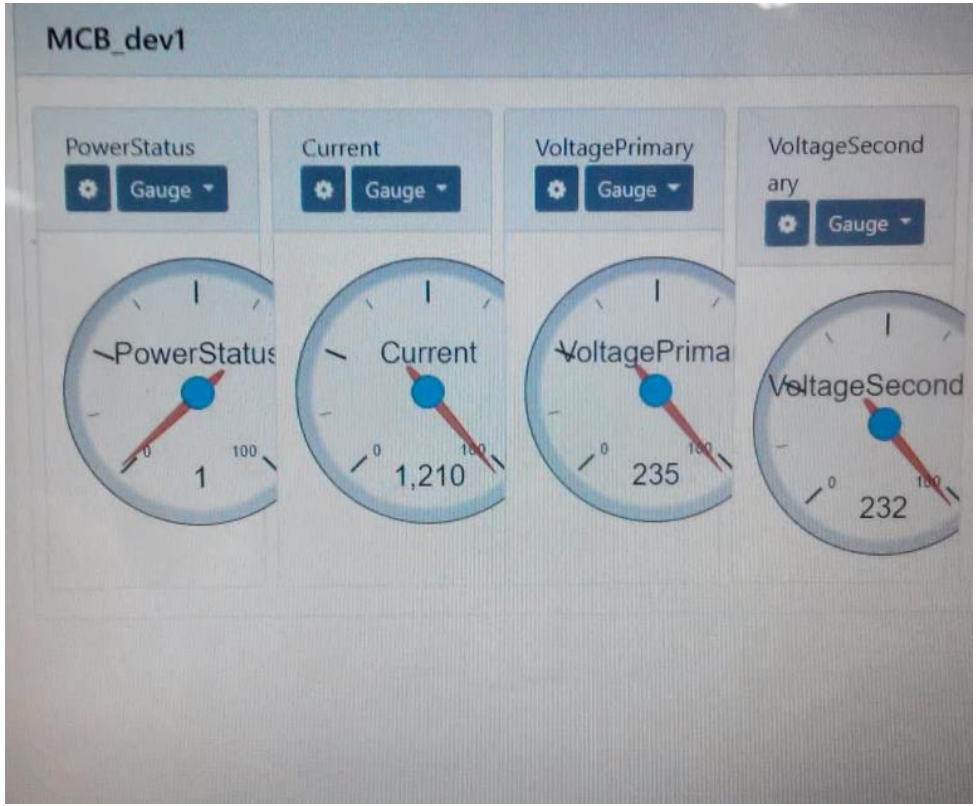
Dashboard (Power OK - Normal State)



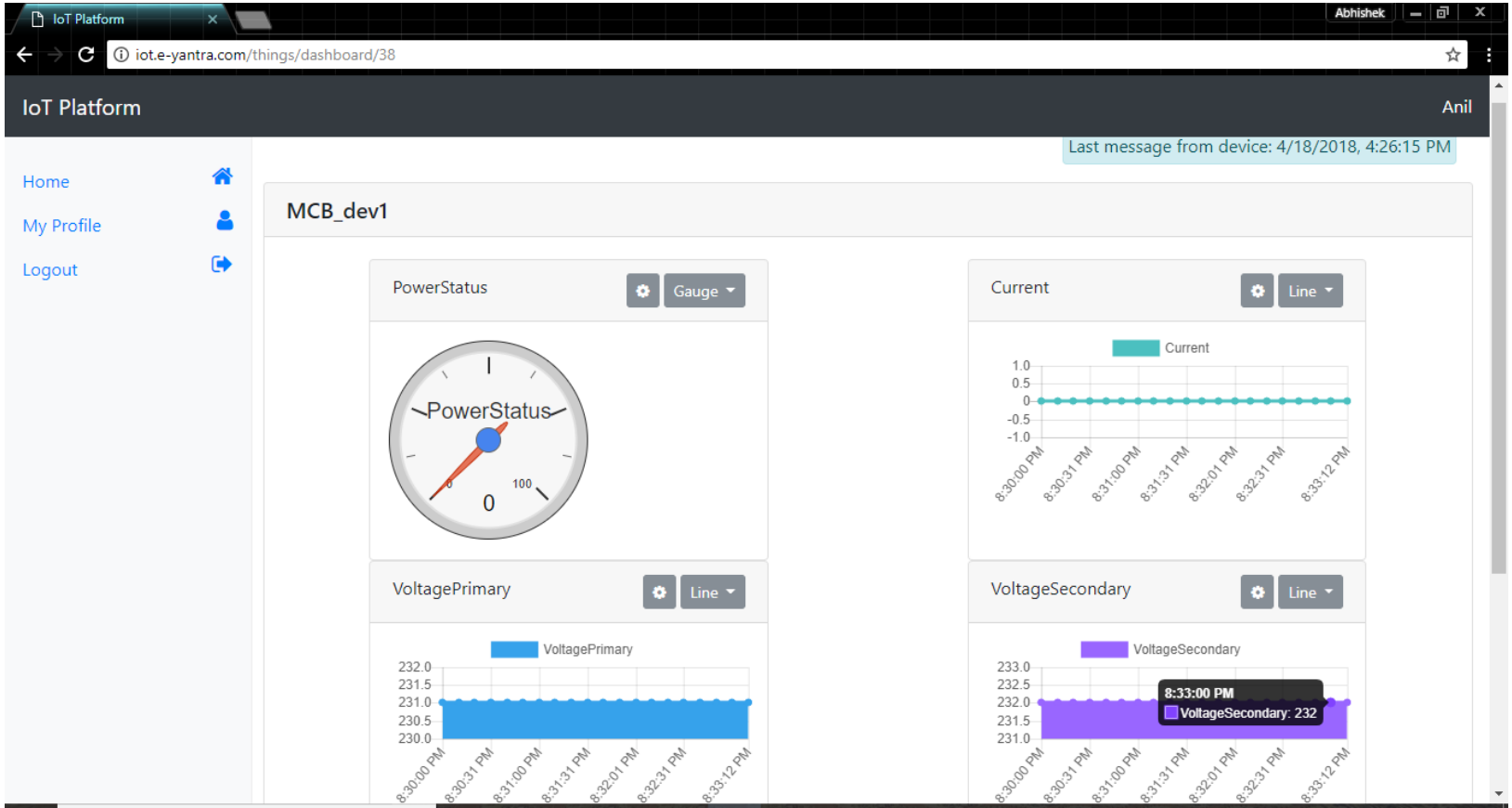
Dashboard (No Power State)



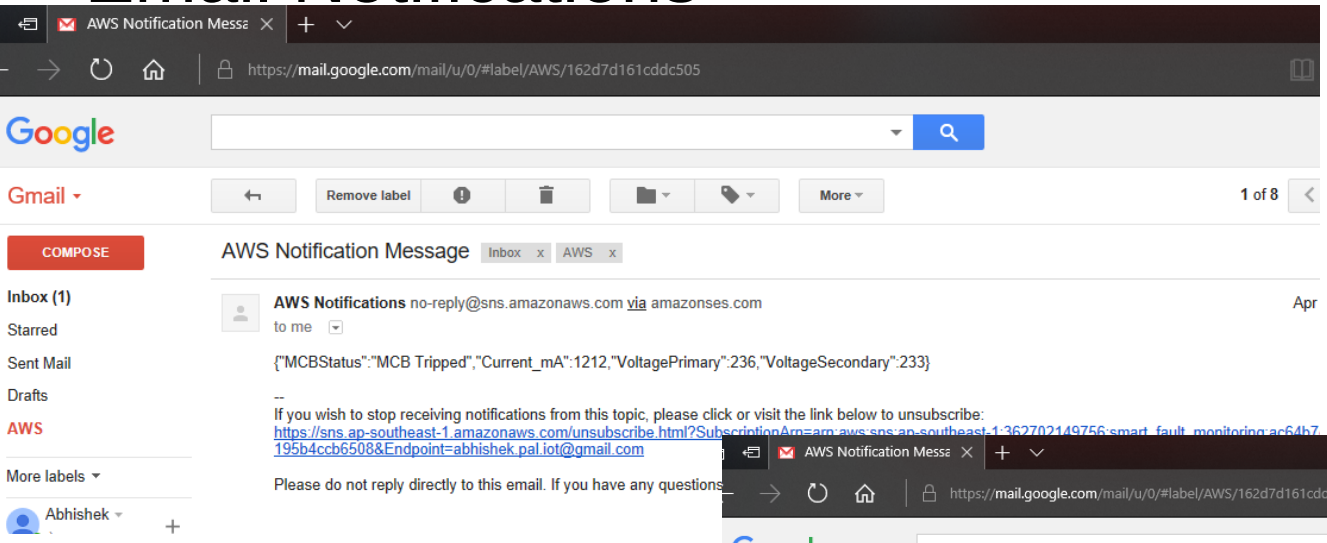
Dashboard (MCB Tripped State)



Alternate Dashboard (Time History – Normal State)

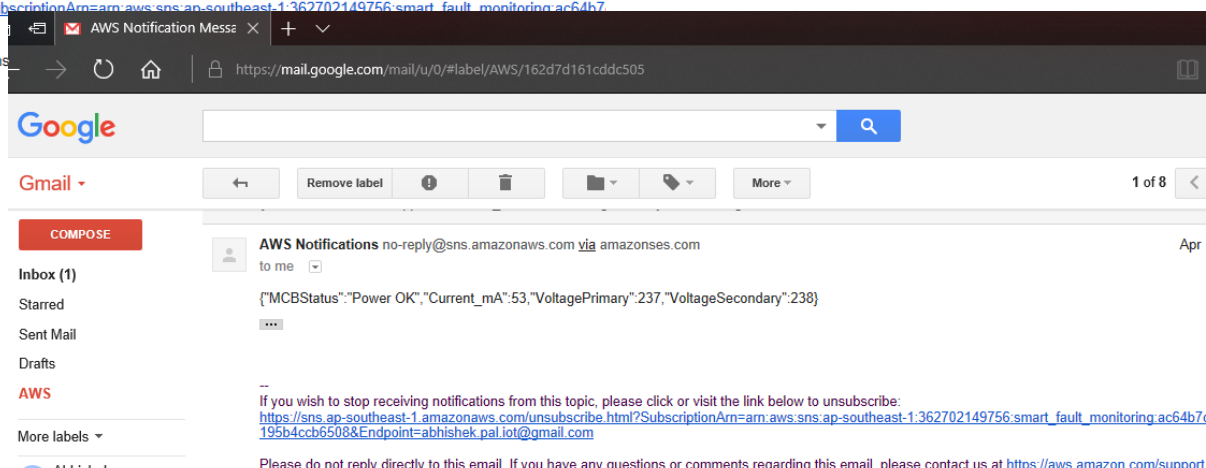


Email Notifications



MCB Tripped State

Power OK State



Timeline

Activity	Timeline (EDC)
Project Discussion & Finalisation	2nd Week – March'18
Component & Sensor Selection	3rd Week – March'18
Component & Sensor Ordering & Receipt	3rd- 4th Week – March'18
Component/Sensor Testing	4-5th Week – March'18
Coding & testing – Microcontroller (measurement & processing)	4-5th Week – March'18
Communication with microcontroller & IoT device	1st Week – April'18
Front-end development & communication with IoT	2nd Week – April'18
Integrated Testing	3rd Week – April'18
Final Presentation	18th April, 2018

Expected output & Status

- Real time data acquisitions of current and voltage : Done
- MCB contact monitoring : Trip or No trip : Done
- Data display on e-yantra IoT platform : Done
- Alert message to user : Done

Approach

- Real time data acquisitions of current and voltage :
  - Collected 16 samples/ cycle (20 millisecond time) and calculated RMS value
  - Buffered all samples of all channels for debugging purpose.
  - Calibration of all current and voltage channels.
  - Runtime DC offset removal logic from input AC signal
  - Latching data whenever fault occurs
- MCB contact monitoring :
  - Implemented logic to derive MCB tripped /power supply status

Approach..

- Data display on e-yantra IoT platform
  - Acquiring the skills for the IoT device programming (MOS/mJS)
  - Establishing internet communication of ESP8266 with e-yantra/AWS using MOS
  - Communication interface between ESP8266 and TIVA board
  - Massage frame formatting and parsing data into JSON string format.
  - Sending data from Tiva to ESP via UART.
- Alert message to user
  - E-yantra IoT platform (AWS SNS service)
  - Email notification

Issue Faced

- Synchronization issue of latched data with pre tripped input signal.
- Exploring options for programming the ESP (Arduino/Mongoose OS)
- String parsing in mJS & extracting the parameter values
- ESP UART0 is driven by USB & GPIO both. Only one can drive at a time.
- UART0 also used for system message logs. So ‘SetDispatcher’ API stops triggering, once ESP connects to WiFi. Otherwise in offline condition it was working
    - Resolution: Used polling method by a timer to read UART data & flush the UART buffer for next reception
- I2C in master mode tested, but had some issues of interrupt handling using Tiva as I2C slave.
- Some times IoT (e-yantra/AWS) server link was down (mostly in evening time). However it was restored later on.

Feature Enhancement

- Android application for easily accessibility
- Universal device for all rating of MCBs
- OTA (Remote firmware upgrade)
- Oscillography during tripping
- Data logging
- Higher precise power analyser for metering application
- Earth fault monitoring system

Thank You