**Smart meter**

Till now I have prepared the following modules of the meter:-

1. LCD driver, LED driver and User Interface library
2. ADC driver and metering library
3. Relay driver
4. Push button driver and logic
5. Timer libraries
6. Prepaid logic and accounting library
7. **LCD driver, LED driver and User Interface library:**

For the LCD of the meter I am using four seven segment displays because these are the most cheap I found till now. We can use other LCD’s but we will require some driver IC for them, which increase the cost. So for now I am using the seven segment displays. We can change that in future if we find some cheap/better option.

The current LCD can display positive/negative numbers and some characters also.

I am also using two LED’s for indication to toggle the information shown on the LCD.

The user-interface library uses LCD, LED and Push button to show the user different information available.

There are three modes available in the UI:-

1. Normal mode
2. Info mode
3. Error mode
4. **Normal mode:**

In this mode the UI continuously shows the balance (units up to 2 decimals. If a customer has purchased just 1 unit, then if he has consumed 0.15 units, then it should show the balance 0.85 units) available to the user and the power of the load connected (in watt) to the meter. It toggles b/w these two information each second.

1. **Info mode:**

This mode is activated when the user press the info button. In this mode the UI toggles b/w the following information each second:

1. Validity (Number of days ramaining)
2. Voltage
3. Current
4. Power (in watt)
5. Can we also measure total electricity consumed by the customer till date (in units)
6. **Error mode:**

This mode gets activated whenever there is some error e.g. Zero balance, Zero validity, Meter tampered.

In this mode the LCD continuously displays the Error code.

1. **ADC driver and metering library**

There is 10-bit ADC available in the Atmaga32 microcontroller. And there are 7 channels available. We can measure up to 7 parameters. I am using the ADC in single ended mode now. For future I want to use it in differential mode so we can measure DC also using the same meter. Right now I don’t know much about the filters to filter the measurable AC quantity. So for simplicity I am using Single ended mode with 5v reference. The Resolution of the ADC is 10-bits.

The sampling rate is 125 Khz.

**Voltage measurement:**

The maximum voltage the meter can measure is 500V AC, and the minimum measurable voltage is 0.48 V.

**Current measurement:**

For current measurement Current Transformer of 3000 turns is being used, with a burden resistance of 2Kohm. The maximum current we can measure using this is 5Amps (this is fine for the time being. Going ahead we should increase it to 10 Amp). We can Increase this limit by changing the burden resistor. But it will decrease the resolution.

The resolution of current measurement is 5 milliamps.

Peak Demand setting of the Meter: We should have an option to set a maximum demand for the customer as an option in the recharge software for the meter. While we create an account for the customer, then it should ask for the maximum demand setting as well. If we set the maximum demand for a customer lets say at 100 watt, then if the customer connects a load beyond 100 watt, then the meter should disconnect the load temporarily say for 15 mnts. We should have the option to increase the maximum demand limit. And we should be able to increase the limit of the meter sitting at head office it self if required by the customer. If customer is repeatedly trying to exceed the maximum demand limit allocated to him, then it should send an alert message to the head office and the plant operator.

**Metering Library:**

This library calculates the RMS values of the AC quantities, and then uses it to calculate the original values using the scale and offset values stored in EEPROM. The scale and offset will be calculated at the time of meter calibration.

To form an RMS 25 raw values are first averaged and form one average raw value.

25 of these averages are then used to calculate the RMS value.

1. **Relay driver:**

A 5 volt 100ohm relay is being used currently. To drive the relay we are using some transistor. The relay driver shuts the relay off when there is some error in the meter e.g. Zero balance, Zero validity etc.

1. **Push button driver and logic:**

The push button is used by the user interface library to active the info mode. The push button is used in active high configuration. It is interrupt based, i.e. some interrupt occurs when we press the button. More code needs to be written to take care of denouncing.

1. **Timer logic:**

Right now one of the timer counter register of the Atmega controller is used to maintain time. Whenever the timer overflows it triggers an interrupt. Timers tick is increased by one on each interrupt (what do you mean by this?). We need to add some backup battery to keep it running when no power to the meter is available, or we can use some RTC like DS1307. OK

1. **Prepaid logic and accounting library:**

The meter works on pay as you go model. There are following variables in the accounting library:

1. **Balance**: The meter shuts down when there is no balance left into it.
2. **Validity**: The meter shuts down when the validity expires. On a new recharge the balance left from previous recharge (unspent) is forwarded next. There would be a maximum limit to the accumulated carry forward unit. This limit we should be able to set/reset in the recharge software. For the time being the maximum carry forward units for the next recharge is kept as 4 units. Any unspent units beyond this limit shall be lapsed. If a person is doing a recharge prior to the due date, then his energy balance should be credited with the purchased units and his timer should be reset. We don’t need any fixed date as due date. It should go as no. of days from the date of recharge. If a customer has purchased 30 days validity, then it should switch off on completion of 30th date. If the customer is recharging on 29th date, then his timer should be reset after the recharge. So that his meter is not switched off on 30th. Time validity options could be 1 day, 7 days, 15 days, 30 days, 60 days, 3 months, 6 months, 1 year, 2 yrs, 3 yrs, 4 yrs & 5 years packages.
3. **Carry forward energy units**: This number of energy units is forwarded to next month.
4. **Recharge**: A recharge contains the following parameters:
   1. **Balance**: Number of energy credits (in no. of units) to be added to the meter.
   2. **Validity**: Validity of the recharge.
5. This feature could be a default feature, controllable at our end.**Recharge Agent**
   1. We would like to have a Recharge agent, to whom recharge services for few microgrids delegated to him as primary contact point for the customer. This agent shall have an overall energy balance limit within which he can provide recharge. Out of this balance only he provides recharges. He has to deposit cash in our bank account to secure his energy balance. Balance is credited to his account with a commission margin. For example. The agent deposits Rs. 2000 in our account. Then he gets a balance worth Rs. 2200 in his account assuming a 10% margin. This margin we should be able to adjust in the recharge software. He can provide recharges to customer till his balance is exhausted. Once exhausted or close to limits, when he deposits money, again his account is credited.
   2. Tariff logic: Various tariff logic depending on different class of customer would be part of recharge software. At present we are considering two class of customer: Residential & Commercial. There would be different prepaid tariff logics for different class of customer. In line with various schemes of full or partial talk time and validity as in case of prepaid mobile phones, we would have different tariff schemes for prepaid electricity.
   3. Control & Recharge option by Head Office: In addition to recharge agent, Head office shall have also option to recharge any customer after payment is received from customer. If there is any tampering, attempt to power theft or repeated attempt to exceed the allocated maximum demand, head office should get alert message on its computer and should be able to switch off the troubling customer sitting in head office (say from Lucknow) itself with an intimation to Plant operator and the recharge agent.
6. **Communication Links:**
   1. As the feedback is coming we should use free RF band without any confusion till the main meter at the mini-grid site in the village. From there onwards till the individual meters there could be use of PLC depending on ease of operation, maintenance issues and cost features. You can let me know the pro & the cons.
7. Enclosure and Metering Standards:
   1. We would like to house the meter in a water-proof and tamper-proof enclosure. Compliance to standards increases the cost, but we would try to maintain compliances to basic minimum standards including accuracy class etc.