SMARTIFY EXISTING E-METERS WITH POWER LINE COMMUNIAION

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Abstract—**World already shifted to smart gadgets as IoT put the giant leap towards automation. Smart appliances chatting with each other reducing human effort are altering the diagnosis to the global economy. But the gains of IoT still lasting as a luxury to mass people. India can take advantage of this booming Automatic Metering technology and smart energy meters to eliminate challenging power theft and metering expenses thereby elevating the bankrupted electricity boards to full fill the emerging energy demand. But these modern smart meters are big-ticket to the Indian economy and they offer a huge working cost. Here we are introducing the economical method to smartify our power grid by reusing existing metering and distributional means with higher efficiency than current smart e-meters.**

Keywords—PL PLC-Power line communication, AMR-Automatic meter reading, GSM- Global System for Mobile communication, FDM- Frequency Division Multiplexing, AFE-Analog front end, PT-potential transformer, CT-Current transformer, GPIO-general-purpose input and output, TOD-Time of day tariff, RTC-Realtime clock ,ABT-Availability based tariff.

I. INTRODUCTION (*HEADING 1*)

Global energy consumption grew by 2.3% in 2018, twice as fast as the average rate over the last ten years [1]. Electric loads are increasing exponentially due to the migration from expensive and insufficient fossil fuels to a single source of electricity. Energy demand will triple around 38,700 terawatt-hours by 2050[2]. As energy demand, power tariffs also began to grow. Spot power tariffs witnessed a sharp increase in September 2018 with the average rate on Indian Energy Exchange increasing to Rs 4.7 per unit from Rs 3.3 in August 2018. Domestic energy demand is rising because of the increasing electric appliances, air conditioners and further on the electric-vehicles. 'Energy monitoring of each appliance or department has become more unavoidable procedure for energy-saving strategies'. But available energy meters or even smart meters don't provide the individual device power monitoring feature.

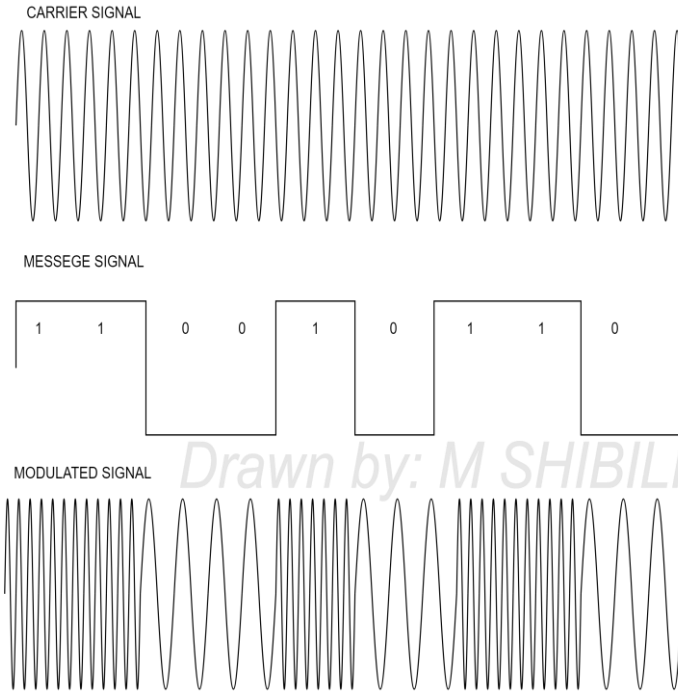
A. *Power theft in India*

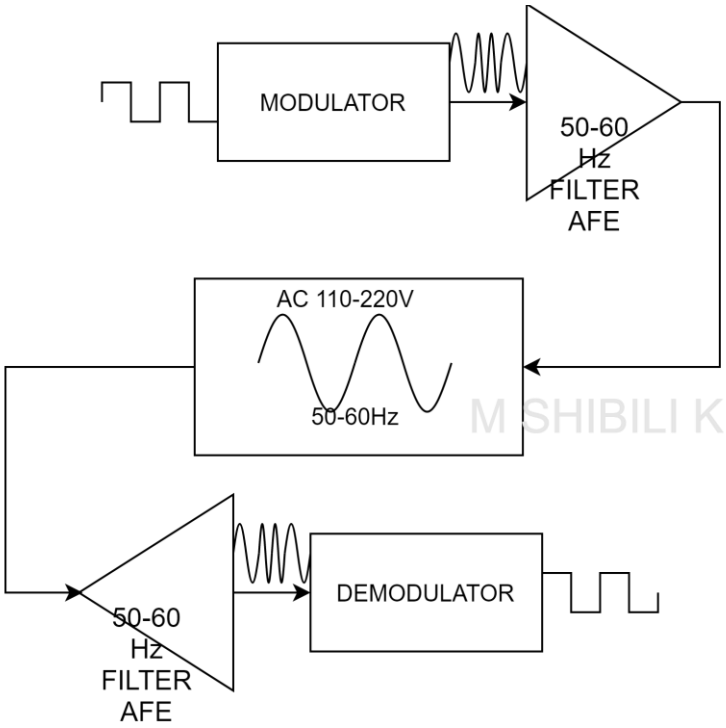
The rise in electricity tariffs will also lead to more illegal theft in power lines which is a great challenge to the nation. Currently, power theft reduces India's GDP by around 1.5%. Indian power sector loses around $16.2 billion to theft every year. Even Mumbai – alone loses $2.8 billion per year, more than all but eight countries in the world [3]. These illegal connections are hard to control since most of the power lines in India are not insulated and power line hooks up is difficult to locate in twisted lines of urban areas. In the current scenario, any subscriber can bypass his meter or hookup to the line and enjoy free energy. No one can track where the energy is being stolen. This advantage is well used by some selfish industries causing the depts of crores on state electricity boards.

B. *What is Power Line Communication?*

Powerline communication (PLC) is a technique in which existing electricity supply networks are re-used for communication. The primary benefit of PLC is the reduction of costs in the realization of new communication networks [4]. That is the AC electric power conductor is also used simultaneously for transmission of data. The existing public and private wirings can be efficiently reused to transmit data regarding power usage and device status. The power line media is free of cost than Narrow Band (single fixed radio frequency) GSM and less attenuated than wide Wi-Fi networks. Soon PLC will have more adaptation for applications like lighting applications (for traffic light control, LED dimming, etc.), industrial applications (for irrigation control, etc.), machine-to-machine applications (like for vending machines or a hotel's reception-to-room communication) [5].

The data transmission in the power line can be done various methods and protocols. The signal to be transmitted is modulated to FM analog signal. The digital one value is represented by the high-frequency components and the digital low value is converted to low-frequency components. Both frequencies are at the range of Kilo Hz (varying for protocols and methods from 10KHz to 130 kHz).





The frequency switching technique is also called FSK (Frequency shift keying) since the digital signal is transmitted through the discrete of the carrier signal. The frequency changed modulated signal then coupled with the AC power line via 'High pass filters' which reject the low frequency 50Hz AC signal and make the wire available for the transmission of data. When multiple devices are interconnected in the PLC network, we use the multiplexing technic called FDM. FDM (Frequency Division Multiplexing) is an encoding method of digital data on multiple carrier frequencies. This method allows simultaneous data transfer on the available frequency range. FDM assigns frequency divisions for each device to enable multiplexing.

Digital data consist of start code, letter code, and number code. The start code will poke the receiver and make it ready to read the data. The letter code consist of transmitting device address and number code enclose the data. Further for more application parameters, the data sequence can be extended. Here we use the following data sequence for efficient AMR and power theft detection.

- Start Code = 4 bits
- House code = 4 bits
- Extended code 1 = 5 bits (01111)
- Unit code (device code) = 4 bits
- Data = 8 bits
- Command = 8 bits

From right to left, data to be transmitted are first modulated (digital bits are converted to analog frequency/sine wave e.g. bit 1 is converted to a sine wave of 20Khz bit 0 is converted to the sine wave of 10Khz). To "clear" the Mains frequency and make the wire available for the transmission of data the 50/60Hz signal is filtered. This filter clears any signal of 50Hz to 60Hz. The transmitted data then are free to travel over the Mains. When they find their destination another 50 to 60Hz filter is involved. After the filter pass, the remaining signal is the modulated transmitted data. This signal is then demodulated and converted to digital bits at the receiver side.

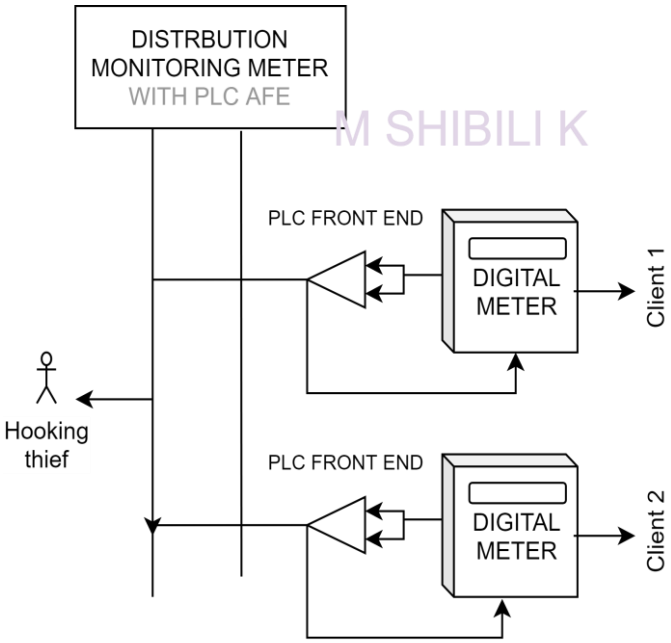
Advantages of power line communication

- **Low Implementation Cost**: It is the major advantage PLC, it does not require any installation of new wires which as a result, would significantly reduce the deployment costs.
- **Large Reach:** It delivers data where ever the power reaches. PLC can access communication with hard to reach nodes where the RF wireless signal suffers from high levels of attenuation like in the concrete buildings or underground structures, or places like hospitals where the wireless signal is undesirable due to the EMI issues.
- **Lower Running Cost:** PLC provides a low-cost solution compared to the other existing technologies such as Wi-Fi or Narrow Band (single fixed radio frequency) GSM.

C. How Power line communication solves the problem?

As mentioned above, power theft is one of the major challenges faced by the Indian economy and it restricts national growth. As per reports, 35% of the total

produced electricity is lost by theft and transmission losses [6]. That is around one by third of energy production is theft through illegal connections. To eliminate the huge loss PLC can be used efficiently without changing the existing meters. Just coupling with the power line and syncing communication with the meter, the device can establish a cost-effective AMR solution. This plug and play PLC EXTENSION CARD can detect the power theft in the line as follows,



- *Distribution monitoring meter*

This is the theft and loss monitoring meter that is fixed on the distribution transformer which acts as PLC receiver for the meter readings as well as the command provider for the PLC clients. It receives the client meter reading values at a particular interval of time. The summation of these values is compared with the total distributed power. If the power theft event has occurred it will send alert to the distribution controller.

The main parts of the distribution transformer are

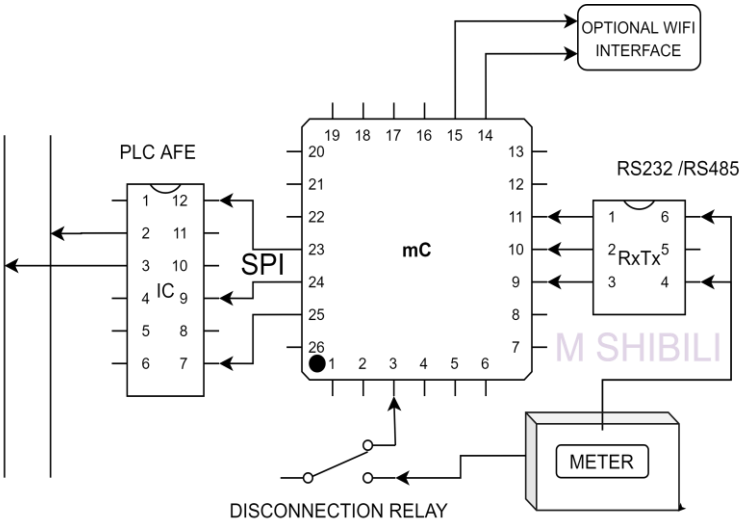
1. Main microcontroller (distribution power metrology, Data analysis and theft detection, controlling PLC)
2. Current transformer front end
3. Voltage front end
4. PLC Front end (Texas instruments AFE 032 or Microchip PL360 or any other low-cost PLC solution)
5. Power supply (cap drop supply to ensure anti-tampering)

- *PLC meter extension card*

As mentioned before this extension equipment installed to the current digital energy meters are responsible for the low-cost AMR solution. It communicates with the digital meter via meter inbuild communication ports. Most of the existing meters have either RS232 or RS485 communication ports and some 3 phase meters have optical ports to communicate with PC. We use RS484 or RS232 communication ports to interface to the main microcontroller of the Meter extension card. In current digital meters, a lot of parameters are measured and saved to the corresponding time. These are some of the parameters measured in common digital meters.

Meter sl.no, Real date and time, instantaneous phase voltages, instantaneous phase currents, frequency, cumulative active power, cumulative reactive power, power-on time, maximum demand in KVA, PT tampering, CT tampering, etc.

These measured quantities read via meter port are analyzed by the main microcontroller and the cumulative values transmitted to distribution monitoring end at a programmed period. PLC front end can be minimized by using the fully integrated front ends available in the market (e.g. PL360 by Microchip and AFE 032 and 031 by Texas instruments). Microcontrollers preferred to have ultra-low energy consumption (such as TI MSP series), the least number of GPIO pins, inbuild simple link capabilities to connect Wi-Fi. Communication chips are preferred by criteria such as size and prize. The high current relay included in the board connected to microcontroller GPIO will be useful in remote disconnection of the subscriber in case of bill pay fails and overloading the transformer by using current above limits.



- *Advantages installation of the proposed extension card*

I. Automated meter reading.
II. Power theft detection

III. Optional Wi-Fi-based usage analysis. (Analyze the energy consumption data from the HTML page created by the microcontroller by connecting your smartphone to the Wi-Fi network).

IV. Remote subscription disconnection in the case of

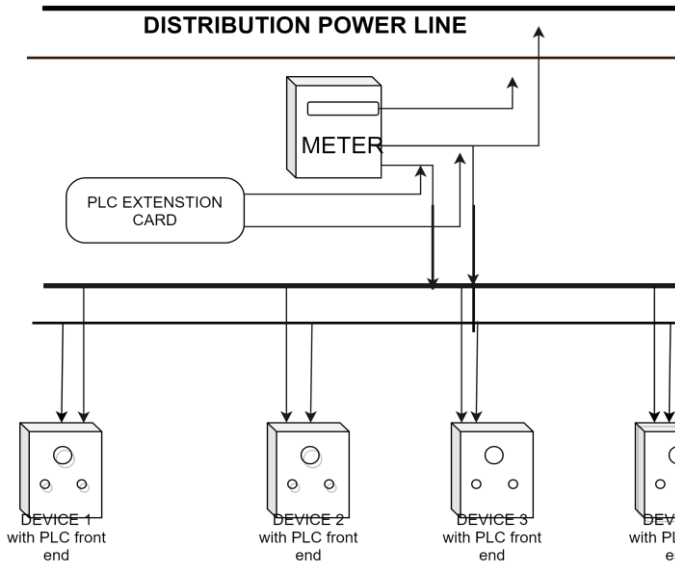
a. Bill payment failure

b. Over-loading of the transformer by using more than rated current.

V. By installing PLC extension card to smartify the energy meter, the subscriber has free access to automate his home and also measure individual device power consumption.

D. How to automate and measure consumption of devices with the installed PLC extension.

The PLC Extension card not only able to communicate with the external power line, but it also coupled with the internal power distribution of house or building. This enables the subscriber to access the PLC to automate the building. By configuring the PLC extension card the subscriber can make communicate with domestic/industrial devices. PLC module plugged into power line can communicate with the meter and thereby this method enables free medium to automate the devices or compartments. this method enables free medium to automate the devices or compartments.



Automation PLC protocol differs from the communication protocol between monitoring meter. Here we prefer the X10 protocol that works very differently than FDM external communication. The device end consists of the microcontroller and PLC AFE. The GPIOs of a microcontroller cheap microcontroller is enough to control the equipment of a large compartment of home or industries. For individual device power monitoring we use CTs on the equipment phase line. The ratio of CT can be preferred by the current drawn by the equipment. Usually CTs with ratio 1000:1 or 2000:1 are commercially available at an economical price.

Advantages of PLC Extension card automation

1. Cheapest and simple automation affordable by mass people.
2. Reuses the existing wirings and no reconstruction of power distribution is needed such as in existing automation techniques.
3. Maintenace, working, installation very costs are less comparatively.
4. It enables optional individual power measurement and analysis by introducing CTs. This feature is extremely helpful in industrial and domestical power management strategies.

E. Why not smart meters?

1) Current digitals meters have 10 to15 years of expectancy and they have many modern features and parameters. Such as,

a. *TOD Tariff assigning*: Day is divided into three categories and the tariff is fixed in such manner that increase in off-peak periods.

b. *RTC based reading and data storing*.

c. *ABT*: Availability based tariff for demand-based billing.

2) We have to dump the current modern digital meters to install new smart meters causing large amount of E-Waste and financial loss.

3) smart meter are very costly and become a necessary.

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