Smart Meter Circuit Electronic Design & Block Diagram

The block diagram of a smart electricity meter can be used to understand their operation and the challenges of their electronic circuit design.

Smart Meters Includes:
Smart meter technology Circuit design

Smart energy meters are being used by many utility companies to reduce the ecological impact of energy usage. Not only do they enable users to see how their energy is being used, but they also provide vital data to utility companies to organise the "Smart Grid" system that is being evolved.

The old style meters have been in use for many years and are extremely accurate and very reliable over long periods of time. However the new smart meters need to be able to provide the same levels of accuracy and long term reliability, while also providing the additional capabilities.

These requirements place many stringent requirements onto the electronic circuit design of the smart meters as they need to perform accurately and also be able to withstand the rigours of the transients they may be exposed to as well as temperature variations.

In addition to this the smart meter electronic circuit design must ensure that the unit is easy to set up, and it reliably communicates with the smart energy monitor or "In-House Display" IHD as well as the utility company communications network.

Smart meter basic block diagram & operation

There are several elements to the block diagram of a smart meter in terms of its functionality. In addition to this a low power power supply is also included and this has a number of special requirements to ensure the successful operation of the whole smart meter.

Basic block diagram of a smart energy meter for electricity consumption

As can be seen from the block diagram, there are several elements to the overall block diagram of the smart meter which need to be considered for the electronic circuit design.

- ***Power supply:*** This section of the smart meter powers the circuitry for the meter and also provides battery back-up as well as protection against transients etc.
- ***Measurement capability:*** This section of the smart energy meter block diagram addresses the basic measurement of the utility that is used. It requires to be

reliable and accurate. It will typically output the data in a digital format and will therefore include a analogue to digital converter.

- ***Processing:*** Any meter like this will require manipulation of the data. It needs to be formatted to send via the communications links as well as displaying on the smart meter itself.
- ***Communications:*** The smart meter needs to communicate the information back to the utility supplier for billing and management of their smart grid. It also needs to provide information tot he user on a smart energy monitor or In-Home Display, IHD. A variety of different communications methods can be used for this including cellular communications, power-line communications, Zigbee, etc.

The different areas of the circuit block diagram have separate functions and often very different forms of electronic circuit.

Power supply

The power supply section for the smart energy meter has some interesting and challenging design constraints.

The power supply technology will use a switched mode technique. This ensures the highest level of efficiency and reduces the current drain caused by the smart meters - an important feature when many millions of them are to be used.

The switch mode power supply, SMPS will take in the line alternating current signal and convert this to the required DC voltage or voltages required to drive all the meter functions. Typically this will be 5volts or below.

The SMPS will also be used to ensure the battery backup is fully charged if a rechargeable battery is used for this purpose. It will also include an electronic switch to change over to the battery backup should the line AC be interrupted for any reason.

The other main function within the power supply region of the meter is to protect the circuitry from any line transients that may appear. Note it will not be used to protect any equipment outside the meter, such as the equipment for which the consumption is being monitored by the smart meter.

The transient protection is typically provided by a combination of an input inductor and varistors - electronic components which absorb transients above a certain voltage. Metal oxide varistors are widely used for this.

In addition to this the input inductor as well as a high voltage differential filter are needed to give good EMC performance. Not only is it necessary for any interference that might be created by the smart meter to be removed before it reaches the power line, but it is also necessary to ensure that the meter operation is not affected by any interference that may appear on the power line.

Sensing & measurement

The sensing and measurement circuitry needs to be particularly accurate for a smart meter. They need to be able to provide the same levels of accuracy as the previous generation manual meters . . if not better.

The accuracy relies on revenue grade measurement components.

The resistors used for current sampling and the scaling resistors for voltage measurements must have a very tight tolerance with a low temperature coefficient so that the measurements remain accurate over a wide temperature range.

Any analogue data must be converted into a digital format, and of course an analogue to digital converter is required for this.

Processing and control

Typically the system will use a microcontroller to provide the processing for formatting the data, processing it, and converting it into the required formats needed for the interfaces.

Even though the data is primarily required to be transmitted, smart meters also have their own display for local readings in case this is required. The display is normally a low current LCD, even though these displays do not work well below 0°C and ultimately stop working if it becomes too cold.

The processor also needs to manage the sending and receiving of data and commands over the various wireless communications interfaces.

Typically these interfaces will include the long distance wireless communications tot he utility provider, and a must shorter distance wireless communications link to the smart energy monitor or In-House Display provided to the consumer.

Typically a microcontroller is used in this application as the processing needs for the smart meter can normally be accommodated by a controller rather than a microprocessor, and the current consumption is typically less, as well as it allowing for a smaller footprint..

Wireless communications interfaces

There are many different wireless communications interfaces that are used for the links to the utility provider and the smart energy monitor in the users premises.

There are many different wireless communications interfaces that are used. These include:

- Broadband over Power Line (BPL)
- Mobile communications or cellular communications. 2G GSM is still widely sued and with GPRS it provides a low cost and reliable access method. 3G is less well used and in fact 3G is being withdrawn earlier than even 2G in many countries so there is even less incentive to use it. Of course 4G and now 5G are also options.

- RF mesh networks including systems such as Zigbee provide a good option for local communications whereas systems like LoRa or SigFox are options for longer range wireless communications.

Whatever the wireless communications system that is chosen, consideration must be given to the overall system communications requirements.

Smart meters are now widely used and have been in use for many years. Their design is always evolving as requirements change, new wireless communications options and other new technologies are deployed.

It is absolutely essential to ensure that whatever is designed into the smart meters and then deployed will be able to operate for many years to come. Some of the old meters have been in service for ten, fifteen, twenty or more years and operate well. As costs for renewal can be high, it is essential to ensure that any smart meter is reliable, accurate and the technologies used are supported for many years to come.

PREVIOUS PAGE NEXT PAGE

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