Power Electronics and Battery Technology for Interfacing with Solar Energy

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DC, and AC, and Solar power

- DC – Constant current and voltage, such as the output from a car battery
- AC – Alternating current and voltage, such as power grid at 220 V, changing direction 100 times per second. Most Domestic and Industrial appliances run on AC.
- Solar power is DC, that varies according to availability of sunlight, time of day, etc.

Domestic and Industrial Equipment

- **Lighting** – Lighting mostly required when sun is down, and must run on stored energy, or power grid. Incandescent bulbs consume much power, but run on DC. Diodes especially well adapted to DC voltage and low power.
- **Electronic equipment** – Basically all electronics run on DC of various voltages. Examples – mobile phone, stereo system, etc. However, larger electronics such as TV may be designed specifically for AC.
- **Fans and Industrial motors** – particularly well adapted to AC, as DC motors require commutators, which cause sparking and must be replaced periodically. Main advantage of DC motor is speed control

Power Electronics and Interfacing of AC, DC, Grid, Battery, Solar Power

- Conditioning of power so as to interface between the various sources above falls within Power Electronics branch of Electrical Engineering.
- Four basic types of power converters: AC-DC converters (rectifiers), DC-AC converters (inverters), DC-DC converters, and AC-AC converters.
- Power electronics – ~ 25 year old field, that was made possible by silicon based high power devices such as diodes, transistors, Silicon Controlled Rectifiers (SCR), Metal Oxide Semiconductor Field Effect Transistors (MOSFET), Insulated Gate Bipolar Transistor (IGBT)

Rectifiers, AC - DC

- for converting AC line voltage to DC voltage of desired value for most electronics, and for battery storage.
- Transformer for step-down, 4 diodes for full-bridge rectification, and capacitor at output for filtering and smoothing output.
- Simple in construction, taught and made in second year lab class

Inverter, DC - AC

- Required for interfacing Solar power or battery power with Power grid, and most electrical appliances.
- More complicated than rectifier because controller (usually Integrated Circuit (IC)) required for controlling gates of device (MOSFET).
- AC can be stepped up to desired line voltage using transformer.
- Minor drawback of sending power into power grid, is injecting harmonics into the power grid.

DC – DC Converters

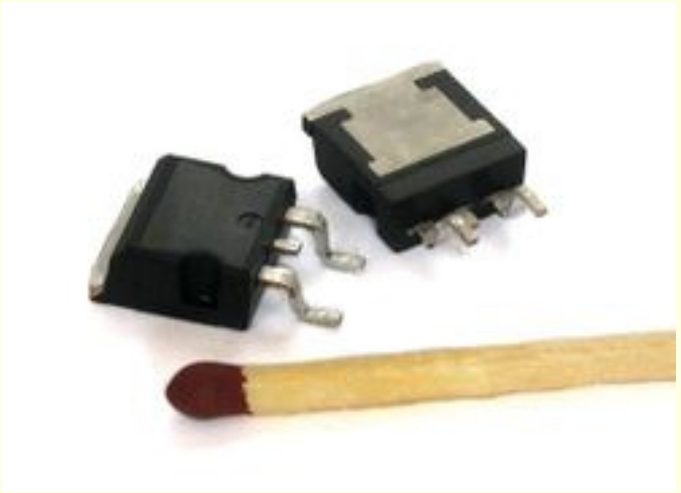
- Like DC – AC converter, requires controller, usually microprocessor.
- Important for project, as solar panel output voltage has variable voltage, but battery charging voltage, and appliance voltage needs to be constant DC.

Semiconductor Devices

- MOSFET device of choice for low voltages, such as up to 20 V. Transistor-transistor logic needs to interface with slightly higher voltage before driving gate of device
- IGBT device of choice for higher voltages, such as up to line voltage of 220 V. Driving voltage is still relatively low (~ 20 V).

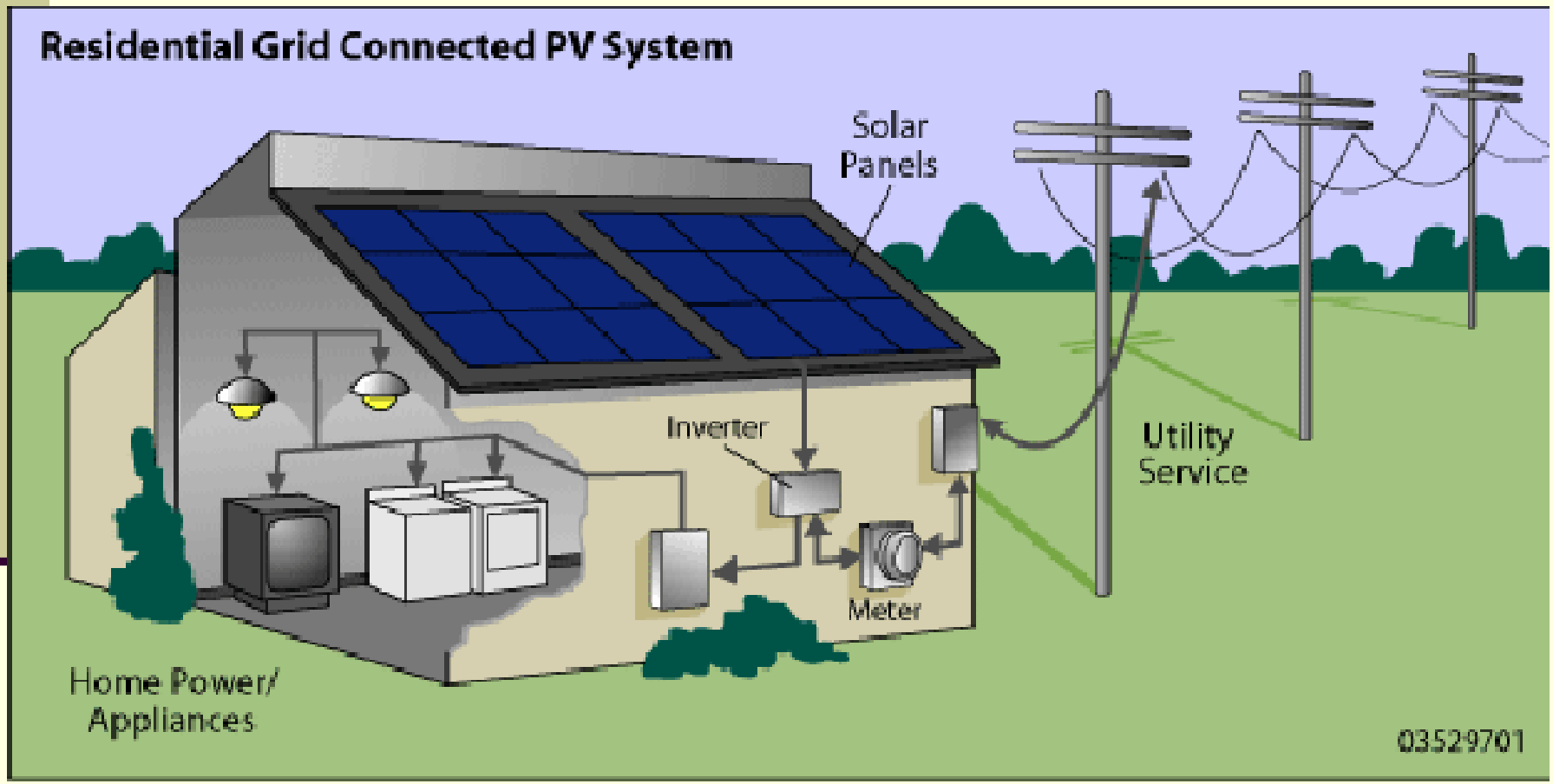
Practical Semiconductor Devices

- A power IGBT



- Two power MOSFETs in the surface-mount package D2PAK. Each of these components can sustain a blocking voltage of 30 volts and a continuous current of 120 amperes.

Solar panel with Appliances and Power Grid



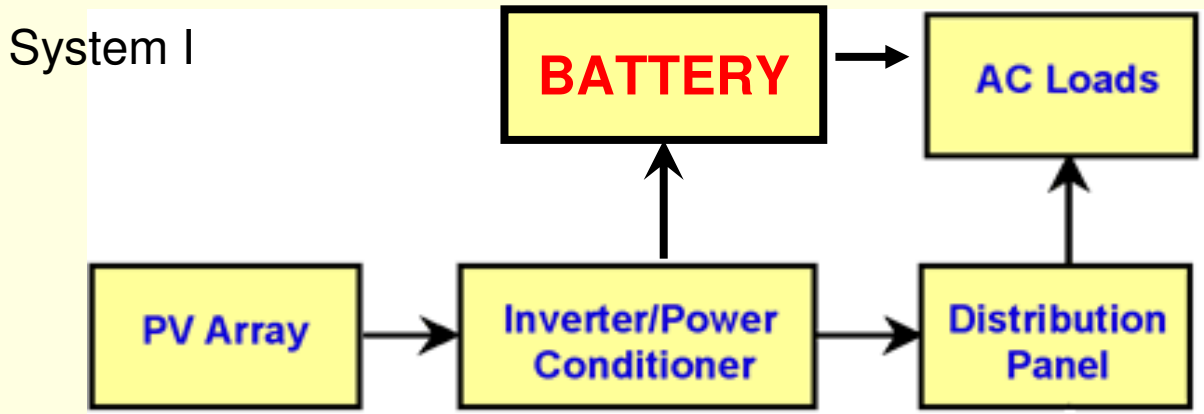
Battery Technology

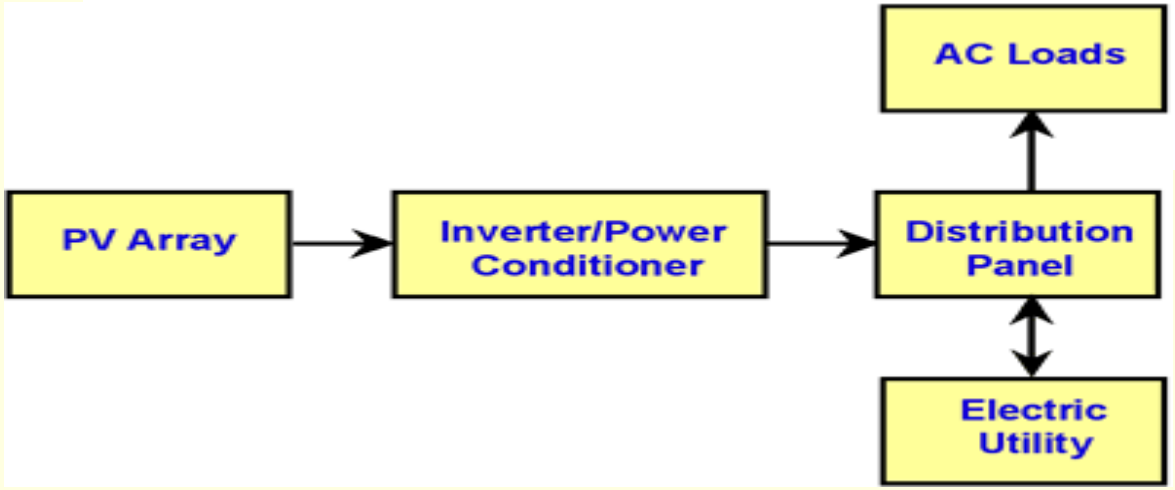
- Battery storage of solar energy is needed as the availability of sunlight is time-varying and may not match time-varying needs of consumers.
- Lighting requires battery storage, as it is needed at night, whereas sunlight is available during day.
- The widely used lead-acid battery is still the best and most inexpensive technology for storing solar energy.

Battery Technology (cont.)

- The problem with the lead-acid cell is its heavy weight, and the limited-life as is characteristic of all batteries.
- For domestic or industrial users, batteries are barely economically viable.
- The need for expensive battery storage is commercially bypassed in the European Union, by buying solar power from domestic users at the rate of 0.40 Euros per KWhr.

System I





System II

IPS/UPS Technology in Bangladesh

- “Instant Power Supply” or IPS/UPS widely manufactured in Bangladesh by SMEs.
- Bangladeshi IPS/UPS technology can be easily modified, so as to be compatible with solar panels.
- Variable voltage of solar panels should go through DC-DC converter to interface with constant voltage battery and constant voltage requirements of appliances and grid.

DC – DC converter - example

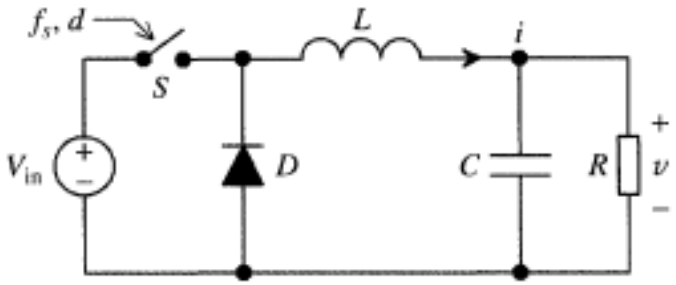


Figure 1.1 The open-loop buck dc/dc converter.

Conclusion

- It is only a question of time – perhaps a few years – before Solar Energy becomes widely viable
- The power electronics and storage issues must be addressed alongside the solar energy itself.
- A minor addition (DC-DC converter) may allow adding solar panels to IPS/UPS technology of Bangladesh