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K S R Institute for Engineering and Technology

Department of Electrical and Electronics Engineering

Department of EEE

BEES

Together We make the Difference

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Li-Fi

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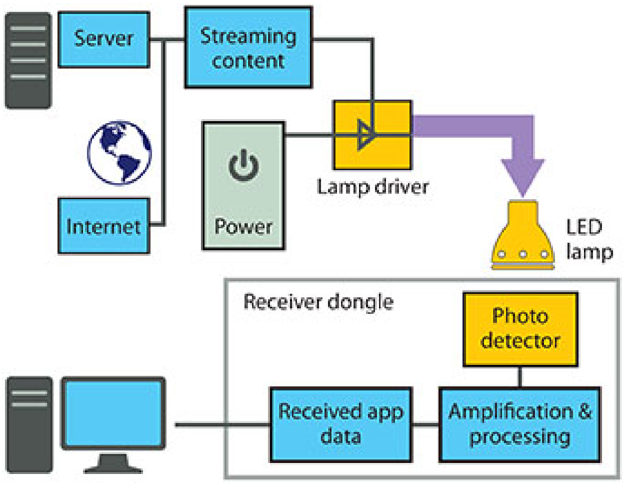
Introduction

Light fidelity, or 'Li-Fi' as coined by inventor Professor Harald Haas, is a wireless communications technology that transmits high-speed data via common household light emitting diodes (LEDs).

Data is streamed via an LED lamp with signal-processing technology As LEDs are semi-conductor light sources, the current of electricity can be brightened and dimmed at ultra-high speeds. Therefore they can be switched on and off faster than the naked eye can detect, making the light source appear to be on continuously. While to us these changes in amplitude go unnoticed, they can in fact enable the transmission of data at rapid speeds.



Data is fed into an LED lightbulb embedded with a microchip with signal processing technology. When the data is streamed, the changes in amplitude causing the LED to turn on and off allow the data to be transmitted in binary code. A photodiode detects the light stream and transforms the amplitude fluctuations into an electric current.
The electrical signals are then converted back into a data stream and transmitted to a computer or mobile device, where a binary data stream runs web, video and audio applications.

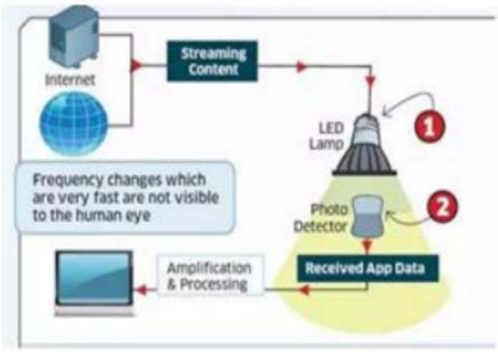
Li-Fi has almost no limitations on capacity as the visible light spectrum is 10,000 times larger than the entire radio frequency spectrum used by Wi-Fi. Li-Fi is also less susceptible to interference, as visible light cannot pass through walls.

Future Scope of Li-Fi

The Li-Fi technology can be used for various purposes, it matters the data transmission through LEDs thus all the screens which illuminate light can be served as a platform for data communication. The screen of the mobile phone, television, bulbs can act as a source of light. On the other hand, the receiving platform, the photo detector can be replaced by a camera in mobile phone for scanning and retrieving data. Its other applications are Li-fi for desktops, smartcard Li-fi, Li-fi for schools, hospitals, Li-fi in cities, smart guides, museums, hotels, fairgrounds, events indoor and LBS(Location-based Services), access control and identification crisis, malls, airport and dangerous environments like thermal power plants. It also has the advantage of being useful in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear power plants without causing electromagnetic interference.

Working of Li-Fi

The functioning of new Li-Fi technology is just simple. You will have a light source at one end like a LED and a photo detector (Light Sensor) on the other end.



As soon as, LED starts glowing, photo detector or light sensor on other end will detect light and get a binary 1 otherwise binary 0. As we know that any data can be transmit or received in terms of digital signal (0 or 1).Then we can convert the data into 0 and 1 after that it can be transmitted received by the Li-Fi Technology easily. Data transmission rate can be depends upon the intensity of the light of the LED used in the system or intensity of light depends upon the power of the electric voltage. It also depends upon the frequency of the input or output signal.

Li-Fi might be used to extend wireless networks throughout the home, workplace, and in commercial areas. Li-Fi is restricted by line of sight, so it won't ever replace Wi-Fi, but it could augment it nicely. Instead of trying to find the perfect sweet spot for your home's Wi-Fi router, it would be much simpler if every light in your house simply acted as a wireless network bridge. While Li-Fi is still in its early stages, the technology could provide an alternative to using radio waves for wireless Internet access. Currently, household Wi-Fi routers and mobile telecommunication towers depend on radio signals to send data wirelessly. But the amount of radio spectrum is limited.

How Li-Fi is different from 0thers

Li-Fi technology is based on LEDs for the transfer of data. The transfer of the data can be with the help of all kinds of light, no matter the part of the spectrum that they belong. That is, the light can belong to the invisible, ultraviolet or the visible part of the spectrum.[5]And also Li-Fi not uses the the RF bandwidth then problems related to bandwidth are not present. As we know that the VLC has a great advantage as compare to other technologies for communication like in terms of speed and security. Then Li -Fi is also differ from other technologies .Noise and interference of other radio waves are also not present then it's provides better quality.

Limitations

- Wherever there is unavailability of light, li-fi cannot work. Also, it cannot work if it's raining.
- Visible light waves cannot penetrate walls.
- It cannot be used for long distance transmission.
- Due to sunlight and other sources of light, there can be variation in the desired results.

Conclusion

Li-Fi is an advanced approach on design, having the best design of internet by largely reducing the size of device which transfers data implementation- by means of having more than 1.4 million light bulbs all over the world if replaced by such LEDS can provide feasible access, and last but not the least enormous applications compared to any other networks in various fields which cannot be concocted by on use networks.

Wireless Electric Vehicles (EV) Charging Technology

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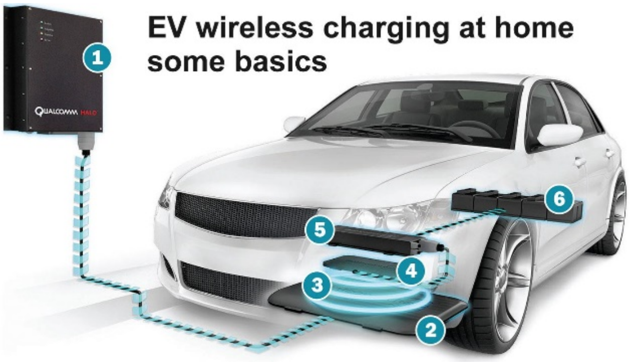
Introduction

Imagine charging an electric vehicle wirelessly in much the same way you can charge an electric toothbrush, shaver or some mobile phones. No more hassling with awkward plugs, seen by many as a major factor slowing the growth of EV sales.

Wireless charging for EVs is on the verge of initial deployment, starting with the Mercedes-Benz S500e plug-in hybrid next year. It is already being piloted by some community bus systems. Some EV experts believe it will supplant the plug-in chargers in use today.

The technology, which dates to inventors such as Michael Faraday in the 1830s and Nikola Tesla in the early 1900s, uses electromagnetic energy to transmit power between two coils. In wireless vehicle charging, the energy moves from a transmitter coil, encased in a pad that sits on pavement, to a receiver coil housed in a pad underneath a vehicle. On the distant horizon, motorists may be able to get a charge from coils embedded in roadways as they travel along.



1) Electric current flows from the wall unit into the primary charging pad.
2) The primary charging pad transmits the power via an electromagnetic field.
3) to the secondary charging pad
4) on the underside of the vehicle.
5) The power is then transferred via an on-board controller
6) to the battery

"Imagine wireless electric-vehicle charging being as easy and widespread as Wi-Fi is today," said Chris Borroni-Bird, former director of advanced technology vehicle concepts at General Motors and now vice president of strategic development for Qualcomm Technologies Inc., a company investing in wireless charging.

Other companies offering wireless charging include Momentum Dynamics Corp. in Malvern, Pa., outside Philadelphia; WiTricity Corp. in Watertown, Mass.; and Wireless Advanced Vehicle Electrification in Salt Lake City.

Luxury leads the way

Mercedes-Benz has said it will offer wireless charging in 2017 on the face-lifted S500e plug-in hybrid sedan. And BMW, working in partnership with Mercedes-Benz on the technology, is developing a wireless charging system for its i3 electric vehicle and i8 plug-in hybrid. A prototype test version, developed by Qualcomm, is already in use on the BMW i8 safety car in the Formula E electric-vehicle race series. Other carmakers are working to make the technology available, likely for the 2020 model year.

"Every carmaker, and I say that meaning *every* carmaker, has an active program at some stage of maturity to introduce vehicles with wireless charging," said David Schatz, vice president of sales and business development at WiTricity. "Other carmakers include Nissan, Honda, Toyota, Ford, just to name a few."

Even as carmakers invest millions to develop new EV models, EV market share remains stubbornly stuck in the single digits.

"Automakers know the key to increased EV sales is to improve the charging or fueling experience," said Andrew Daga, CEO of Momentum Dynamics. "They want to get inductive charging into the market as fast as possible."

Proponents say wireless charging will play a key role in autonomous vehicles as urban transportation infrastructures become connected and smart.

"If you have autonomous vehicles you have to be looking at this," said Tony Posawatz, former vehicle line director for the Chevrolet Volt and now a consultant to a number of automotive and technology companies. "You can't have a bunch of autonomous vehicles with guys waiting for cords.

That's because, disconnected from plugs and wires, charging will become "opportunistic." Instead of having to get out and plug in, EV drivers will be able to top up mileage as they go about their daily business by parking over electromagnetic charging pads either on the pavement or embedded in it.

Charging pads are likely to appear first in home garages, much the same as plug-in charging stations did. They'll pair with a wall unit, such as BMW's i Wallbox prototype, and a cord that runs to the primary pad on the floor.

"Home units will be priced on par with plug-in charging equipment," Daga said. "If you're going to buy a home charger that's inductive, you're going to be paying less than $1,500 for an 11-kilowatt charger." Such a charger would be capable of charging a Nissan Leaf to 80 percent in 30 minutes and a full charge in two hours.

A company called EVAtran already offers aftermarket wireless charging units for the first-generation Chevrolet Volt ($1,260), Nissan Leaf ($1,540) and Cadillac ELR ($1,940). Kits for the second-generation Volt and Tesla Model S are on the way. The EVAtran website says the adapter kits do not void the vehicle's warranty.

Experts predict more powerful wireless stations later will appear at office buildings, shopping centers and restaurants, enabling EVs to quickly top up. But pricing will be key, says Lisa Jerram, an analyst at Navigant Research.

Wireless vs. wired

There's also a debate about whether wireless charging is as efficient as wired charging. Chuck Caisley, vice president of marketing and public affairs for KCP&L, says the new technology needs to mature. Kansas City Power & Light Co., a regional electric utility, believes there's plenty of life left in plug-in networks. KCP&L has been one of the most aggressive utilities in the country in installing an EV charging network, building more than 1,000 plug-in stations.

"It's more expensive to put into a car," he said of wireless charging. "It is not as efficient as plug-in charging." He said some models arriving in 2018 that will offer a wireless charging option will also be equipped with a plug-in connector.

But consultant Posawatz says wireless can be just as fast and efficient, providing the technology is correctly aligned.

Wireless charging is gaining some acceptance among urban bus authorities around the country. By permitting short-haul buses to top up with power frequently, the bus companies are saving hundreds of thousands of dollars because they can use smaller batteries.

Initially, charging will be static, meaning a vehicle will have to be parked to charge up. But so-called dynamic charging, where moving vehicles can get a charge by driving over transmitter coils embedded in the roadway, is on the horizon, likely appearing first on buses or delivery trucks running on fixed routes.

The basic wireless charging system uses two coils. The primary coil, encased in a pad that sits on the floor of a garage or parking structure, is connected to a power source. Alternating current flows from an outlet into the coil, creating an electromagnetic field that enables the power to jump to a secondary coil in a pad attached to the bottom of the vehicle. When the vehicle parks in the proper position over the primary coil, an indicator light goes on and charging begins. The two coils must be within about 8 inches of each other for effective charging, according to Daga.

Plug-in charging has been an obstacle to electric-vehicle ownership for many consumers.

Said Qualcomm's Borroni-Bird: "Even for short trips, we find people with electric vehicles just park the car for half an hour and often don't bother plugging in. If you do that several times, the battery drains significantly."

Plug-in stations also can be easily damaged in crowded cities. A number of municipalities have reported thieves have cut EV charging cables to steal the copper from the wires. High-powered Level 3 stations, also called DC fast-charge, have large cables, which make them even more attractive to thieves.

"Copper theft of charging stations has increased, and the stations remain energized after the cables have been severed," which can pose a danger to the public, according to *PropertyCasualty360*, an insurance industry publication.

Said Daga: "With wireless, there is nothing to cut, nothing to break. You can hit it with a baseball bat and not break it. It is designed to be driven over by a heavy truck. The lifetime of our units for buses is 20 years."

With all its promise, wireless charging faces hurdles. It means adding another layer of infrastructure to an already complicated EV landscape. Prospective EV buyers worry that there aren't enough plug-in stations. Charging pads will be even scarcer, at least initially.

No standard yet

One major issue -- automakers, suppliers and wireless companies have not yet reached agreement on a compatible standard that would be "interoperable" everywhere. It's a problem that hobbled the rollout of plug-in charging.

Said WiTricity's Schatz: "If you're aware of wired charging history, you know that it was not so well done. They ended up with multiple connector standards depending on where you live."

Last year, engineering trade group SAE International issued a wireless charging standard called SAE TIR J2954. The standard is undergoing testing but has not been adopted. Daga, of Momentum Dynamics, believes the process could move faster if technology providers work directly with Tier 1 suppliers and automakers.

Posawatz says it's difficult to arrive at a standard before the technology gets tested in real-world conditions.

Buck-Boost Transformer

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Introduction

A buck-boost transformer is a type of transformer which is primarily used to adjust the voltage level applied to various electric equipment. Buck-boost transformers are utilized in in several applications such as uninterruptible power supplies (UPS) units for computers.

When an existing AC electrical circuit suffers from excessive voltage drop along the length of the conductors, a conventional transformer, given the correct primary and secondary voltage ratings, can be wired as an autotransformer to boost the sagging voltage. The polarities of the two series-connected windings would have to be configured in additive **polarity** to add the lower secondary winding voltage to the primary-winding / line voltage.

When the AC distribution voltage within a building or other structure is of higher voltage rating than the voltage rating of a unit of electrical utilization equipment, a conventional transformer, given the correct primary and secondary voltage ratings, can be wired as an autotransformer to buck the too-high system voltage. The polarities of the two series-connected windings would have to be configured in subtractive polarity to subtract the lower secondary winding voltage from the primary winding/line voltage.

Transformer Polarities (The Dots)

To understand what is meant by transformer polarities, you must consider the voltage produced across a winding by a single-phase 2-wire AC sine waveform at some point in time. When a building or other structure electrical-power distribution circuit operates at 60-Hz AC. The voltage as indicated in *Figure 1*, changes polarity a total of 120 times per second. **Transformer polarity** involves the relationship between the different windings at the same point in time. When investigating winding polarity, it is assumed that this point in time occurs when the peak positive voltage is being produced across both windings in question.

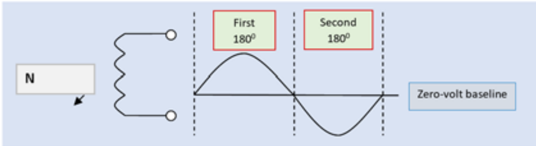

Figure 1. Generation of a single-phase 2-wire AC sine waveform electrical supply from a rotating magnetic field

On a wiring diagram (whether an electrical drawing or on the nameplate of a buck or boost transformer), it is common practice to indicate the polarity of the transformer windings by placing a **solid black dot** beside one end of each winding as shown in*Figure 2*. These dots (bullets) signify that the polarity is at the same point in time for each winding. Another way to describe winding polarity is to say the two winding-voltage waveforms are in phase. This same type of polarity notation is also used for transformers that have more than one primary or more than one secondary winding.

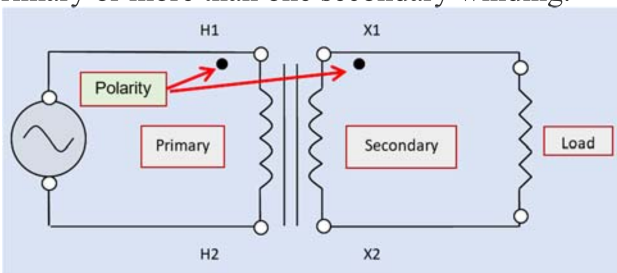

Figure 2. Diagram of the single-phase AC transformer circuits with dots indicating winding polarity

The windings of a conventional (isolating) transformer can be tested for the buck or boost wiring configuration by connecting the primary and secondary windings as an autotransformer as shown in *Figure 3*, and testing for either additive or subtractive polarity.

When additive-polarity connections are used to increase a too-low circuit voltage, the circuit is normally referred to as a boost configuration, because the secondary winding voltage is added to the line or supply voltage (to "boost" the primary winding voltage).

When subtractive-polarity connections are used to decrease a too-high circuit voltage, the circuit is normally referred to as a buck configuration, because the secondary winding voltage is subtracted from the line or supply voltage (to "buck" the primary winding voltage). Either boosting or bucking the supply voltage is accomplished by connecting one lead of the secondary winding to one lead of the primary winding and applying the voltage across both windings to the connected load.

The transformer shown in *Figure 3* has a primary voltage rating of 120 volts and a secondary voltage rating of 30 volts. Notice that neither the primary nor secondary windings are lead or polarity identified and that the secondary winding has been connected in series with the connected load. The transformer now contains only one winding and is, therefore, an autotransformer.

When the 120-volt supply is applied to the primary winding, the voltmeter connected across the load will indicate either the sum of the two winding voltages (boost configuration) or the difference between the two winding voltages (buck configuration). If the voltmeter readout is 150 volts, the primary and secondary windings are connected in additive polarity (120V + 30V = 150V). If the voltmeter readout is 90 volts, the primary and secondary windings are connected in subtractive polarity (120V – 30V = 90V).

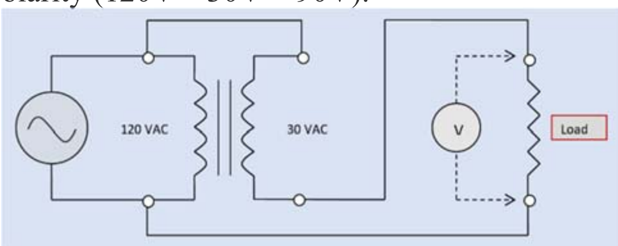

Figure 3. Diagram of a single-phase AC transformer connected as an autotransformer for either buck or boost configuration

When the polarity dots are not shown on a given transformer-wiring diagram with the respective-circuit lead identification, it is normally assumed that H1 in the primary (or the higher-voltage winding for step-down configuration) and X1 in the secondary (or the lower-voltage winding for step-down configuration) are in phase (have the same transformer winding polarity). Some schematics shown the H1 and X1 lead with the accompanying polarity dots. Polarity dots are always used when the H1 and X1 leads are not of the same polarity — to show which identified winding leads are of the same polarity.

The basic boost or buck circuit of *Figure 3* is drawn expanded in *Figures 4* and *5* to show the polarity aspects of the primary and secondary windings.

Single-Phase Boost Transformers

A voltage-boost situation could arise when a 230-volt, single-phase AC induction motor is installed on a 200-volt power supply. At the lower-voltage rating, the motor would overheat, even under light-loading conditions.

As shown in *Figure 4* an isolation transformer with a 200-volt primary and a 30-volt secondary can be wired to deliver 230 volts to the motor. The boost operation occurs when the 30-volt secondary winding is wired in additive polarity with the 200-volt primary winding. The 30-volt secondary voltage is effectively added to the 200-volt primary voltage. The motor load receives 230 volts.

Another typical application of this boost configuration is to correct for voltage drop on a distant motor load, such as a rural well pump, where both the circuit supply and the motor are rated at 230 volts, but the circuit conductors were not sized correctly to compensate for the voltage drop on initial installation, and replacement of the circuit conductors is cost prohibitive. The circuit current in this boost application will increase the existing load current drawn from the branch-circuit supply. The increase in the supply-circuit load current will equal the current drawn by the primary winding of the transformer. The boost operation of the transformer will convert the current in the primary winding operating at the lower supply-line voltage, to the secondary winding voltage that will add to the lower supply-line voltage at the original motor-load current value in the secondary circuit.

If the full-load current rating of the AC electric motor in *Figure 4* is 8 amps, this 8 amps flows through the 30-volt winding of the transformer which is in series with the motor.

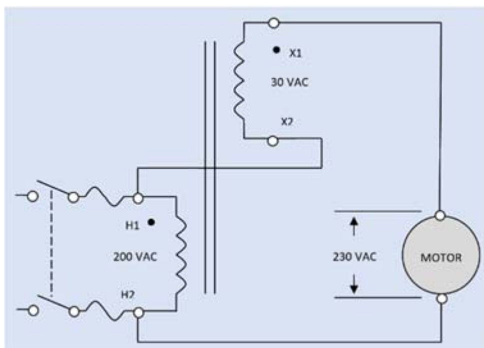

Figure 4. An isolation transformer can be wired as an autotransformer in a boost configuration

Projected into the primary winding circuit by the inverse of the voltage ratio:

(30 volts ÷ 200 volts) × 8 amps = 1.2 amps

The primary winding full-load current, to provide an increase in the secondary circuit of 30 volts, requires 1.2 amps. From the branch-circuit supply, the two currents add:

8 amps + 1.2 amps = 9.2 amps

Both the AC electric motor and the transformer are allowed to operate in a 125% overload condition:

125% of 9.2 amps = 11.5 amps

Using the next higher standard size, the boost transformer and the motor circuit would both be protected by a fuse or circuit breaker rated at 15 amps. The transformer's minimum power rating would be based on the motor's full-load current rating and the secondary voltage rating of 30 volts:

30 volts × 8 amps = 240 volt-amps

In *Figure 4*, the secondary winding has been connected in series with the connected load with secondary (or lower-voltage) lead X2 connected to one side of the transformer/load power supply and the primary (or higher-voltage*)* lead H1. Leads H1 and X1 are polarity dotted, indicating these two points in the transformer circuit are in phase. The H1 – X2 connection is a dot – to – no-dot connection, which should yield additive polarity. The load voltage, indicated by the voltmeter readout, is the sum of the 200-volt branch-circuit supply / primary voltage rating and the 30-volt secondary voltage rating: 230 volts.

Single-Phase Buck Transformers

A buck situation could arise when a 208-volt, single-phase AC resistive load must be installed on a 277-volt power source (branch circuit). At the higher-voltage rating, the resistive load would overheat to the point of destruction or at least damage to the heating elements. As shown in *Figure 5*, an isolation transformer with a 277-volt primary and a 69-volt secondary can be wired in a buck configuration to deliver 208 volts to the resistive load. The buck operation occurs when the secondary winding is wired in subtractive or reverse polarity to the primary winding. The 69-volt secondary voltage is effectively subtracted from the 277-volt primary voltage. The resistive load receives 208 volts.

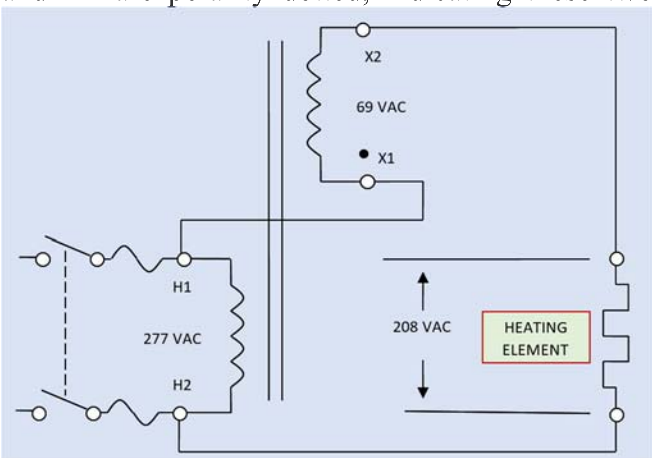

Figure 5. An isolation transformer can be wired as an autotransformer in a buck configuration

If the resistive heating load in *Figure 5* is rated at 10 kW, the full-load current is calculated as:

[1000 (/k) x 10 kW] ÷ 208 volts = 48.1 amps

The 48.1 amp heater current will flow through the 69-volt winding that is in series with the heater assembly. Projected into the primary circuit by the inverse of the voltage ratio:

(69 volts ÷ 277 volts) × 48.1 amps = 12.0 amps

The primary full-load current, to provide a decrease in the secondary circuit of 69 volts, requires 12.0 amps. Since the secondary winding is wired in subtractive polarity (indicated by the winding jumper being interconnected between H1 and X1), the 12-amp primary is effectively subtracted from the secondary load amperage to calculate the branch-circuit supply current:

48.1 amps – 12 amps = 36.1 amps

The power ratings of the two transformer circuits are equal:

277 volts × 36.1 amps = 208 volts × 48.1 amps = 10,000 volt-amps

The circuit for both the resistive heating load and the transformer are sized at 125% of these calculated full-load current ratings. The calculated branch-circuit OCPD rating is:

125% of 36 amps = 45 amps

The calculated primary-circuit current is:

125% of 12 amps = 15 amps

The calculated secondary-circuit current, which includes both the secondary winding and the heating assembly, is:

125% of 48 amps = 60 amps

As a general rule, autotransformers cannot be used to supply individual branch or feeder circuits, unless the common lead connection is to the grounded-circuit conductor in a 2-wire branch circuit.

Smart Grid Technology

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Introduction

A Smart Grid is essentially an electricity generation, transmission and distribution system that can automate and manage the increasing degrees of complexity and requirements associated with modern power networks. One of the more crucial aspects of the Smart Grid is the ability to monitor and control the grid, thereby enabling optimal management of grid assets and, as a direct consequence, the reduction in occurrences of unplanned outages.

Furthermore, the technology deployed to implement a Smart Grid will integrate and support renewable energy sources such as solar, wind and hydro, as well as provide consumers with real-time information concerning their energy consumption and thereby empowering them to effectively manage their electricity usage.

Why are smart grids necessary?

Traditional grids still operate in a similar manner as those of almost 100 years ago, i.e. energy flows over the grid from central power plants to consumers, and reliability is ensured by preserving surplus capacity. The result of this philosophy is an incompetent and environmentally extravagant system that is the primary emitter of greenhouse gases and consumer of fossil fuels. Nevertheless, fossil fuels continue to form the dominant source of energy, particularly in industrialised countries. Existing grid topologies are simply not well suited to distributed, renewable solar and wind energy sources, as the capricious and often intermittent nature of these sources pose significant problems in a grid that cannot disseminate information to control centres rapidly.

Recently, a paradigm shift has taken place in the way electricity is generated, transmitted and consumed. The aging power grid also faces new challenges posed by higher demands and increasing digital and nonlinear loads. And the sensitivity of digital equipment (as found in data centres and consumer electronics) to intermittent outages has certainly redefined the concept of reliability.

Continued economic growth and improvements in the quality of human life is very much dependent upon access to affordable and reliable electricity. However, more often than not, existing grids suffer infrastructural problems due to the fact that systems are simply outdated and unfit to deal with increasing demand. As a result, network congestion occurs more frequently as the ability to react quickly does not exist. Ultimately these limitations can lead to blackouts and the consequent domino effect due to the lack of communication between the grid and its control centres.

Currently consumers do not have access to real-time information that could empower them to make optimal decisions regarding power usage relative to the market. This could enable them to reduce consumption during the most expensive peak hours and take advantage of reduced tariffs during off-peak times.

Smart Grid represents a host of solutions that can address all of the above-mentioned. Indeed, a complete implementation will make renewable power feasible and equip the grid to meet increasing energy demands. More importantly perhaps, the technology will also allow consumers near real-time control of their energy bills and facilitate large-scale electric vehicle charging.

Characteristics and benefits of Smart Grid

In summary, Smart Grid involves innovative products and services in conjunction with intelligent monitoring, control, communication and self-healing technologies. The following attributes can be associated with Smart Grid:

- Allows consumers to play a role in the optimisation and operation of the system and provides consumers with greater information and choice of supply
- Demand response and demand side management are enabled through the integration of smart meters, smart appliances and consumer loads, micro-generation, and electricity storage (electrical vehicles) and by providing customers with information related to energy use and pricing

- Dynamic energy pricing allows consumers to adjust when and how high-load devices are operated, ultimately lowering energy bills and reducing the demand spikes which can lead to power outages

- Facilitates the integration of all renewable energy sources, distributed generation, and residential micro-generation, which is inherently unpredictable in nature. This includes the integration of storage options, e.g. plug in electric vehicles

- Efficiently operates assets by intelligent operation of the delivery system (rerouting power, working autonomously) and pursuing efficient asset management. This includes utilising assets depending on what is needed and when it is needed

- Increased physical, operational, and cyber security attributes which will improve resilience to attacks and/or natural disasters

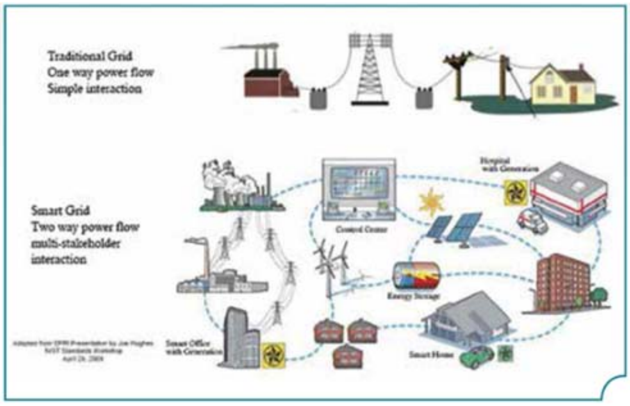
- Improved reliability and security of supply by anticipating and responding in a self-healing manner

- Quality of supply is generally improved thus more aligned with that required by sensitive digital equipment

A noteworthy consideration is also the cost of energy to the consumer. The seemingly relentless price increments can surely be, at least in part, attributed to the numerous inefficiencies associated with current grid infrastructure. Since Smart Grid will certainly address many of these and bring additional enhancements, it is envisaged that the consequent reduced operations and management costs incurred by utilities will ultimately drive energy costs down for the end consumer.

Smart grid vs. standard grid

There are numerous issues that contribute to the incapability of traditional grids to competently address the demand for consistent power supply. Table 1 contains a comparison between the characteristics of a traditional grid and those of an equivalent Smart Grid while Figure 1 illustrates this in a graphical representation.



Communications

Within the Smart Grid environment reliable and real time information is a crucial aspect to ensure reliable delivery of power from generating units to the end user. Hence, intelligent monitoring and control, enabled by modern information and communication technologies, is a crucial requirement to ensure effective operation and management of the system.

Assuming the utility already has an extensive backhaul network in place, the additional requirement for AMI (Advanced Metering Infrastructure) communications will usually involve the provision of online communication facilities between smart meters and the utility backhaul network. Essentially two types of communications infrastructures are required to provide for information flow within a Smart Grid system:

1) From sensors and electrical appliances to smart meters; and

2) Between smart meters and the utility's data centres.

Technologies

Many different communications and networking technologies, using the two main communications mediums – wired and wireless – are available to support Smart Grid applications. These include traditional twisted-copper phone lines (DSL and ADSL), cable lines, fibre optic cables (OPGW etc.), cellular (GSM, GPRS), satellite, microwave, WiMAX, power line carrier, and broadband over power line as well as short-range in-home technologies such as WiFi and ZigBee.

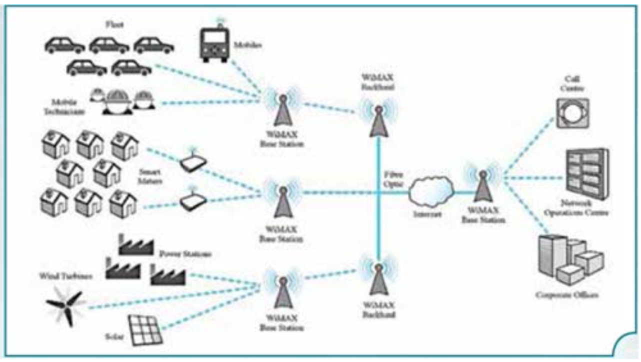
Smart Grid applications such as HAN (Home Area Networks), WASA (Wide Area Situational

Awareness), enhanced SCADA (Substation Supervisory Control and Data Acquisition) systems, distributed generation monitoring and control, demand response and pricing systems, and charging systems for plug-in electric vehicles can readily be supported by the above-mentioned telecommunications technologies.

From the above it can be ascertained that, irrespective of networking technologies employed, wireless communications will play a key role in the deployment of a Smart Grid communications system and, as such, will require significant additional radio frequency spectrum. Hence, to accommodate the spectrum requirements for Smart Grid it will certainly be prudent for the utility to engage the Regulator to explore available alternatives; these may include the leasing of additional spectrum, or even the investigation of options to share spectrum with other users.

However, before these negotiations can take place, it will be advisable for utilities to conduct studies, possibly in conjunction with telecommunications service providers, to accurately determine the spectrum retirements and also to obtain a good insight regarding particular uses, e.g. mobile and/or fixed access.

The transition to Smart Grid does not replace the existing grid; rather it represents a significant revamping, using new sensing, measurement, control, and automation technologies – some of which are illustrated in Figure 2.



In general, technologies required to successfully implement the diverse necessities of Smart Grid will include the following:

1. AMI (Advanced Metering Infrastructure) is one aspect of Smart Grid technologies that is already operational in many networks worldwide. In general, AMI can be defined as a two-way communications network and is the integration of sensors, smart meters, monitoring systems and data management systems that enable the dissemination and collection of information between customer meters and utilities.
2. PMU (Phasor Measurement Units) and WAMPAC (Wide Area Monitoring Protection and Control) to ensure the security of the power system.
3. IEDs (Intelligent Electronic Devices) enable two-way digital communication where each device on the network is equipped with sensing capabilities to gather important data for wide situational awareness of the grid. Computer-based remote control and automation ensures that these devices can be efficiently controlled and adjusted at the node level as changes and disturbances on the grid occur. Furthermore, IEDs communicate with SCADA systems and amongst one another, thereby enabling distributed intelligence to be applied to achieve faster selfhealing methodologies, as well as fault location and/or identification.
4. Two-way communication technologies as discussed under the communications heading in this article.
5. Power electronics and energy storage, which include HVDC (High Voltage DC), FACTS (Flexible AC Transmission Systems) to enable long distance transport and integration of renewable energy sources as well as other FACTS devices such as series capacitors and UPFC (Unified Power Flow Controllers).

Impediments and concerns

As is the case with most new and innovative technological developments, Smart Grid is subject to a number of implementation issues as well as concerns and oppositions – typically those expressed by public consumer groups. The following represents a non-exhaustive list of current, more challenging topics.

High initial cost

There can be little doubt that significant costs will be incurred to implement pilot projects and this can, of course, serve as a major deterrent to acceptance and ultimate adoption by utilities and consumers alike. Cost sharing amongst stakeholders and potential beneficiaries could perchance help to alleviate this concern.

Security

A typical Smart Grid system could incorporate millions of consumers and devices; hence, reliability and security is a crucial consideration. The prominence of information technology, as automation, remote monitoring/controlling and the interconnection of supervision entities increases, will quite likely introduce new cyber security vulnerabilities. Thus, mitigating security risks is arguably one of the most important research and development topics.

Consumer opposition

The Smart Meter, or AMI, is an integral component of any smart grid system and although the deployment of these devices has steadily increased in recent years, many utilities, both in the USA and Europe, still struggle to garner overall customer acceptance. The two primary concerns fuelling the opposition to these meters relate to health and data privacy issues.

Health

Since smart meters typically employ wireless technologies to communicate information, exposure to radio frequency radiation, and possible carcinogenic effect normally attributed to cell phone usage, has become a serious concern for many customers. This is further exacerbated by the probable eventual incorporation of transmitting devices into all household appliances. Many eminent studies have shown that the levels of radiation emitted by Smart Grid transmitting devices are well below that which is considered harmful to mammalian life forms. Yet these perceptions persist and indeed form the mainstay of opposition held by many extremely vociferous consumer groups worldwide.

Privacy

Smart meters measure customer electricity usage in far more granular time increments than standard meters; this has led to a perception amongst some customers that utilities will have access to more intimate information concerning their electricity usage. Rightly or wrongly, some customers are uncomfortable with utilities, or any other outside party, possessing such fine levels of information.

To mitigate the privacy concerns it is suggested that utilities educate customers regarding their privacy policies; specifically as to why their data may be shared, ways that they can access their data, and means by which complaints can be registered. In addition, an unambiguous publicly available policy can certainly alleviate some customer concerns, and will also help to create a more general acceptance of smart meter technology and the implementation thereof.

Fear of obsolescence

Early adoption of any cutting-edge technology, especially those that are propriety to a specific manufacturer, carries with it the risk of incompatibility and limited expansion and upgrade options. To effectively address this concern, it is imperative that interoperability standards and backward compatibility of technologies are incorporated into the development of new technologies.

Conclusion

The growth of electricity grids in the previous century has no doubt brought many socio-economic benefits for mankind as a whole. Unfortunately, the basic principles have changed very little since inception and most grids are still heavily dependent upon fossil fuels with consequent serious repercussions for the global environment. Worldwide demand for electrical energy is expected to rise 82% by 2030 (Energy Information Administration, US)

Smart Grid represents an unprecedented opportunity to move the energy industry into a new era of reliability, availability and efficiency that can significantly contribute toward economic prosperity, address many environmental concerns and reduce overall consumption. Thus viewed at its highest level, Smart Grid can be understood as any and all technologies, standards and practices that contribute to a more efficient and more reliable power grid. Finally, the overarching goal of Smart Grid remains the enablement of greater consumer participation, and it is this aspect alone that can accomplish many of the superior goals and ideals of a Smart Grid system.

Technologies for Smart Cities

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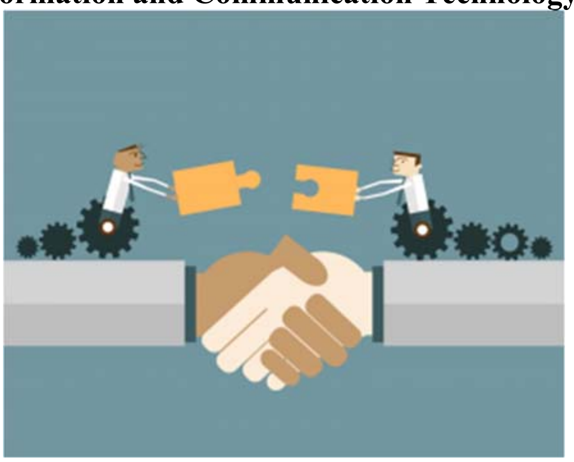
Introduction

Smart cities are cites where everything is connected to each other and this is highly depended on technologies. So let's have a look at six technologies crucial for smart cities.

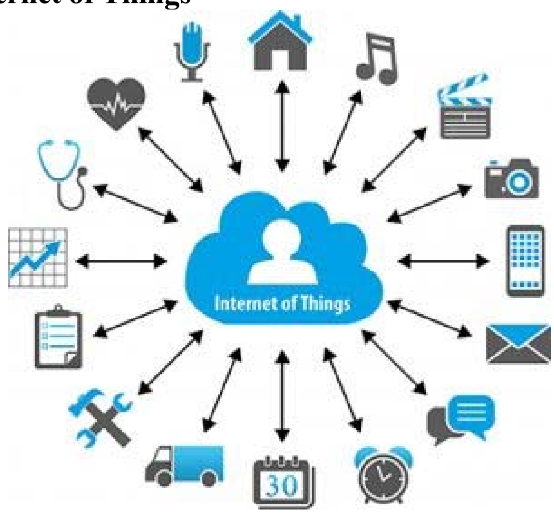
Technological literacy is a key to turn a city into smart city which is well connected, sustainable and resilient, where information is not just available but also findable. It is not a new thing that smart city is all about providing smart services to its citizens which can save their time and ease their lives. It is also about connecting them to the governance where they can give their feedback to the government as of how they want their city to be. And this aim can't be turned into reality without technology.

Information and Communication Technology



Creating a two-way communication channel is very important for a city to be smart. And here comes the role of Information and communication technology. ICT builds a bridge between the citizens and the government where the citizens can interact with the government and in return, the government can build a city which the choice of its citizens. ICT helps the government to analyze the demand pattern of the state and thus create a pool of resources to address the same online. The electronic medium of communication in a community helps in creating a collective intelligence which can be deployed for resource optimization with the help of analytics and deep learning.

Internet of Things



Internet of things is like veins of the city spread all across and connecting each dot. Every device that is part of a smart city needs to be connected to each other so that they can talk amongst and can take decisions for themselves which in return allows managing resources of a megacity population. This is where the IoT comes in, providing the perfect template of a body of communicating devices that provides smart solutions to everyday problems. All smart solutions in smart cities are based on Internet of things where they are connected and smart enough to decide their action.

Sensors

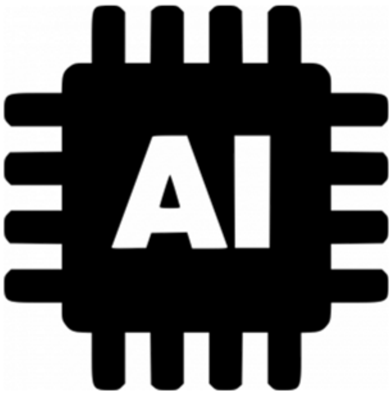
Sensors are hidden but ubiquitous components of the urban landscape. Sensors are a crucial component of any intelligent control system. A process is improved based on its environment and for a control system to be aware of its environment, it is typically fitted with an array of sensors, from which it collects the required data. It then uses the appropriate variables to characterize its environment and adjusts its operations accordingly. The availability of a multitude of different sensors and continuously evolving technology enables applications that were infeasible in the past due to high costs and limited availability. Sensors are like converters which convert parameters of a physical nature to an electronic signal, which can be interpreted by humans or can be fed into an autonomous system. These signals for conventional sensors, amongst others, include light, pressure, temperature, humidity, moisture and a variety of other parameters.

Geospatial Technology

Whatever is built in a smart city has to be right and so to build right a right plan is the need which is sustainable and this requires accurate, concise and detail data and here comes the role of Geospatial technologies which provide the underlying foundation and ultimately the fabric upon which solution can be built. It provides location which allows pinpointing exactly on the need so that better solution can be applied to it. Geospatial technology provides a necessary framework for collecting data and transforming observation in these collections to facilitate software-based solution around smart infrastructure

Artificial Intelligence

Smart city is a digital revolution generating a huge amount of data. Those data are of no use until and unless they are processed, which generates information in return. This massive amount of data generation brings the role of Artificial intelligence that can make sense out of those data.



AI allows machine to machine interaction by processing the data and making senses out of that. To understand the interesting aspect of Artificial intelligence in the context of smart cities, let us take an example. In a system where energy spikes tend to happen, AI can learn where they usually occur and under which circumstances and this information can be used for better management of the power grid. Likewise, Artificial Intelligence also plays a role in intelligent traffic management and healthcare facilities.

Blockchain

Blockchain application is new to smart city concept. Blockchain technology secures data flow. Its integration into smart cities could better connect all city services while boosting security and transparency. In some ways, blockchain is expected to influence cities through smart contracts, which help with billing, processing transactions and handling facilities management. Smart contracts are self-executing contracts with the terms of the agreement between buyer and seller directly written into lines of code. They permit trusted transactions and agreements to be carried out among disparate parties without the need for a mediating third party, making the process safer, cheaper and faster. Blockchain can also be used in smart grids to facilitate energy sharing, a concept which is trending these days.

Programmable Logic Controllers & Ladder Logic

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Introduction

The programmable logic controller, or PLC, is ubiquitous in process and manufacturing industries today. Initially built to replace electromechanical relay systems, the PLC offers a simpler solution for modifying the operation of a control system. Rather than having to rewire a large bank of relays, a quick download from a PC or programming device enables control logic changes in a matter of minutes or even seconds.

A PLC is an industrial-grade digital computer designed to perform control functions—especially for industrial applications.

The majority of PLCs today are modular, allowing the user to add an assortment of functionality including discrete control, analog control, PID control, position control, motor control, serial communication, and high-speed networking. Compared to older technologies, the PLC is easier to troubleshoot, more reliable, more cost-effective, and far more versatile.

Modicon, shortened from modular digital controller, is both the name of the first PLC product and the brand that invented it. Below is a picture of a Modicon PLC.

Modicon PLC with CPU, I/O, and communication cards.

While it may not look like a typical computer, at the core of a PLC is the very same technology seen in the computers and smart devices most people use in their everyday life.

Basic Components

A PLC is composed of a few basic parts. These include a power supply; a central processing unit, or CPU; input/output cards; and a backplane, carrier, or rack that these parts are placed into. The backplane, as shown in Figure 2, creates an electrical connection between all of the separate components, giving the PLC its modular design. This electrical connection includes both power and communication signals. Many PLC manufacturers use proprietary communication protocols on the backplane so that I/O can securely talk to the CPU.

Allen-Bradley Control Logic backplane

The Power Supply

The power supply provides either 125VAC or 24VDC depending on the application and the circumstances of the installation. As mentioned above, this voltage is bussed down the backplane providing power for the CPU and I/O modules, which come in the form of "cards". These cards can quickly be added or removed from their slot in the carrier.

The Programming Device and Human-Machine Interface

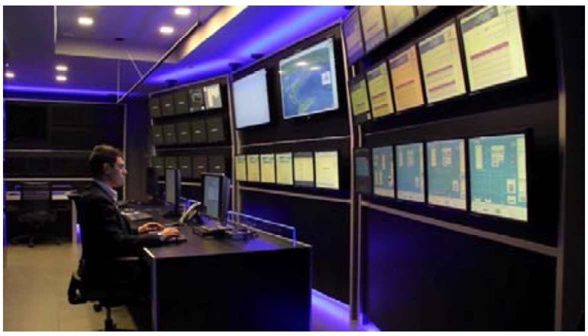
Outside of the PLC itself are two very important components: the programming device and the human-machine interface (HMI). The programming device can be a desktop computer, laptop, or hand-held instrument from the same manufacturer. There are also fixed I/O PLCs with built-in displays and buttons that allow programs to be written directly on the PLC.

While the programming device allows the user to view and modify the code running on the PLC, the HMI provides a higher level of abstraction, modeling the control system as a whole. Figure 3 shows an integrated touchscreen that can be used in the control room or out in the "field" closer to the process. These types of interactive displays are very common and will often be mounted directly on the PLC enclosure or nearby for operator use.

The "field" is the area of the plant or factory where the actual control is done. This is where you would find pumps, motors, valves, temperature and pressure sensors, heat exchangers, mass flow meters, robotic arms, and raw materials.

Some touch panels can monitor the control system or interact with the process,

In today's large, complex industries, the HMI has become a critical feature in the implementation and deployment of a control system. As its name implies, the human-machine interface is a user's window into the control scheme or process. It allows the user to monitor, interact with, and, if necessary, shut down the control system.



Control rooms

This high-level view of the PLC is the domain of automation and control engineers. These engineers understand control systems, control algorithms, and configuration. They model the process and determine the size and scale of the system needed. From there, the PLC and all of its components are purchased. This could be a single rack with eight I/O cards, or twenty racks all communicating over an industrial network with thousands of I/Os. The key takeaway here is that all of the control is done by a single CPU.

Ladder Logic

Ladder diagram, better known as ladder logic, is a programming language used to program PLCs (programmable logic controllers). This article will briefly describe what ladder logic is and go over some examples of how it functions.

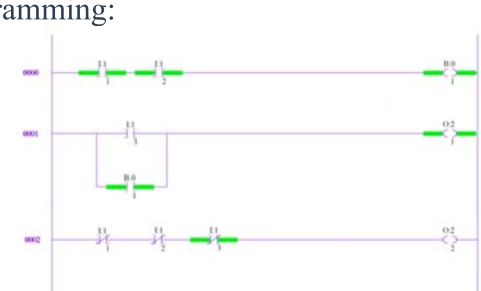
Programmable logic controllers or PLCs are digital computers used to perform control functions, usually for industrial applications. Of the various languages one can use to program a PLC, ladder logic is the only one directly modeled after electromechanical relay systems.

It uses long rungs laid out between two vertical bars representing system power. Along the rungs are contacts and coils, modeled after the contacts and coils found on mechanical relays. The contacts act as inputs and often represent switches or push-buttons; the coils behave as outputs such as a light or a motor.

Outputs don't have to be physical, though, and can represent a single bit in the PLC's memory. This bit can then be used later on in the code as another input. Contacts are placed in series to represent AND logic and in parallel when using OR logic. As with real relays, there are normally open contacts and normally closed contacts.

An Example of Ladder Logic

Let's take a look at an example of ladder logic programming:



A simple ladder logic program

This ladder logic program is three rungs long. The program is "scanned" or run by the CPU from left to right and top to bottom. The symbols placed throughout the rungs are actually graphical instructions. The names for these instructions are:

- XIC (Examine If Closed)
- XIO (Examine If Open)
- OTE (Output Energize).

First Rung

Looking at the first rung, notice the first two inputs I:1/1 and I:1/2. The symbol is an XIC, and the I denotes that this is an input. This instruction represents a physical input found on one of the discrete input cards.

I:1 means that this input card has been placed in slot 1, directly adjacent to the processor. The /1 indicates the bit of interest. Input cards have more than one channel, and if the instruction specifies /1, the instruction accesses channel 1.

The second input represents channel 2 on the same card. An XIC instruction really means true if closed. That is, this instruction will be true if the input device it represents is closed. If an instruction is true it is highlighted in green. The only way for an output to be energized is if a path of true instructions can be traced from the left rail to the right rail. Therefore, the output on rung one will be true because a path of true instructions, I:1/1 and I:1/2, exists. This is effectively an AND operation. The output in this case, B:0/1, is actually an internal bit stored in the PLC's memory. That's why it's labeled B instead of O for "output." These internal bits work great when a certain state or set of inputs needs to be recorded without actually turning on a physical output.

Second Rung

On the second rung, we have a third input labeled I:1/3 and our internal bit is now used with an input instruction instead of an output.

The second rung represents a third input used with an input instruction. These two inputs are placed in parallel and represent an OR condition. O:2/1 is an output instruction that represents channel 1 on a physical discrete output card placed in slot 2. This second rung could be rewritten without the internal bit by replacing B:0/1 with the two inputs from rung one. Thus, output O:2/1 will be true if I:1/3 is true OR if both I:1/1 AND I:1/2 are true. This is the basic structure of all ladder logic programs.

Third Rung

The third rung introduces the XIO instruction. An XIO instruction is best described as true if open.

The third rung introduces the XIO instruction. The XIO will be true only if the input connected to it is open. In the case of internal bits, this instruction is true if the internal bit is off. Therefore, because I:1/1 and I:1/2 are both closed, the XIO instructions representing those inputs are false. The XIO representing I:1/3 is true because the input device it represents is open. Without a path of true instructions from left to right, the output on rung three, O:2/2, is off.

PLC System Instructions

The instructions discussed above are the most fundamental instructions in PLC systems, but they represent a small portion of the entire instruction set. The majority of PLCs include timer, counter, latching, and advanced logic instructions.

Figure 5 shows a slightly more complicated level-control program written by the author for an Allen-Bradley PLC.

For starters, you might notice the input I:1/0. Confusingly, Allen-Bradley names the first channel on any card channel 0. This is similar to the way array indices start at zero.

This program uses two level switches, attached to a tank, to activate two pumps that must begin operation one after the other rather than simultaneously. Notice the same two XIC inputs control both pump A and B. However, an internal bit is used with an XIC to control pump A and with an XIO to control pump B. If rung 0000 is true, pump A gets latched using a latch instruction.

If rung 0001 is true, pump B gets latched. Once a latch instruction goes true, the output remains on until a complementary unlatch instruction is activated. The last rung controls the pump toggle, using a one-shot and an XOR instruction.

The one-shot, when activated, stays true for a single program scan, while the XOR behaves as usual. This is an easy way to toggle a bit with a single input.

Augmented Reality (AR) Technology

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Introduction

Since the early 70's video games have been a great entertainment for all of us. With the recent boom in technology, computer graphics has been so advanced that graphic games are being introduced into the real world surroundings. The photo reality is mind boggling to such an extent that you feel that the games have been plucked out of your display monitors and integrated into your surroundings. Not only the video part, but also sound and also other sense enhancements are integrated into the real world. Such a technology is called Augmented Reality, which clearly makes us doubt whether what we see, hear, smell and feel is real or not.

Augmented Reality [AR] can actually be defined as the integration of graphics into the physical real world without a single change in the perspective, which is every image shown will be adjusted to every angle of movement of the user's head and eyes. Thus a widely produced graphics in augmented reality will surely enhance everyone's perception of the real world.

Thus AR is a combination of three factors. They are

- Real and virtual world.
- Interaction in the real time.
- 3D world.

With the wide use of AR, the entire view of the world will surely change. Just think of yourself, sitting at home, while an exact replica of yourself walking through the streets. When you view such a person's image the audio will coincide with the image automatically. The changes will be made continuously to reflect the movements of your view. Such applications are most commonly seen nowadays in smart phones.

Technology

To know the technology used in AR it is necessary to know the basic components used in Augmented Reality. There are four basic components used in AR. They are 1. Display, 2. Tracking and Orientation, 3. Portable Computer, 4. Software

These four components are combined together to make a highly efficient AR device. Devices like high speed multi-processors, high resolution cameras, accelerometers and are also used to enhance the reliability of the AR equipped device.

Now let us learn about each component in detail.

1. Displays

Tree types of displays are used in AR technology. They are

• Head Mounted Displays [HMD]

This device keeps both the images of the real physical world and the virtual graphical world over the user's world view. HMD are either an optically transparent or video transparent device. In an optically transparent display device, partial silver mirrors are used to pass the views of the real world through a lens. At the same time the virtual images are reflected into the user's eyes. A 6-degrees of freedom [dof] sensor must be used to track the

HMD device. Such a tracking method helps in relating the virtual world to the real world.

• Handheld Displays

Such displays are small in size and will easily fit in one hand. These devices use video transparent techniques to relate the virtual world to the real world. Here also 6-degrees of freedom [dof] sensors are used apart from devices like GPS trackers, and digital compasses. This display technology is the biggest success for Augmented Reality till now. Since they are easily portable and due to the bulk use of camera phones, they are used widely.

• Spatial Displays / Spatial Augmented Reality

This is very different from the other two techniques explained above. There is no need t carry the display, instead, the graphical image is related to physical objects by using a digital projector. The only problem is that the user will have no contacts with the display.

The main advantage of such a device when compared to other displays is that the user doesn't have to carry the equipment along with him. Thus the users can easily see each other's faces. Since a projector system is used, these displays have better resolution than the others. The resolution can be further increased by expanding the display area by using more projectors.

2. Tracking and Orientation

As the name refers, tracking and orientation is needed to know the user's exact location in comparison to his surroundings and also is used for tracking the exact eye and head movements of the user. This is the most complex part of the Augmented Reality technology as three major functions such as tracking the overall location, movement of the user's head and eye and adjusting the graphics to be displayed are done with utmost precaution. There has not been a single system than can produce AR without a small delay between the real world and the graphical world till now.

3. Portable Computer

For this technology to sustain, the computers used must have high speed processors. Even now, the computers used for this purpose, does not have enough efficiency. For using 3-D graphics in systems, the configuration must be high end.

4. Applications

• Gaming and Entertainment

This is the biggest field in which AR has really made progress in. The games can be enhanced to such an extent that the user will fell like he is one of the characters of the game. Even movies can be watched with such enthusiasm as you will feel that the characters are walking past you.

• Education

AR system can be greatly helpful to students as it can be used to re-create historic events of great importance in relation to its real time background. Thus the students will have a better idea of all the facts in life, providing them with a better education.

• Security and Defence

AR technology helps in giving the soldiers in the field vital information about their surroundings, friendly troops and also the movement of their enemies. Even police officers will have a great help from such a technology as they have a complete and inmost view of a crime scene or robbery.

• Medicine

During a medical operation, AR technology can be used to provide the doctor a better sensory perception of the patient's body.

Thus, the risk factor involved in an operation can be greatly reduced and the efficiency can be increased. The technology can also be used to provide the patient's medical records digitally in page wise manner, immediately after an X-ray or MRI, so that a quick decision can be taken.

Wireless Power Transmission Via Solar Power Satellite

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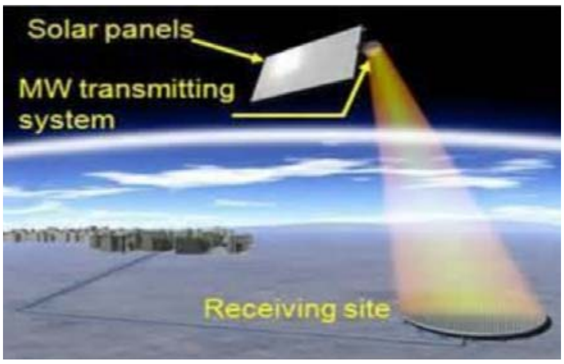
Introduction

In our present electricity generation system we waste more than half of its resources. Especially the transmission and distribution losses are the main concern of the present power technology. Much of this power is wasted during transmission from power plant generators to the consumer. The resistance of the wire used in the electrical grid distribution system causes a loss of 26-30% of the energy generated. This loss implies that our present system of electrical distribution is only 70-74% efficient. We have to think of alternate state - of - art technology to transmit and distribute the electricity. Now- a- days global scenario has changed a lot and there are tremendous development in every field. If we don‟t keep pace with the development of new power technology we have to face a decreasing trend in the development of power sector. The transmission of power without wires may be one noble alternative for electricity transmission. Projections of future energy needs over this new century show an increase by a factor of at least two and half, perhaps by as much as a factor of five. All of the scenarios indicate continuing use of fossil sources, nuclear, and large hydro. However, the greatest increases come from "new renewable" and all scenarios show extensive use of these sources by 2050. Indeed, the projections indicate that the amount of energy derived from new renewable by 2050 will exceed that presently provided by oil and gas combined. This would imply a major change in the world‟s energy infrastructure. It would be a herculean task to acquire this projected amount of energy. Wireless transmission of power, also called wireless power transfer (WPT), is a means of delivering power to an end-use device without wires or contacts.

Solar Power Satellite Concept

Basic idea of SPS is to collect the solar energy in orbit and send it to ground by microwave, laser beam or some other ways. The concept of the Solar Power Satellite energy system is to place giant satellites, covered with vast arrays of solar cells, in geosynchronous orbit 22,300 miles above the Earth's equator. Each satellite will be illuminated by sunlight 24 hours a day for most of the year. Because of the 23" tilt of the Earth‟s axis, the satellites pass either above or below the Earth‟s shadow. It is only during the equinox period in the spring and fall that they will pass through the shadow. They will be shadowed for less than 1% of the time during the year. The solar cells will convert sunlight to electricity, which will then be changed to radio-frequency energy by a transmitting antenna on the satellite and beamed to a receiver site on Earth. It will be reconverted to electricity by the receiving antenna, and the power would then be routed into our normal electric distribution network for use here on the Earth.



Basic Conversion Process

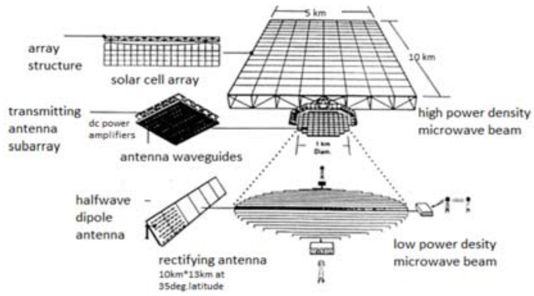
Figure illustrates the concept. The great advantage of placing the solar cells in space instead of on the ground is that the energy is available 24 hours a day, and the total solar energy available to the satellite is between four and five times more than is available anywhere on Earth and 15 times more than the average location. Testing has demonstrated that wireless energy transmission to the Earth can be accomplished at very high efficiencies. Tests have also shown that the energy density in the radio-frequency beam can be limited to safe levels for all life forms. The concept is simple; the technology exists

Wireless Power Transmission

In 1893, Nikola Tesla demonstrated the illumination of vacuum bulbs without using wires for power transmission at the World Columbian Exposition in Chicago. William C. Brown, the pioneer in wireless power technology, had designed, developed a unit and demonstrated to show how power can be transferred through free space by microwaves. In 1961, Brown published the first paper proposing microwave energy for power transmission, and in 1964 he demonstrated a microwave-powered model helicopter that received all the power needed for flight from a microwave beam at 2.45 GHz from the range of 2.4GHz – 2.5 GHz frequency band which is reserved for Industrial, Scientific, and Medical (ISM) applications. Typical WPT is a point-to-point power transmission. For the WPT, we had better concentrate power to receiver. It was proved that the power transmission efficiency can approach close to 100%.

Components of Solar Power Satellites

The main components of Wireless Power Transmission are Microwave Generator, Transmitting antenna and Receiving antenna (Rectenna). These essential components are further described in detail



1) Microwave Generator:

The Microwave generator takes the DC power generated by the solar cells and converts it to radiated RF output. It consists of a DC-RF conversion oscillator, which is typically low-power and followed by a gain stage and finally a power amplifier (PA).Typically the microwave generating devices are classified as microwave tubes (e.g klystron, magnetron, TWT etc) or semiconductor MW devices.

2) Transmitting Antenna:

The slotted wave guide antenna, microstrip patch antenna, and parabolic dish antenna are the most popular type of transmitting antenna. The slotted waveguide antenna is ideal for power transmission because of its high aperture efficiency (> 95%) and high power handling capability. We need higher efficient generator/amplifier for the MPT system than that for the wireless communication system. For highly efficient beam collection on rectenna array, we need higher stabilized and accurate phase and amplitude of microwave when we use phased array system for the MPT.

3) Rectenna:

A Rectenna is a Rectifying antenna, a special type of antenna that is used to directly convert microwave energy into DC electricity. Its elements are usually arranged in a multi element phased array with a mesh pattern reflector element to make it directional. Rectennas are being developed as the receiving antennas in proposed microwave power transmission schemes, which transmit electric power to distant locations using microwaves. Rectennas are used in RFID tags; the energy to power the computer chip in the tag is received from the querying radio signal by a small rectenna. One possible future application is a receiving antenna for solar Power satellites. A simple rectenna element consists of a dipole antenna with a Schottky diode placed across the dipole elements. The diode rectifies the AC current induced in the antenna by the microwaves, to produce DC power. Schottky diodes are used because they have the lowest voltage drop and highest speed and therefore waste the least amount of power due to conduction and switching.

Advantages

Wireless Power Transmission system would completely eliminates the existing high-tension power transmission line cables, towers and sub stations between the generating station and consumers and facilitates the interconnection of electrical generation plants on a global scale. It has more freedom of choice of both receiver and transmitters. Even mobile transmitters and receivers can be chosen for the WPT system. The cost of transmission and distribution becomes less and the cost of electrical energy for the consumer also would be reduced. The power could be transmitted to the places where the wired transmission is not possible. Loss of transmission is negligible in the Wireless Power Transmission; therefore, the efficiency of this method is very much higher than the wired transmission. Power is available at the rectenna as long as the WPT is operating. The power failure due to short circuit and fault on cables would never exist in the transmission and power theft would be not possible at all.

Disadvantages

The Capital Cost for practical implementation of WPT seems to be very high and the other disadvantage of the concept is interference of microwave with present communication systems.

Biological Impacts

Common beliefs fear the effect of microwave radiation. But the studies in this domain repeatedly proves that the microwave radiation level would never be higher than those received while opening the microwave oven door, meaning it is slightly higher than the emissions created by cellular telephones. Cellular telephones operate with power densities at or below the ANSI/IEEE exposure standards. Thus, public exposure to WPT fields would also be below existing safety guidelines.

Conclusion

The concept of Microwave Power transmission (MPT) and Wireless Power Transmission system is presented. The technological developments in Wireless Power Transmission (WPT), the advantages, disadvantages, biological impacts and applications of WPT are also discussed. This concept offers greater possibilities for transmitting power with negligible losses and ease of transmission than any invention or discovery heretofore made.

Program Outcomes (POs)

PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, and engineering fundamentals to solve the complex electrical engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex Electrical and Electronics Engineering problems enabling attainment of conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/Development of Solutions:** Design solutions, components or process for complex Electrical Engineering problems to meet the specified needs considering public health, safety and environmental considerations.
PO4	**Conduct Investigations of complex problems:** Exercise research knowledge and technical methodology for design, analysis and interpretation of data to converge to a suitable solution.
PO5	**Modern Tool Usage**: Use modern engineering tools, softwares and equipments to predict, analyze and model engineering problems.
PO6	**The Engineer & Society:** Apply reasoning skills to assess societal, health, safety, legal and cultural issues relevant to the professional engineering practice and take consequent responsibilities in the society
PO7	**Environment and Sustainability:** Realize the impact of the professional engineering solutions and demonstrate the knowledge for sustainable development in environmental context
PO8	**Ethics:** Apply and realize the professional ethics and responsibilities in Electrical engineering practice.
PO9	**Individual and Team Work:** Exhibit Individuality, Leadership and Team spirit in multidisciplinary settings.
PO10	**Communication:** Communicate, comprehend, write reports, design documentation and presentation effectively on complex engineering activities
PO11	**Project Management & Finance:** Demonstrate the Electrical engineering and management principles adhering to financial strategies to manage projects as a member or leader in a team
PO12	**Life Long Learning:** Inculcate independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO 1: Electrical drives and control: Graduates will Analyze, design and provide Engineering solutions in the field of Power Electronics and Drives

PSO 2: Embedded system: Graduates will Simulate, experiment and solve complex problems in Embedded System.

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To become a globally recognized Institution in Engineering Education, Research and Entrepreneurship.

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- ❖ Accomplish quality education through improved teaching learning process.
- ❖ Enrich technical skills with state of the art laboratories and facilities.
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To produce world class Electrical and Electronics Technocrats and Entrepreneurs with social responsibilities.

MISSION

- ❖ Impart quality education in the field of Electrical and Electronics Engineering through state of the art learning ambience.
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