Power Management

Task for 25 Apr 22

Batteries & Cells

What Is Battery?

An Italian physicist, Alessandro Volta, invented the first battery in 1800. Since then, battery technology has been used around the world.

A battery is a collection of one or more cells, storing electrical energy for powering electrical devices.

How does it work?
Chemical reactions create the flow of electrons within a circuit. The stored chemical energy is then converted into direct current electric energy.

Cell and Battery

We all know how capable a battery is for supplying electric power. But what we might not know is the underlying component inside it, which has a major part in producing voltage and current.

The *Cell.* This basic electrochemical unit handles the actual storage of energy in a battery.

A cell contains three main components: **two electrodes and an electrolyte.**

Let's begin with the electrodes. There are two types: the *Anode* and the *Cathode*.

The anode is the negative electrode, whereas the cathode is the positive one.

When the anode loses electrons to the external circuit, it gets oxidised. It's also called the Fuel Electrode or the Reducing Electrode.

In contrast, once the cathode accepts electrons from the internal circuit, it gets reduced. It's also called the Oxidising Electrode.

This is where the energy conversion happens in a battery. It's due to the electrochemical oxidation-reduction reaction of a cell component.

The third element is the *electrolyte*. It acts as the medium for transferring charge in the form of ions between two electrodes.

An electrolyte isn't electrically conductive but is an ionic conductive. It is often referred to as Ionic Conductor.

Overall, the cells in a battery provide the necessary voltage and current levels.

Batteries & Cells

Difference Between Cell and Battery

When we look at the differences between cell and battery, the biggest distinction would be – a battery typically stores energy whereas a cell generates energy by converting available resources. However, you will find some other differences between the two below.

Difference Between Cell and Battery	
Cell	Battery
A cell is a single unit device which converts chemical energy into electric energy.	A battery usually consists of group of cells.
Depending on the types of electrolytes used, a cell is either reserve, wet or dry types. Cell also includes molten salt type.	A battery is either a primary battery or a secondary battery meaning it is rechargeable or non-chargeable.
A cell is usually light and compact as it has a single unit.	Battery normally consists of several cells thus giving it a bigger size and is bulky.
A cell supplies power for a shorter period of time.	A battery can supply power long durations.
A cell is used mostly for lighter tasks which requires less energy. It is used in lamps, clocks, lamp, etc.	A battery is mostly used for heavy-duty tasks. It is used in inverters, automobiles, inverter, etc.
Cells are usually cheap	Batteries are much costlier.

Types of Batteries

Different Types of Batteries

Electrochemical cells and batteries are categorised into two types. Although there are several other classifications, these two are the basics:

- Primary (non-rechargeable)
- Secondary (rechargeable)

Primary batteries are non-rechargeable ones. This means they can't be recharged with electricity.

The secondary batteries work otherwise. They're ideal for recharging.

Type	Anode	Cathode	Voltage	Wh/kg
Alkaline MnO_2	Zn	MnO_2	1.5	145
Li/FeS_2	Li	FeS_2	1.5	260

Primary Cells or Batteries

Type	Anode	Cathode	Voltage	Wh/kg
Pb acid	Pb	PbO_2	2	35
Ni-Cd	Cd	Ni oxide	1.2	35
Li-Ion	Li_xC_6	$Li_{(1-x)}CoO_2$	4.1	150

Secondary Cells or Batteries

Primary Batteries

A primary battery is a convenient sources of power for portable electronics and devices. This includes radios, watches, toys, lights, camera, and more.

Since they can't be recharged once they run out of power, they're the type to *"discard immediately when discharged"*. **In short, they can't be used again.**

Primary batteries are inexpensive, lightweight, and convenient to use with no maintenance. The majority used in domestic applications are single cell type.

They usually come in a cylindrical form, such as *Alkaline batteries*. They got their name from the electrolyte used in them: potassium hydroxide—a pure alkaline substance.

This type of primary battery is a chemical composed of zinc (Zn) and manganese dioxide (MnO2). It has a power density of 100 Wh/kg.

Other shapes and sizes of a primary battery include a coin-shaped one, a.k.a. *coin cell batteries*. They are often used in torches, remotes, wall clocks, small portable gadgets, and more.

The chemical composition of a coin cell battery is also alkaline. But it also contains lithium and silver oxide chemicals.

These compounds make this small battery more efficient, providing steady and stable voltage. It has a power density of 270 Wh/kg.

Other types of primary batteries include:

Battery Type	*Characteristics*	*Applications*
Alkaline (Zn/Alkaline/MnO2)	Very popular, moderate cost, high performance	Most popular primary batteries
Magnesium (Mg/MnO2)	High capacity, long shelf life	Military and aircraft Radios
Mercury (Zn/HgO)	Very high capacity, long shelf life	Medical (hearing aids, pacemakers), photography
Lithium/Solid Cathode	High energy density, low temp performance, long shelf life	Replacement for button and cylindrical cells
Lithium/Soluble Cathode	High energy density, good performance, wide temp range	Wide range of applications with a capacity between 1 – 10,000 Ah
Lithium/Solid Electrolyte	Low power, extremely long shelf life	Memory circuits, medical electronics
Silver/Zinc (Zn/Ag2O)	Highest capacity, costly, flat discharge	Hearing aids, photography, pagers
Zinc – Carbon	Common, low cost, variety of sizes	Radios, toys, instruments

Courtesy of *Electronics Hub*.

Alkaline Batteries

Mercury Batteries

Silver-Zinc Batteries

Lithium Batteries

Secondary Batteries

Secondary Batteries

The main advantage of these batteries is they can be recharged and reused. Hence the other term: rechargeable batteries.

Secondary batteries usually cost more than primary ones. But considering they're rechargeable, they can have a longer lifespan.

Used for two applications:

- energy storage devices
- applications where the battery is used and discharged as a primary battery

In the first application, secondary batteries supply and store energy for devices such as:

- Uninterrupted Power Supplies (UPS)
- Hybrid Electric Vehicles (HEV)

This means they're used as energy storage devices where they're electrically connected to the main energy source. At the same time, they're charged by it, supplying the needed energy.

For instance, a UPS. It's a battery backup, especially for computers. It provides reserve power when your regular power source fails.

As for the second application, rechargeable batteries also work for portable electronics like:

- Mobiles
- Laptops
- Electric vehicles

Once they're completely or almost discharged, they can be recharged with a charging mechanism.

For example, smartphone batteries. Most models have a *lithium-ion battery* that lives longer when charged often.

This type of battery acts as their main power source, their *primary* one. But unlike the standard primary batteries, lithium-ion is rechargeable and reusable.

For one, instead of discarding it, you pull out your cable wire or charger then plug it into a socket to charge it.

Another great example is the *lead-acid batteries* found in most cars and vehicles. It comes with a nominal voltage starting from 2V to 24V with a 7 Wh/kg power density. Plus, it's considered one of the four major types of secondary batteries, along with lithium-ion.

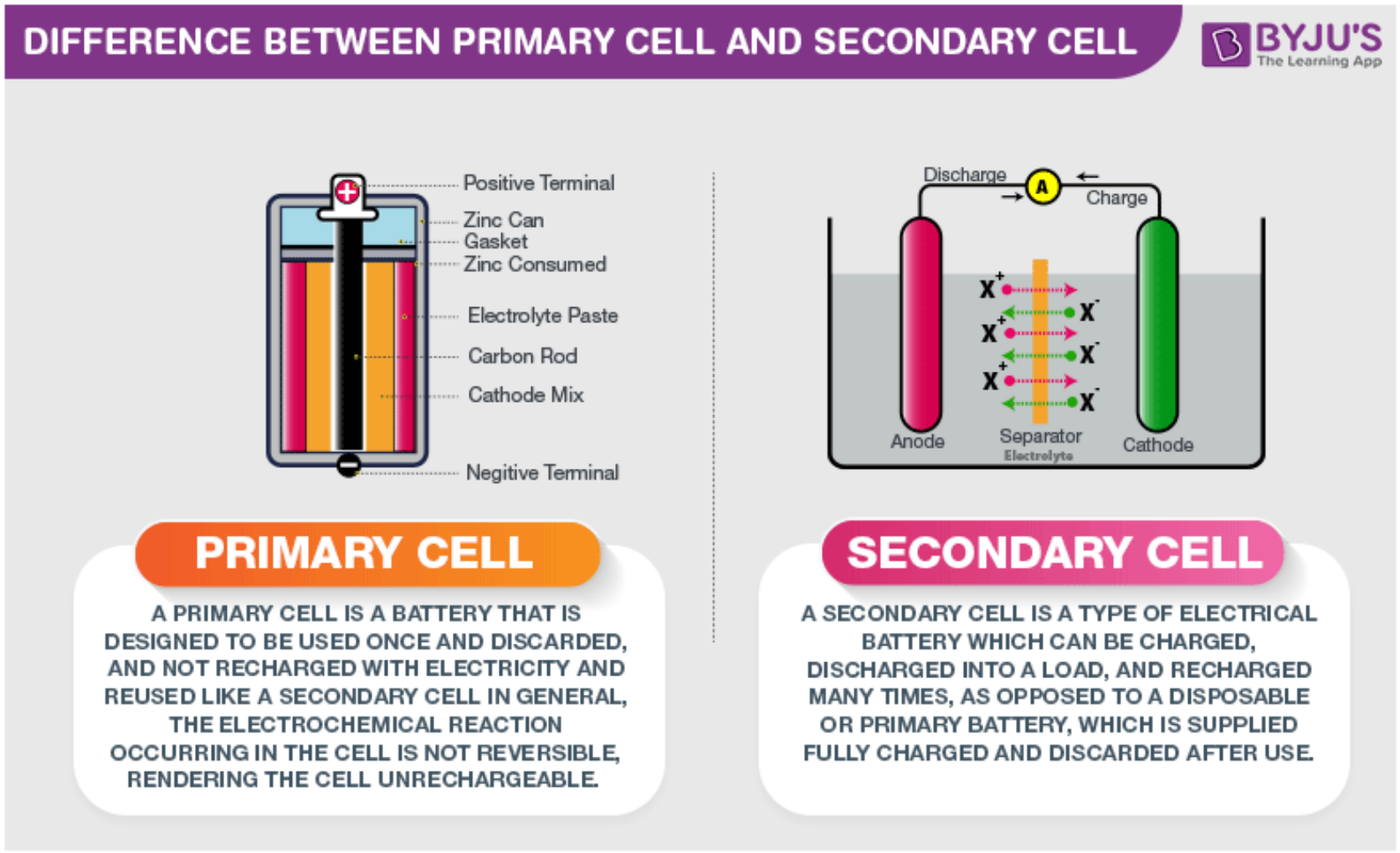
Other major types of rechargeable batteries include:

- **Nickel – Cadmium Batteries.** One of the oldest battery types available today. They have a very long life and are also very reliable and sturdy.
- **Nickel – Metal Hydride Batteries.** They're a new type of battery, an extended version of Nickel – Hydrogen Electrode Batteries. Ideal use in aerospace applications (satellites).

NiCd Batteries

NiMH Batteries

Primary Vs Secondary Batteries



Battery Application

Battery Applications

Primary and secondary batteries are both used in a lot of appliances, such as:

- **Portable electronic devices:** Smartphones, watches, cameras, laptops, calculators, including testing equipment like multimeters.
- **Entertainment:** Radios, MP3 and CD players, infrared remote controls, toys and games, etc.
- **Household:** Smoke detectors, alarms, clocks, UPS, portable power tools, and more.

Choosing the right battery for your needs

Performance and cost are the main characteristics you should look for when buying batteries. On top of these two, you also might want to consider the following:

- Primary or secondary
- Energy or power
- Shelf life
- Energy efficiency and recharge rate
- Battery life
- Battery temperature

Alkaline batteries

- **9V Alkaline batteries.** Reliable power for your everyday devices like motorized toys, flashlights, portable games consoles, remote controls, CD players, etc.
- **Alkaline specialty batteries**. For cameras, car remotes and more.
- **AA Alkaline batteries**.
- **AAA Alkaline batteries**.
- **C & D Alkaline batteries**.

Battery Application

Lithium batteries

Reliable and longer life. Unlike alkaline batteries, high-performance Lithium batteries boast an exceptional shelf life. This means they will be ready when you need them. See the full range of Lithium batteries here.

- **3V coin cell Lithium batteries**. Reliable performance. Often used in heart-rate monitors, keyless entry, glucose monitors, toys & games.
- **LiFePO4 Lithium batteries**
- **Lithium specialty batteries**
- **Memory backup lithium batteries**
- **PLC Lithium batteries**

Rechargeable batteries

In a life full of energy you don't want to be stopped. That's why you use rechargeable batteries – you'll never run out if you keep some of these handy batteries charged!

Available in Lithium, Ni-Cad, NiMH and battery packs.

- **Lithium rechargeable batteries**
- **Ni-Cad rechargeable batteries**
- **NiMH rechargeable batteries**
- **Rechargeable battery packs**

Sealed Lead-acid batteries

Browse through our high performance, multi-purpose lead-acid batteries here. They provide dependable primary and backup power in domestic and also commercial applications.

Battery Life Calculation

How to calculate the battery runtime?

It would be wonderful never to have to charge a smartphone again. You're probably painfully aware of the fact that no battery lasts forever, though. This battery life calculator finds out the approximate runtime of your battery basing on the following formula:

```
battery life = capacity / consumption * (1- discharge safety)
```

where

- **Capacity** is the capacity of your battery, measured in ampere hours. You can usually find this value printed on your battery.
- **Consumption** is the average current draw of your electronic device, expressed in amperes. (If you want to learn more about the electric current, make sure to check out the Ohm's law calculator!)
- **Discharge safety** is the percentage of your battery capacity that is never used. For example, if you use a LiPo battery to fly a drone, you should never discharge it below 20% - otherwise, it can be damaged. Our battery life calculator assumes a default discharge safety of 20%, but feel free to change it as you wish.

How long will a battery last: sleep mode

Now, let's imagine you are building an IoT device that spends most of the time in sleep mode. You'll probably want to calculate how long will a battery last in such a case. All you have to do is open the advanced mode to find out!

In the advanced mode, you can adjust the following additional parameters:

- **Awake time** is simply the time that your device is not sleeping during one operational cycle - for example, 2 seconds.
- **Consumption in sleep mode** is the average consumption of your device in sleep mode, measured in amperes. This value is probably much lower than the consumption in awake mode.
- **Sleep time** is the time that your device spends sleeping during one operation cycle.

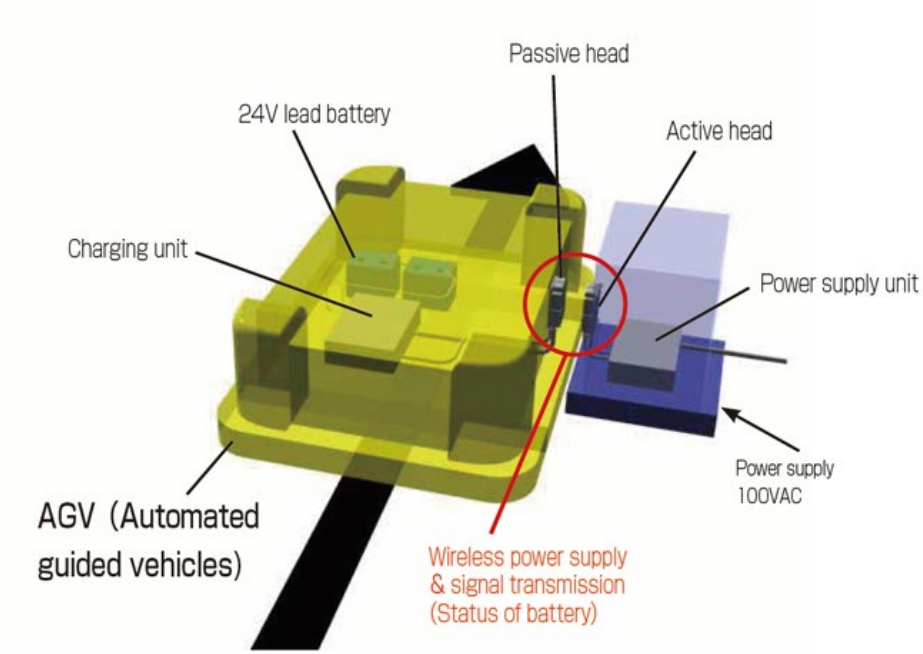
Based on the parameters listed above, the battery life calculator finds the average consumption according to the equation

```
average consumption = (consumption1 * time1 + consumption2 * time2) / (time1 + time2)
```

where index `1` describes the awake mode, and index `2` the sleep mode.

Wireless Charging AGV/AMR

Wireless charging is a trending topic in the **AGV and AMR industry**. More and more Automated Guided Vehicle (AGV) suppliers are slowly incorporating this technology into their robots.



What is AGV wireless charging?

With an **inductive wireless charging system** AGVs and AMRs can perform contactless battery opportunity charging.

The system counts on a **stationary active fixed coil** on the floor on on a wall and on a **mobile passive coil on the mobile robot**.

The active coil generates a magnetic field that induces an alternated current in the mobile coil. This current is used to charge the mobile robot battery.

AGV Wireless Charging Manufacturers

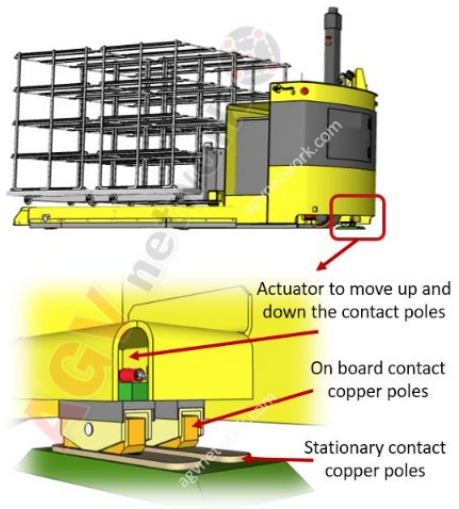
The main AGV and AMR Wireless Charging Systems manufacturers are:

- **B&PLUS**
- **Daihen**
- **Delta Energy Systems**
- **In2Power**
- **WiBotic**
- **Wiferion**

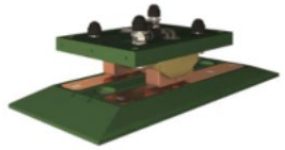
Manufacturer	Description	Available Power (W)
B&PLUS	While many companies are new entrants to the development of wireless power supply technology, we have more than 30 years of experience in developing and manufacturing wireless power supply devices. Rising above the competition, B&PLUS JAPAN provides wireless power transfer (WPT) technologies with wide power range solutions and options for signal transmission.	600 W
DAIHEN	Through the combination between the electric energy specialists DAIHEN and the patented coil technology of Electricity, D-Broad allows for an charging area that is unchallenged in its width. It allows for wireless charging with a maximum gap of 40mm for power receiving & transmission, while the AGV can be stopped with a gap up to 10mm. D-Broad has a charging success rate of 100% (a charging failure = stoppage of the AGV). Until now, a charging failure complaint has not been registered from any of our customers.	Up to 4 kW
DELTA	Delta Energy Systems (Germany) GmbH is the world's leading producer of power supplies for the top names in industrial, medical and consumer electronics devices. We offer innovative wireless battery charging systems for AGV and Forklift applications. No more expensive connectors and cables to replace. Safe, highly reliable, programmable charging for any battery type with CANBus communication and over 93% effi ciency.	From 1 KW up to 30 KW
IN2POWER	In2Power specialises in maximizing the use of time. By optimizing charging opportunities with cutting-edge wireless technology, we are able to create more efficient movements, within the same time frame, compared to traditional charging systems.	1.5/2.5kW (M-SERIES) output <40A 16kW (L-SERIES) in two versions: <250A (18-60VDC) <125A (60-120VDC) It is possible to arrange parallel / multiple application to increase outputs.
WIBOTIC	WiBotic core technology was developed by co-founders, Ben Waters (CEO) and Professor Joshua Smith, at the University of Washington in Seattle. Now headquartered near the UW, the company continues to benefit from a rich pool of technical and managerial talent in one of the country's fastest growing markets. Whether you're landing drones on rooftops, deploying mobile robots across wide areas, attempting to re-power AUVs at depth, or need to reliably power industrial automation equipment, WiBotic offers a wireless charging solution that keeps you moving forward.	Up to 300 W
Wiferion	Wiferion develops and sells energy systems for mobile robotics applications. Our inductive charging system in combination with standardized battery modules, the company offers scalable and modular energy systems. Wiferion's battery modules were optimized for use along with wireless etaLINK chargers. In the system network, Wiferion implements optimal charging processes and can thus ensure the best possible and economical use of the energy storage system.	3kW 12 kW

Contact Charging AMR/AGV – Working Principle

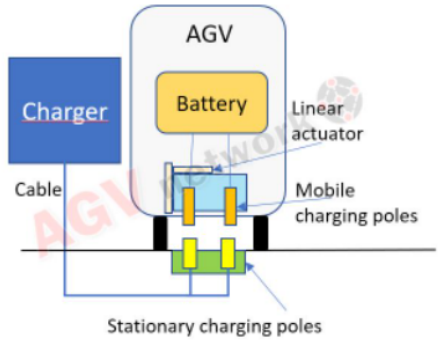
AGV and AMR contact charging system



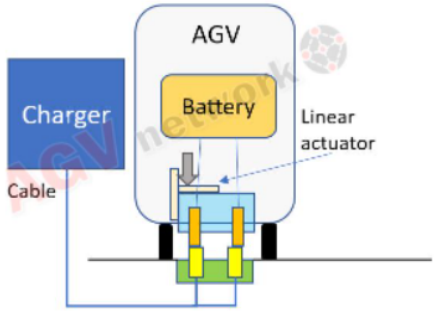
AGV with contact charging poles



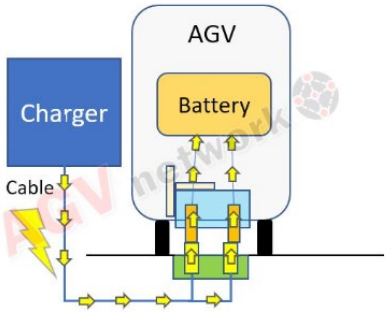
Typical contact charging poles



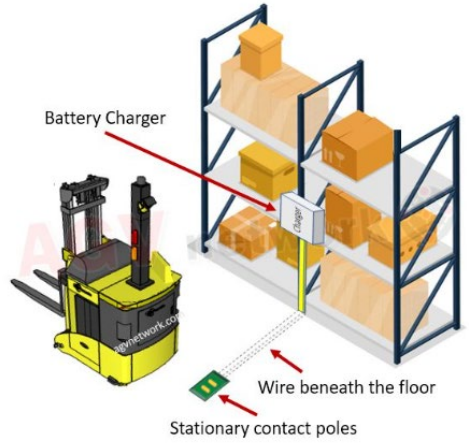
The agv with the onboard charging poles arrives to the charging station. The charging station is composed by the stationary contact poles and the charger.



The AGV moves down the contact poles, in general, tanks to a linear actuator.

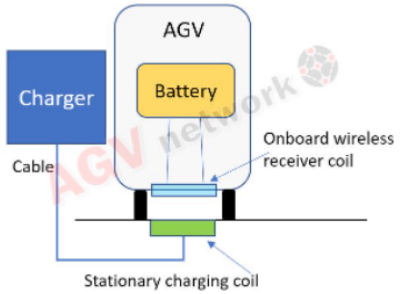


The poles (onboard and stationary) touch. The charger verifies the voltage differential and starts the charging cycle.

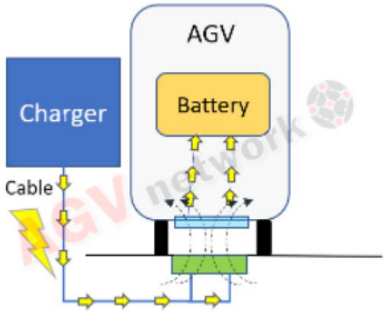


Wireless Charging AMR/AGV – Working Principle

AGV and AMR wireless charging system

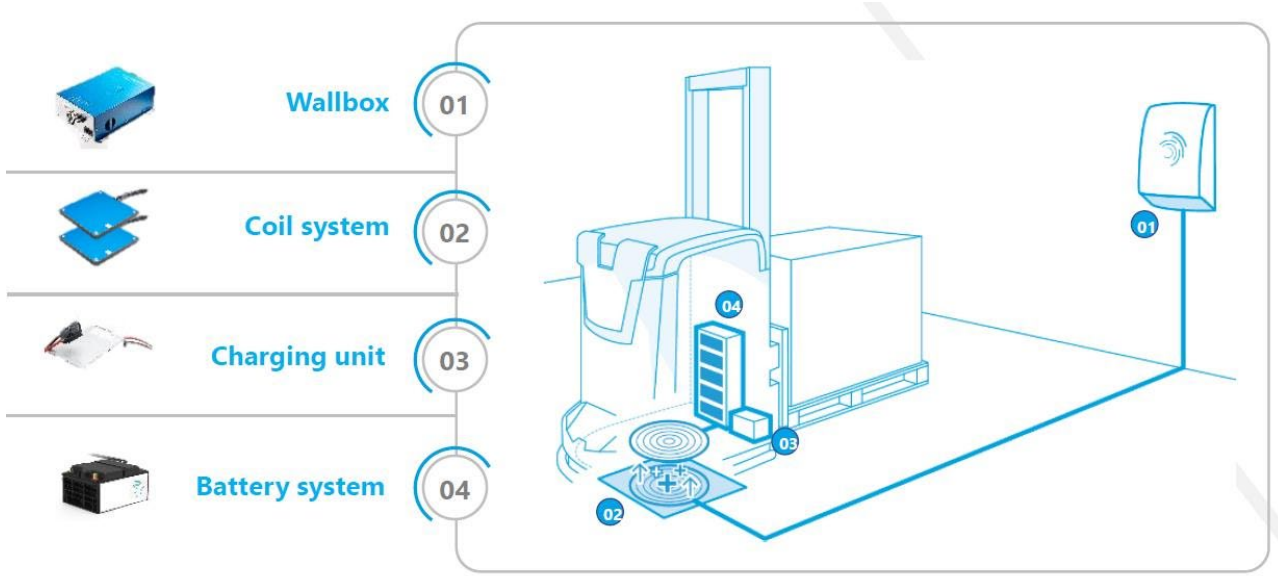


The agv with the onboard charging "coil" arrives to the charging station. The charging station is composed by the "stationary coil" and the charger.



As soon as the onboard coil and the stationary coil overlap, the power is **"magically" transferred without any contact** thanks to the inductive principle.

Mobile Robots Wireless Charging



Basically, regardless the supplier or technology, there are two group elements:

Stationary (on floor or wall): A power transmitter connected to the grid

- Power supply unit (charger).
- Active Coil (stationary charging pad)

Mobile (in the robot): A power receiver attached to the battery.

- Passive Coil (receiver pad)
- Charging unit (to convert AC into DC suitable for the mobile robot batteries)
- Battery

Advantages of Wireless Charging AGV/AMR

The main benefits of contactless charging technology are:

- High Efficiency 93%-95%
- Full Power Of High-Energy Streams Immediately After Start
- No Wear And Tear Or Maintenance As There Are No Contacts Involved
- High Mobile Robot Positioning Tolerance Compared To Contacts And Omnidirectional Charging
- One single wireless charging system can supply power to different vehicles and batteries
- Intelligent data transfer during wireless charging

Full Power Of High-Energy Streams Immediately After Start

With the wireless systems, the battery starts to charge faster compared with contact charging solutions.

In the contact solution, we have a charging module installed in the mobile robot that must move while starting/finishing to charge. This operation is time consuming. Maybe only few seconds, but those seconds add up over time, and time = money.

No Wear And Tear Or Maintenance As There Are No Contacts Involved

As indicated, in the wireless solution, nothing moves. It means a simpler mechanical solution avoiding springs or linear actuators needed in the traditional contact opportunity charging.

It is not easy to define the operational cost due to the “moving parts”, but you can be sure that in the long run, maintenance cost of the whole charging system will be lower with the wireless solution.

Further, traditional contact copper electrodes tend to get dirty and create debris. Debris materials create spiked current arcs that could represent a problem for the robot electronics if not properly protected.

Advantages of Wireless Charging AGV/AMR

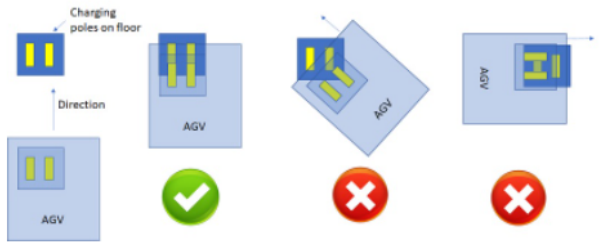
High Mobile Robot Positioning Tolerance Compared To Contacts And Omnidirectional Charging

I love this feature because it is intimately linked to technology behind the mobile robot industry.

The contact charging poles must be in **"contact"**, so AGV positioning will depend on the shape and dimension of these poles (on board and on floor or wall).

Moreover, with the contact charging poles, your Automated Guided Vehicle will probably be required to arrive to the charging station from one single direction.

This feature is very interesting for Autonomous Mobile Robots (AMR), which do not follow a given path and can vary their trajectory depending on surrounding environment.



AGV with contact electrodes for opportunity charging is obliged to arrive from one direction

One single wireless charging system can supply power to different vehicles and batteries

One wireless charging system can provide different Voltages for different battery types.

This means you only need one charging system to charge different vehicles, for example an AGVs with a 48 V lithium-ion battery and an industrial truck with a 24 V lead-acid battery.

All vehicles can use the same charging pad and the system autonomous chooses the right power for the vehicle.

Intelligent data transfer during wireless charging

Some suppliers offer CAN connection allowing to transfer data during the charging process. All the relevant battery and vehicle data can be transferred into a cloud or directly to the AGV management system.

This feature helps to manage and monitor the AGV fleet together with advanced programming of predictive maintenance in order to optimize your logistic process.

Disadvantages of Wireless Charging AGV/AMR

The main drawback for contactless AGV charging is **the financial aspect.**

Initial investment is **relatively high** compared to traditional contact opportunity charging.

Cost (USD)	Contact opportunity charging	Wireless opportunity charging
3 kW battery charger	$ 600,00	$ 1.500,00
On floor charging device (poles or pad)	$ 300,00	$ 500,00
On Vehicle charging device	$ 1.000,00	$ 2.000,00
Total	**$ 1.900,00**	**$ 4.000,00**