Automatic Charging- Electric Vehicles

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***Abstract*—This document is a Thesis and Scientific approach to power saving and autonomous charging capabilities to any automobile running electrically. This can be applied to Ev, Fully-electrical, and Turbocharged vehicles. This approach enables the vehicle to charge on its own with its autonomous capabilities, purely based on Electronics Engineering, programming is merely involved or not involved in some cases depending on the type of vehicle. It works differently for 'Ev', 'Fully-electrical', and 'Turbocharged'. In the process of providing autonomous capabilities right from the book, we will realize that it works much better in India than in any other country. By using this approach, a vehicle does not discharge until the vehicle is stopped, it recharges itself based on RPM and pressure/force. It works on the principle of "Conversion of Rotational Energy into Electrical Energy", by using electrical Transducers, which can convert every possible mechanical impact to electrical energy. The amount of the out generated will always be directly proportional to the input given to the transducer.**

Keywords—Ev, Fully-electrical, Turbocharged, Autonomous, Transducers, RPM, Impact, Rotational energy, Mechanical energy, Electrical energy, Proportionality.

I. Introduction

This is a detailed introduction to electric cars. Today, a majority of electric cars are either DC powered cars or AC powered cars. Due to the complexities involved in the production of AC cars, most of the automobile companies opted for DC a few years ago. This notation and old-school thoughts were provoked and built contemporary AC motor cars with fully-autonomous capabilities including auto-pilot. Whichever type of car it may be, they use batteries to power the motors of the car. Few use multiple batteries in series, few- parallel charging and discharging methods, and few use Lithium-polymer batteries with the advancement of technology.

An **electric car** is a car that is propelled by one or more electric motors, using energy stored in rechargeable batteries. The first practical electric cars were produced in the 1880s. Compared to an Internal Combustion Engine (ICE) cars, electric cars are quieter, have no Exhaust emissions, and lower emissions overall. In the United States, as of 2020, the total cost of ownership of recent EVs is cheaper than that of equivalent ICE cars, due to lower re-fuel and maintenance costs. Charging an electric car can be done at a variety of charging stations; these charging stations can be installed in both houses and public areas.

Several countries have established government incentives for plug-in electric vehicles, phase-out of fossil fuel vehicles, and California, which is one of the largest vehicle markets, has an executive order to ban sales of new gasoline-powered vehicles by 2035.

The Tesla Model 3, which has a maximum range of 570 km (353 miles) according to the EPA, was the world's best-selling electric vehicle (EV) on an annual basis starting in 2018 and became the world's all-time best selling electric car in early 2020.

As of December 2019, the global stock of pure electric passenger cars totaled 4.8 million units, representing two-thirds of all plug-in passenger cars in use. In 2019, over half (54%) of the world's all-electric car fleet was in China. Despite rapid growth, the global stock of *pure electric* and *Plugin hybrid (PHEV)* cars represented about 1 out of every 200 vehicles (0.48%) on the world's roads by the end of 2019, of which pure electrics comprised 0.32%.

An **induction motor** or **asynchronous motor** is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. An induction motor can therefore be made without electrical connections to the rotor. An induction motor's rotor can be either wound type or squirrel-cage type.

Three-phase squirrel-cage induction motors are widely used as industrial drives because they are self-starting, reliable, and economical. Single-phase induction motors are used extensively for smaller loads, such as household appliances like fans. Although traditionally used in fixed-speed service, induction motors are increasingly being used with variable-frequency drives (VFD) in variable-speed service. VFDs offer especially important energy savings opportunities for existing and prospective induction motors in variable-torque centrifugal fan, pump, and compressor load applications. Squirrel-cage induction motors are very widely used in both fixed-speed and variable-frequency drive applications.

Figure-1: Tesla Induction Motor, Tesla Museum, Belgrade, Serbia

(By Ctac - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=22227209)

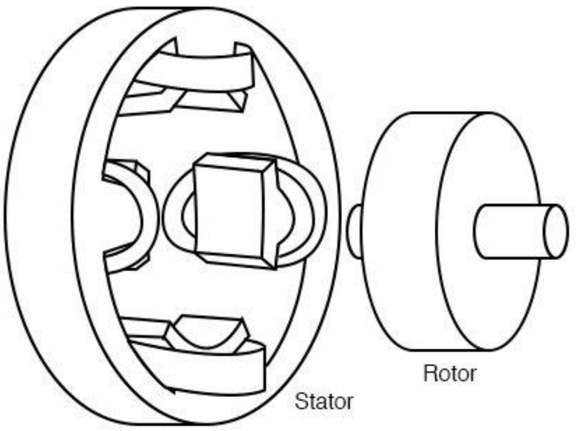

Figure- 2: Tesla Poly-phase AC Induction Motor

https://www.allaboutcircuits.com/textbook/alternating-current/chpt-13/tesla-polyphase-induction-motors/

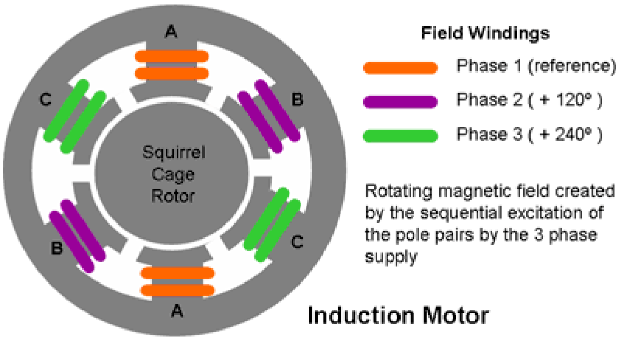

Figure- 3: Internal Structure of Poly-phase AC Induction motor.

https://www.mpoweruk.com/motorsac.htm

A **transducer** is a device that converts energy from one form to another. Usually, a transducer converts a signal in one form of energy to a signal in another. Transducers are often employed at the boundaries of automation, measurement, and control systems, where electrical signals are converted to and from other physical quantities (energy, force, torque, light, motion, position, etc.). The process of converting one form of energy to another is known as transduction.

An **electrical transducer** is a device that is capable of converting physical quantities into a proportional electrical quantity such as voltage or electric current. Hence it converts any quantity to be measured into a usable electrical signal. This physical quantity which is to be measured can be pressure, level, temperature, displacement, etc. The output which is obtained from the transducer is in the electrical form and is equivalent to the measured quantity. For example, a temperature transducer will convert temperature to an equivalent electrical potential. This output signal can be used to control the physical quantity or display it.

Instrumentation is the heart of industrial applications. Instrumentation is the art and science of measuring and controlling different variables such as flow, level, temperature, angle, displacement, etc. A basic instrumentation system consists of various devices. One of these various devices is a **transducer**. A **transducer** plays a very important role in any instrumentation system.

Note that any device which can convert one form of energy into another form is called a **transducer**. For example, even a speaker can be called a transducer as it converts an electrical signal to pressure waves (sound). But an electrical transducer will convert a physical quantity to an electrical one.

A. Types of Transducer

There are many different **types of transducer**, they can be classified based on various criteria as:

1) Types of transducer based on the quantity to be measured:

- Temperature Transducers (e.g. Thermocouples)
- Pressure transducers (e.g. a diaphragm)
- Displacement transducers (e.g. LVDT)
- Oscillator transducers
- Flow transducers
- Inductive Transducer

2) Types of Transducer based on the Principle of Operation:

- Photovoltaic (e.g. a solar cell)
- Piezoelectric transducer
- Chemical
- Mutual induction
- Electromagnetic
- Hall effect
- Photoconductors

3) Types of Transducer based on Whether an External Power Source is required or not:

- ***Active Transducer:***

Active transducers are those which do not require any power source for their operation. They work on the energy conversion principle. They produce an electrical signal proportional to the input (physical quantity). For example, a thermocouple is an active transducer.

- ***Passive Transducer:***

Transducers which require an external power source for their operation is called as a passive transducer. They produce an output signal in the form of some variation in resistance, capacitance or any other electrical parameter, which than has to be converted to an equivalent current or voltage signal. For example, a photocell (LDR) is a passive transducer which will vary the resistance of the cell when light falls on it. This change in resistance is converted to proportional signal with the help of a bridge circuit. Hence a photocell can be used to measure the intensity of light.

Rotary Torque Sensors are widely used to verify the torque of tools. These strain gage-based transducers are fitted on the output drive of a power tool and measure the torque applied by the tool on an actual assembly. This measurement provides important information about the tool shut off and can assist in establishing specifications for proper assembly.

When equipped with an optional angle encoder, the rotary torque transducer can also measure the angle of rotation which is an important indication of joint integrity.

Figure- 4: Angle Encoder (https://www.heidenhain.us/resources-and-news/heidenhain-eca-4000-absolute-angle-encoder-high-precision-modular-robust-universal-utilization/)

Torque-angle transducers can provide the data to draw torque vs. time or torque vs. angle plots that can help analyze problems and determine appropriate strategies. They are also a key component of a threaded torque tension testing machine.

Rotary torque transducers are available in capacities ranging from 32 ozf-in to 18k lbf-ft (0.23 to 25k Nm).

Figure- 5: Rotary Torque Transducers

(https://www.pcb.com/sensors-for-test-measurement/fastener-technology/fastener-testing/rotary-torque-transducers)

The above shown rotary torque transducers are a type of electromechanical type transducers, which convert mechanical signals/energy to electrical signals/energy. In our case, it is “RPM/torque is converted to electrical signals.”

Such conversion and measurement ensure the power-saving and intimation about failure and can provide electrical feedback. These transducers when interfaced with either a microcontroller or a tank circuit or a signal conditioning system, can generate higher amplitude signals by removing noise by signal conditioning circuits and increasing frequency by tank circuits.

Tank circuits usually are used to generate desired frequencies from a limited power supply. That simply means we are converting a DC source to an AC signal by using tank circuits. These tank circuits when employed along with Oscillators, can achieve desired frequencies by adjusting LC and RC circuits. By increasing the resistance of the resistors, capacitance of capacitors, inductance of inductors, in the circuit we can bring out required technical AC frequencies.

The main types of Oscillators include:

- Wien Bridge Oscillator
- RC Phase Shift Oscillator
- Hartley Oscillator
- Voltage Controlled Oscillator
- Colpitts Oscillator
- Clapp Oscillators
- Crystal Oscillators
- Armstrong Oscillator
- Tuned Collector Oscillator
- Gunn Oscillator
- Cross-Coupled Oscillators
- Ring Oscillators
- Dynatron Oscillators
- Meissner Oscillators
- Opto-Electronic Oscillators
- Pierce Oscillators
- Robinson Oscillators
- Tri-tet Oscillators
- Pearson-Anson Oscillators
- Delay-Line Oscillators
- Royer Oscillators
- Electron Coupled Oscillators
- Multi-Wave Oscillators

The most commonly used oscillators are:

B. ***Hartley Oscillator:***

Hartley Oscillator is a type of harmonic oscillator which was invented by Ralph Hartley in 1915. These are the Tuned Circuit Oscillators which are used to produce the waves in the range of radiofrequency and hence are also referred to as RF Oscillators. Its frequency of oscillation is decided by its tank circuit which has a capacitor connected in parallel with the two serially connected inductors, as shown in Figure below.

Here the R_C is the collector resistor while the emitter resistor R_E forms the stabilizing network. Further the resistors R_1 and R_2 form the voltage divider bias network for the transistor in common-emitter CE configuration. Next, the capacitors C_i and C_o are the input and output decoupling capacitors while the emitter capacitor C_E is the bypass capacitor used to bypass the amplified AC signals. All these components are identical to those present in the case of a common-emitter amplifier which is biased using a voltage divider network. However, Figure 1 also shows one more set of components viz., the inductors L_1 and L_2, and the capacitor C which form the tank circuit (shown in the red enclosure).

On switching ON the power supply, the transistor starts to conduct, leading to an increase in the collector current, I_C which charges capacitor C. On acquiring the maximum charge feasible, C starts to discharge via the inductors L_1 and L_2. These charging and discharging cycles result in the damped oscillations in the tank circuit. The oscillation current in the tank circuit produces an AC voltage across the inductors L_1 and L_2 which are out of phase by 180^o as their point of contact are grounded.
Further from the figure, the output of the amplifier is applied across the inductor L_1 while the feedback voltage drawn across L_2 is applied to the base of the transistor. Thus, one can conclude that the output of the amplifier is in-phase with the tank circuit's voltage and supplies back the energy lost by it while the energy fed back to the amplifier circuit will be out-of-phase by 180^o. The feedback voltage which is already 180^o out-of-phase with the transistor is provided by an additional 180^o phase-shift due to the transistor action. Hence the signal which appears at the transistor's output will be amplified and will have a net phase-shift of 360^o.

$$\beta = \frac{L_1}{L_2};\ \textit{if the coils are wound on different cores}$$

$$\beta = \frac{L_1 + M}{L_2 + M}$$

Figure- 6: Calculation of magnetic Induction produced by the tank circuit
https://www.electrical4u.com/hartley-oscillator/

$$F = \frac{1}{2\pi\sqrt{L_{eff}C}}$$

$$L_{eff}\ \textit{is the effective series inductance which is expressed as}$$
$$L_{eff} = L_1 + L_2;\ \textit{if the coils are wound on different cores}$$
$$L_{eff} = L_1 + L_2 + 2M;\ \textit{if the coils are wound on the same core}$$

Figure- 7: Calculation of frequency produced by the tank circuit
https://www.electrical4u.com/hartley-oscillator/

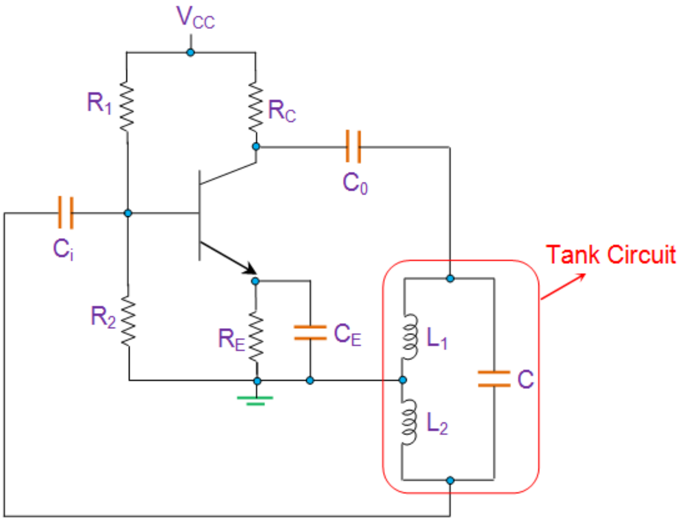

Figure- 8: Circuit Diagram of Hartley Oscillator with a tank circuit

https://www.electrical4u.com/hartley-oscillator/

C. *Collpit's Oscillator*

Colpitts Oscillator is a type of LC oscillator which falls under the category of Harmonic Oscillator and was invented by Edwin Colpitts in 1918. Figure 1 shows a typical Colpitts oscillator with a tank circuit in which an inductor L is connected in parallel to the serial combination of capacitors C_1 and C_2 (shown by the red enclosure). On switching ON the power supply, the transistor starts to conduct, leading to an increase in the collector current, I_C which charges capacitor C. On acquiring the maximum charge feasible, C starts to discharge via the inductors L_1 and L_2. These charging and discharging cycles result in the damped oscillations in the tank circuit. The oscillation current in the tank circuit produces an AC voltage across the inductors L_1 and L_2 which are out of phase by 180^o as their point of contacts are grounded.

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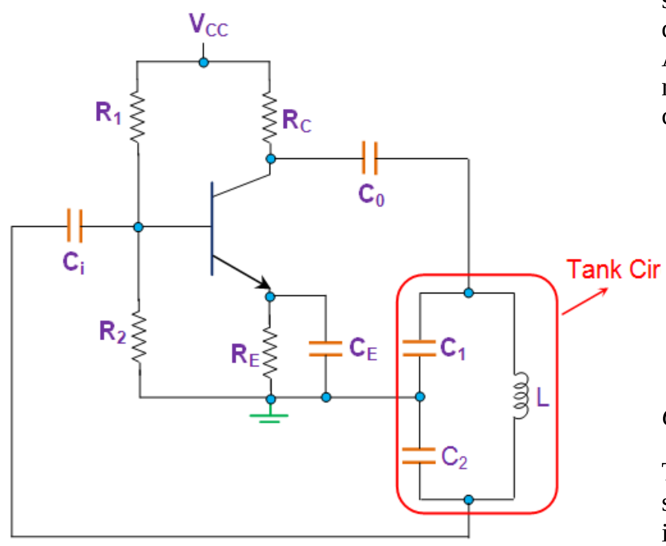

Figure- 9: Circuit Diagram of Colpitts Oscillator with a tank circuit

https://www.electrical4u.com/colpitts-oscillator/

Hence from fig.6, we can say that the frequency produced by the circuit is dependent on the values of the tank circuit, LC values. Thus, by changing the values of the tank circuit we can ensure the production of desired frequencies required enough.

II. Ease of Use

A. *Maintaining the Integrity of the Specifications*

First, confirm that we have properly calculated the required frequency and power required by the lithium-ion or lithium-polymer batteries used in cars, we design the tank circuit and set the LC values accordingly. Once we set LC values, we get the desired frequency, which is required by the AC induction motor.

Now, decide the values of the resistors and capacitors of the oscillator circuit or purchase an after-market readymade oscillator. Connect the tank circuit to the oscillator. (If purchased an after-market oscillator, look into the datasheet provided by the manufacturer for the technical specifications of the oscillator. Check with the specifications and purchase the oscillator).

B. *Assembly of the hardware*

Once all the values are properly diagnosed by mainstream experts, we can start the assembly process.

The Assembly process starts by connecting all the individual electronic components. To start with, connect the oscillator to the transducer followed by the signal conditioning circuit, the output of the signal conditioning circuit is connected to the battery. This mechanism is called feedback to the battery. As the batteries are rechargeable, we can connect the output leads of the signal conditioning system to the charging circuit. This way, a two-way charging mechanism is achieved and employed in the system.

The torque transducers convert the RPM to 5v electrical signal, which is then given to the oscillator circuit to get the desired frequency and amplified voltage. Thus, the produced Ac signal is sent to the signal conditioning systems to remove any noise. The clean signal is then sent to the charging circuit of the battery to ensure two-way charging.

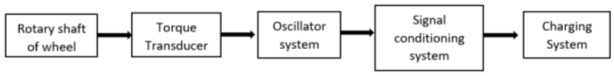

Figure- 9.1: Block diagram

C. *Implementation for Indian roads*

The above-designed system can convert RPM to electrical signals, but cannot ensure proper working due to the irregularities on Indian local roads.

On uneven roads, when the wheels travel they undergo the impact of shocks which are absorbed by the shock absorbers, usually torsion springs, hydraulic suspension, air suspension. Despite such absorption, rotating wheels stop the rotation on such roads for a few seconds, the speed also must be reduced on such bumps or potholes to ensure vehicle health. Under such circumstances, the above designed/described system may not justify the cause.

Hence, we need to develop a system along with the above one.

Here, we need to employ another flagship electromechanical transducer, which should take the impact of the shock absorbers as mechanical input and convert this mechanical force/pressure/strain/displacement to electrical output.

The force/pressure/displacement/strain is decided according to the suspension used in the vehicle. Because different suspensions undergo different types of impacts. For example, torsion springs undergo strain, force, and pressure, also displacement but negligible amount hence ruled out that parameter. So, in the case of torsion spring, we must use strain-electrical or force-electrical or pressure-electrical transducers. Likewise, the employment of transducers is decided by the vendor then are manufactured to the cause.

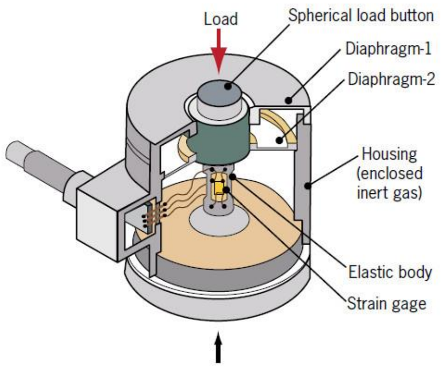

Figure- 10: Force transducer/ Load cell
https://www.tekscan.com/resources/whitepaper/load-cell-vs-force-sensor

Figure- 11: Ring force transducer
(By https://www.wika.co.in/f6212_en_co.WIKA)

This can be used only for axial forces. For multi-purpose utility, we can high sensitivity load cell or force transducers. These load cells and force transducers work on a principle of converting force or strain imposed on the transducer is converted into electrical output. Such produced electrical would be very less, thus needed to be optimized to the requirements of the user.

Usually, the transducers come with various specifications, those specifications can be known by skimming through the datasheet provided by the manufacturer

Figure- 12: Compression force transducer
https://www.flintec.com/br/sensores-de-peso/sensores-de-forca/miniatura/mht2

Instead of using this compression type force transducers, we can also opt for load cells, load cells also operate merely on the same principle but the working and practicality are different. Here, only the compression pressures/forces are converted, whereas in the load cells even the small amount of strain also can be converted to electrical output.

Figure- 13: Load cell type transducer
https://www.flintec.com/weight-sensors/force-sensors/miniature/mk

Whenever the button on the load cell subjects to any load, it detects the amount of load applied and is converted to electrical output.

Such produced electrical output is given to circuits. In our case, replace torque transducers with these, and the rest of the circuitry remains the same.
Likewise, we can convert the impact of shocks to required electrical output and feed to the charging leads of the charging system of the car by ensuring two-way charging.

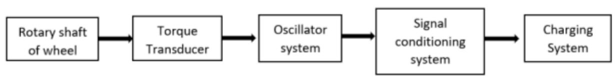

Figure- 12.1: Block diagram

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