Near East University

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FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRIC-ELECTRONIC ENGINEERING

EE400 GRADUATION PROJECT

(Energy Conservation)

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INTRODUCTION

In daily life, when electrical motors operate excess energy is obtained in the system. Motors used in pumping system. For example use to much energy to start and they should be turned on and off continuously for some cases.

While runing such engine systems by the help of an extra belt and flywheel mechanism can transfer the extra energy produced to low power systems to operate them by rotating an alternator, to save energy.

ABSTRACT

In this Project the electrical energy is converted to mechanical energy and then the mechanical energy is converted to electrical energy and in this way an energy gain is achieved. This system is build and operated.

The system equipment and the properties of these equipment are explained in detail in the text. The system is designed according to the specifications of the equipment used.

Special case should be taken while working with the system as high-voltage and high-speed elements are present in the system.

CHEPTER 1

POWER INVERTER

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).

The input voltage, output voltage and frequency, and overall power handling, are dependent on the design of the specific device or circuitry.

A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

1.1 Input and output

1.1.1 Input voltage :

A typical power inverter device or circuit will require a relatively stable DC power source capable of supplying enough current for the intended overall power handling of the inverter. Possible DC power sources include: rechargeable batteries, DC power supplies operating off of the power company line, and solar cells. The inverter does not produce any power, the power is provided by the DC source. The inverter translates the form of the power from direct current to an alternating current waveform.

The level of the needed input voltage depends entirely on the design and purpose of the inverter. In many smaller consumer and commercial inverters a 12V DC input is popular because of the wide availability of powerful rechargeable 12V lead acid batteries which can be used as the DC power source.

1.1.2 Output waveform :

An inverter can produce square wave, modified sine wave, pulsed sine wave, or sine wave depending on circuit design. The two dominant commercialized waveform types of inverters as of 2007 are modified sine wave and sine wave.

There are two basic designs for producing household plug-in voltage from a lower-voltage DC source, the first of which uses a switching boost converter to produce a higher-voltage DC and then converts to AC. The second method converts DC to AC at battery level and uses a line-frequency transformer to create the output voltage.

1.1.2.1 Square wave :

This is one of the simplest waveforms an inverter design can produce and is useful for some applications.

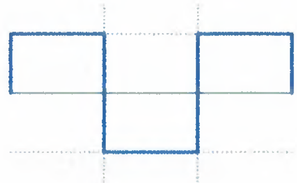

Fig . 1.1.2.1 Square wave

1.1.2.2 Sine wave :

A power inverter device which produces a smooth sinusoidal AC waveform is referred to as a sine wave inverter. To more clearly distinguish from "modified sine wave" or other creative terminology, the phrase pure sine wave inverter is sometimes used.

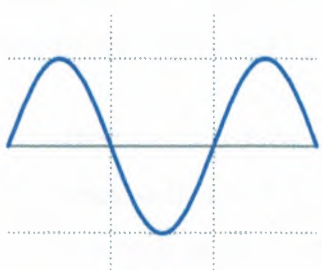

Fig. 1.1.2.2 Sine wave

In situations involving power inverter devices which substitute for standard line power, a sine wave output is extremely desirable because the vast majority of electric plug in products and appliances are engineered to work well with the standard electric utility power which is a true sine wave.

At present, sine wave inverters tend to be more complex and have significantly higher cost than a modified sine wave type of the same power handling.

1.1.2.3 Modified sine wave :

The terminology "modified sine wave" has come into use and refers to an output waveform that is a useful rough approximation of a sine wave for power translation purposes.

The waveform in commercially available modified-sine-wave inverters is a square wave with a pause before the polarity transition, which only needs to cycle through a three-position switch that outputs forward, off, and reverse output at the pre-determined frequency. Switching states are developed for positive, negative and zero voltages as per the patterns given in the switching Table 2. The peak voltage to RMS voltage do not maintain the same relationship as for a sine wave. The DC bus voltage may be actively regulated or the "on" and "off" times can be modified to maintain the same RMS value output up to the DC bus voltage to compensate for DC bus voltage variation.

The ratio of on to off time can be adjusted to vary the RMS voltage while maintaining a constant frequency with a technique called PWM. The generated gate pulses are given to each switch in accordance with the developed pattern and thus the output is obtained. Thus the Simulink model and output voltage waveform of Asymmetric multilevel inverter circuit uses asymmetric voltages sources to produce 27 levels.Harmonic spectrum in the output depends on the width of the pulses and the modulation frequency. When operating induction motors, voltage harmonics is not of great concern, however harmonic distortion in the current waveform introduces additional heating, and can produce pulsating torques.

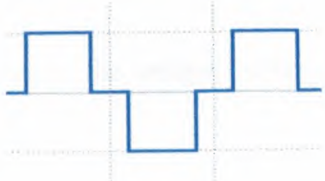

Fig. 1.1.2.3 Modifild sine wave

Numerous electric equipment will operate quite well on modified sine wave power inverter devices, especially any load that is resistive in nature such as a traditional incandescent light bulb.

Most AC motors will run on MSW inverters with an efficiency reduction of about 20% due to the harmonic content.

1.1.2.4 Other waveforms :

By definition there is no restriction on the type of AC waveform an inverter might produce that would find use in a specific or special application.

1.1.3 Output frequency :

The AC output frequency of a power inverter device is often the same as the standard power line frequency, for example 60 or 50 cycles per second.

If the output of the device or circuit is to be further conditioned (say stepped up by a follow on transformer) then the frequency may be much higher for good transformer efficiency.

1.1.4 Output voltage :

The AC output voltage of a power inverter device is often the same as the standard power line voltage, such as household 120VAC or 240VAC. This allows the inverter to power numerous types of equipment designed to operate off the standard line power.

The designed for output voltage is often provided as a regulated output. That is, changes in the load the inverter is driving will not result in output voltage change from the inverter.

In a sophisticated inverter, the output voltage may be selectable or even continuously variable.

1.1.5 Output power :

A power inverter will often have an overall power rating expressed in watts or kilowatts. This describes the power that will be available to the device the inverter is driving and, indirectly, the power that will be needed from the DC source. Smaller popular consumer and commercial devices designed to mimic line power typically range from 150 to 3000 watts.

Not all inverter applications are primarily concerned with brute power delivery, in some cases the frequency and or waveform properties are used by the follow on circuit or device.

1.2 Applications

1.2.1 DC power source utilization :

An inverter converts the DC electricity from sources such as batteries or fuel cells to AC electricity. The electricity can be at any required voltage; in particular it can operate AC equipment designed for mains operation, or rectified to produce DC at any desired voltage.

1.2.2 Uninterruptible power supplies :

An uninterruptible power supply (UPS) uses batteries and an inverter to supply AC power when main power is not available. When main power is restored, a rectifier supplies DC power to recharge the batteries.

1.2.3 Electric motor speed control :

Inverter circuits designed to produce a variable output voltage range are often used within motor speed controllers. The DC power for the inverter section can be derived from a normal AC wall outlet or some other source. Control and feedback circuitry is used to adjust the final output of the inverter section which will ultimately determine the speed of the motor operating under its mechanical load. Motor speed control needs are numerous and include things like: industrial motor driven equipment, electric vehicles, rail transport systems, and power tools. Switching states are developed for positive, negative and zero voltages as per the patterns given in the switching Table 1.The generated gate pulses are given to each switch in accordance with the developed pattern and thus the output is obtained. Thus the Simulink model and output voltage waveform of Symmetric multilevel inverter

1.2.4 Power grid :

Grid-tied inverters are designed to feed into the electric power distribution system. They transfer synchronously with the line and have as little harmonic content as possible. They also need a means of detecting the presence of utility power for safety reasons, so as not to continue to dangerously feed power to the grid during a power outage.The subsystem which includes sinusoidal and triangular subsystem brief about the comparison of sine wave which is the modulated signal and is compared with carrier signal. When the reference signal is greater than or equal to carrier signal, then the output waveform is above the reference and otherwise it will be below the reference.

1.2.5 Solar :

A solar inverter can be fed into a commercial electrical grid or used by an off-grid electrical network. Solar inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection. Micro-inverters convert direct current from individual solar panels into alternating current for the electric grid. They are grid tie designs by default.

1.2.6 Induction heating :

Inverters convert low frequency main AC power to higher frequency for use in induction heating. To do this, AC power is first rectified to provide DC power. The inverter then changes the DC power to high frequency AC power.Due to the reduction in the number of DC Sources employed the structure become more reliable and the output voltage has higher resolution due to increase in the number of steps and the reference sinusoidal voltage can be better achieved. This configuration recently becomes very popular in AC power supply and adjustable speed drive applications. This new inverter can avoid extra clamping diodes or voltage balancing capacitors There are three kinds of level shifted modulation techniques, namely;

Phase Opposition Disposition (POD)

Alternative Phase Opposition Disposition (APOD) Phase Disposition (PD)

1.2.7 HVDC power transmission :

With HVDC power transmission, AC power is rectified and high voltage DC power is transmitted to another location. At the receiving location, an inverter in a static inverter plant converts the power back to AC. The inverter must be synchronized with grid frequency and phase and minimize harmonic generation.

1.2.8 Electroshock weapons :

Electroshock weapons and tasers have a DC/AC inverter to generate several tens of thousands of V AC out of a small 9 V DC battery. First the 9VDC is converted to 400–2000V AC with a compact high frequency transformer, which is then rectified and temporarily stored in a high voltage capacitor until a pre-set threshold voltage is reached. When the threshold (set by way of an airgap or TRIAC) is reached, the capacitor dumps its entire load into a pulse transformer which then steps it up to its final output voltage of 20–60 kV. A variant of the principle is also used in electronic flash and bug zappers, though they rely on a capacitor-based voltage multiplier to achieve their high voltage.

1.3 Circuit description

1.3.1 Basic designs :

In one simple inverter circuit, DC power is connected to a transformer through the center tap of the primary winding. A switch is rapidly switched back and forth to allow current to flow back to the DC source following two alternate paths through one end of the primary winding and then the other. The alternation of the direction of current in the primary winding of the transformer produces alternating current (AC) in the secondary circuit.

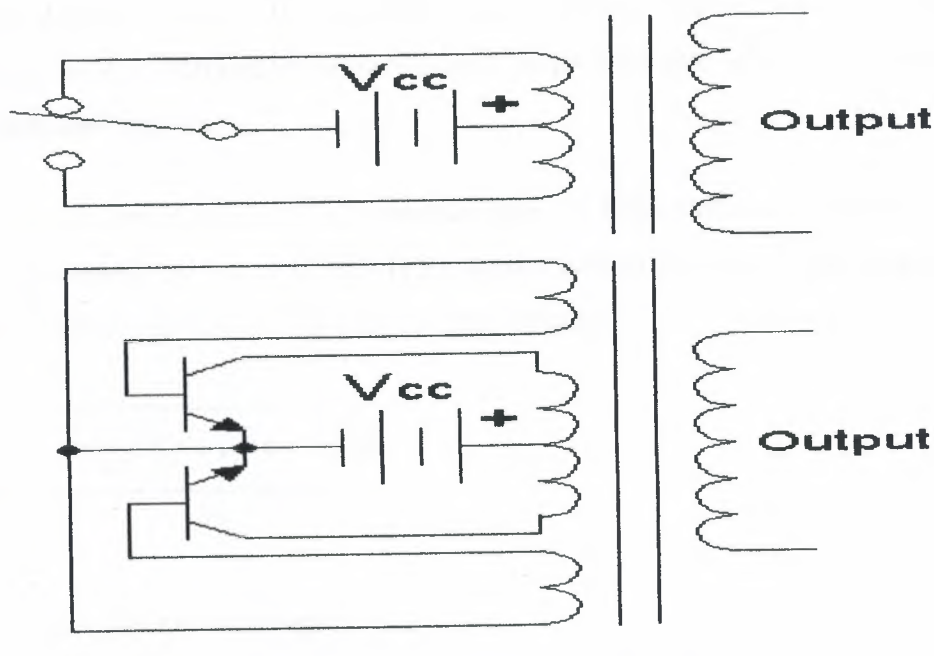

Fig. 1.3.1.1 Basic power inverter circuit

The electromechanical version of the switching device includes two stationary contacts and a spring supported moving contact. The spring holds the movable contact against one of the stationary contacts and an electromagnet pulls the movable contact to the opposite stationary contact. The current in the electromagnet is interrupted by the action of the switch so that the switch continually switches rapidly back and forth. This type of electromechanical inverter switch, called a vibrator or buzzer, was once used in vacuum tube automobile radios. A similar mechanism has been used in door bells, buzzers and tattoo machines.

As they became available with adequate power ratings, transistors and various other types of semiconductor switches have been incorporated into inverter circuit designs. Certain ratings, especially for large systems (many kilowatts) use thyristors (SCR). SCRS provide large power handling capability in a semiconductor device, and can readily be controlled over a variable firing range.

The switch in the simple inverter described above, when not coupled to an output transformer, produces a square voltage waveform due to its simple off and on nature as opposed to the sinusoidal waveform that is the usual waveform of an AC power supply. Using Fourier analysis, periodic waveforms are represented as the sum of an infinite series of sine waves. The sine wave that has the same frequency as the original waveform is called the fundamental component. The other sine waves, called harmonics, that are included in the series have frequencies that are integral multiples of the fundamental frequency.

Fourier analysis can be used to calculate the total harmonic distortion (THD). The total harmonic distortion (THD) is the square root of the sum of the squares of the harmonic voltages divided by the fundamental voltage:

$$\mathrm{THD} = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \cdots + V_n^2}}{V_1}$$

1.3.2 Advanced designs :

There are many different power circuit topologies and control strategies used in inverter designs. Different design approaches address various issues that may be more or less important depending on the way that the inverter is intended to be used.

The issue of waveform quality can be addressed in many ways. Capacitors and inductors can be used to filter the waveform. If the design includes a transformer, filtering can be applied to the primary or the secondary side of the transformer or to both sides. Low-pass filters are applied to allow the fundamental component of the waveform to pass to the output while limiting the passage of the harmonic components. If the inverter is designed to provide power at a fixed frequency, a resonant filter can be used. For an adjustable frequency inverter, the filter must be tuned to a frequency that is above the maximum fundamental frequency.

Since most loads contain inductance, feedback rectifiers or antiparallel diodes are often connected across each semiconductor switch to provide a path for the peak inductive load current when the switch is turned off. The antiparallel diodes are somewhat similar to the *freewheeling diodes* used in AC/DC converter circuits.

Fourier analysis reveals that a waveform, like a square wave, that is anti-symmetrical about the 180 degree point contains only odd harmonics, the 3rd, 5th, 7th, etc. Waveforms that have steps of certain widths and heights can attenuate certain lower harmonics at the expense of amplifying higher harmonics. For example, by inserting a zero-voltage step between the positive and negative sections of the square-wave, all of the harmonics that are divisible by three (3rd and 9th, etc.) can be eliminated. That leaves only the 5th, 7th, 11th, 13th etc. The required width of the steps is one third of the period for each of the positive and negative steps and one sixth of the period for each of the zero-voltage steps.

Changing the square wave as described above is an example of pulse-width modulation (PWM). Modulating, or regulating the width of a square-wave pulse is often used as a method of regulating or adjusting an inverter's output voltage. When voltage control is not required, a fixed pulse width can be selected to reduce or eliminate selected harmonics. Harmonic elimination techniques are generally applied to the lowest harmonics because filtering is much more practical at high frequencies, where the filter components can be much smaller and less expensive. Multiple pulse-width or carrier based PWM control schemes produce waveforms that are composed of many narrow pulses. The frequency represented by the number of narrow pulses per second is called the switching frequency or carrier frequency. These control schemes are often used in variable-frequency motor control inverters because they allow a wide range of output voltage and frequency adjustment while also improving the quality of the waveform.

Multilevel inverters provide another approach to harmonic cancellation. Multilevel inverters provide an output waveform that exhibits multiple steps at several voltage levels. For example, it is possible to produce a more sinusoidal wave by having split-rail direct current inputs at two voltages, or positive and negative inputs with a central ground. By connecting the inverter output terminals in sequence between the positive rail and ground, the positive rail and the negative rail, the ground rail and the negative rail, then both to the ground rail, a stepped waveform is generated at the inverter output. This is an example of a three level inverter: the two voltages and ground.

1.3.3 More on achieving a sine wave :

Resonant inverters produce sine waves with LC circuits to remove the harmonics from a simple square wave. Typically there are several series- and parallel-resonant LC circuits, each tuned to a different harmonic of the power line frequency. This simplifies the electronics, but the inductors and capacitors tend to be large and heavy. Its high efficiency makes this approach popular in large uninterruptible power supplies in data centers that run the inverter continuously in an "online" mode to avoid any switchover transient when power is lost. (See related: Resonant inverter)

A closely related approach uses a ferroresonant transformer, also known as a constant voltage transformer, to remove harmonics and to store enough energy to sustain the load for a few AC cycles. This property makes them useful in standby power supplies to eliminate the switchover transient that otherwise occurs during a power failure while the normally idle inverter starts and the mechanical relays are switching to its output.

1.3.4 Enhanced quantization :

A proposal suggested in Power Electronics magazine utilizes two voltages as an improvement over the common commercialized technology which can only apply DC bus voltage in either directions or turn it off. The proposal adds an additional voltage to this design. Each cycle consists of sequence as: v1, v2, v1, off/pause, -v1, -v2, -v1.

1.3.5 Three phase inverters :

Three-phase inverters are used for variable-frequency drive applications and for high power applications such as HVDC power transmission. A basic three-phase inverter consists of three single-phase inverter switches each connected to one of the three load terminals. For the most basic control scheme, the operation of the three switches is coordinated so that one switch operates at each 60 degree point of the fundamental output waveform. This creates a line-to-line output waveform that has six steps. The six-step waveform has a zero-voltage step between the positive and negative sections of the square-wave such that the harmonics that are multiples of three are eliminated as described above. When carrier-based PWM techniques are applied to six-step waveforms, the basic overall shape, or envelope, of the waveform is retained so that the 3rd harmonic and its multiples are cancelled.

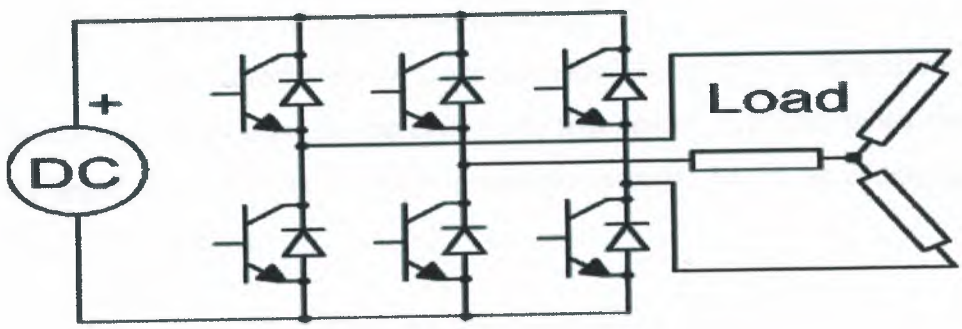

Fig. 1.3.5.1 Basic three phase inverters circuit

To construct inverters with higher power ratings, two six-step three-phase inverters can be connected in parallel for a higher current rating or in series for a higher voltage rating. In either case, the output waveforms are phase shifted to obtain a 12-step waveform. If additional inverters are combined, an 18-step inverter is obtained with three inverters etc. Although inverters are usually combined for the purpose of achieving increased voltage or current ratings, the quality of the waveform is improved as well.

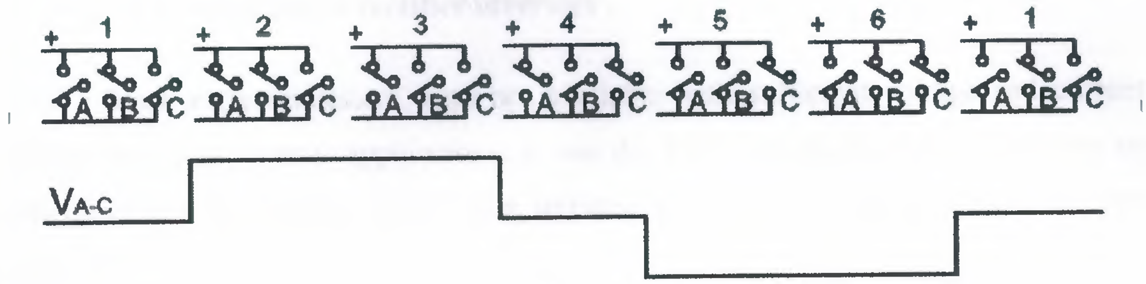

Fig. 1.3.5.2 Three phase inverter wave diagram

1.4 History

1.4.1 Early inverters :

From the late nineteenth century through the middle of the twentieth century, DC-to-AC power conversion was accomplished using rotary converters or motor-generator sets (M-G sets). In the early twentieth century, vacuum tubes and gas filled tubes began to be used as switches in inverter circuits. The most widely used type of tube was the thyratron.

The origins of electromechanical inverters explain the source of the term inverter. Early AC-to-DC converters used an induction or synchronous AC motor direct-connected to a generator (dynamo) so that the generator's commutator reversed its connections at exactly the right moments to produce DC. A later development is the synchronous converter, in which the motor and generator windings are combined into one armature, with slip rings at one end and a commutator at the other and only one field frame. The result with either is AC-in, DC-out. With an M-G set, the DC can be considered to be separately generated from the AC; with a synchronous converter, in a certain sense it can be considered to be "mechanically rectified AC". Given the right auxiliary and control equipment, an M-G set or rotary converter can be "run backwards", converting DC to AC. Hence an inverter is an inverted converter.

1.4.2 Controlled rectifier inverters :

Since early transistors were not available with sufficient voltage and current ratings for most inverter applications, it was the 1957 introduction of the thyristor or silicon-controlled rectifier (SCR) that initiated the transition to solid state inverter circuits.

The commutation requirements of SCRs are a key consideration in SCR circuit designs. SCRs do not turn off or commutate automatically when the gate control signal is shut off. They only turn off when the forward current is reduced to below the minimum holding current, which varies with each kind of SCR, through some external process. For SCRs connected to an AC power source, commutation occurs naturally every time the polarity of the source voltage reverses. SCRs connected to a DC power source usually require a means of forced commutation that forces the current to zero when commutation is required. The least complicated SCR circuits employ natural commutation rather than forced commutation. With the addition of forced commutation circuits, SCRs have been used in the types of inverter circuits described above.

In applications where inverters transfer power from a DC power source to an AC power source, it is possible to use AC-to-DC controlled rectifier circuits operating in the inversion mode. In the inversion mode, a controlled rectifier circuit operates as a line commutated inverter. This type of operation can be used in HVDC power transmission systems and in regenerative braking operation of motor control systems.

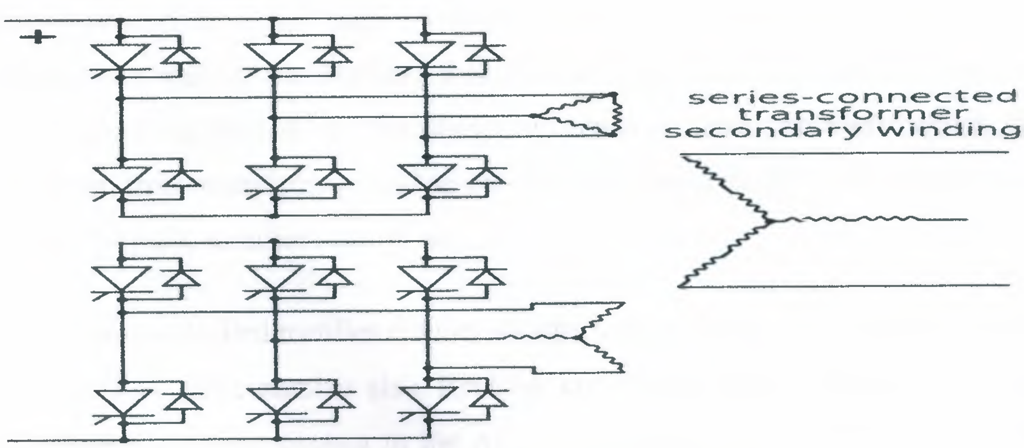

Fig. 1.4.2.1 basic Controlled rectifier inverters circuit

Another type of SCR inverter circuit is the current source input (CSI) inverter. A CSI inverter is the dual of a six-step voltage source inverter. With a current source inverter, the DC power supply is configured as a current source rather than a voltage source. The inverter SCRs are switched in a six-step sequence to direct the current to a three-phase AC load as a stepped current waveform. CSI inverter commutation methods include load commutation and parallel capacitor commutation. With both methods, the input current regulation assists the commutation. With load commutation, the load is a synchronous motor operated at a leading power factor.

As they have become available in higher voltage and current ratings, semiconductors such as transistors or IGBTs that can be turned off by means of control signals have become the preferred switching components for use in inverter circuits.

1.4.3 Rectifier and inverter pulse numbers :

Rectifier circuits are often classified by the number of current pulses that flow to the DC side of the rectifier per cycle of AC input voltage. A single-phase half-wave rectifier is a one-pulse circuit and a single-phase full-wave rectifier is a two-pulse circuit. A three-phase half-wave rectifier is a three-pulse circuit and a three-phase full-wave rectifier is a six-pulse circuit.

With three-phase rectifiers, two or more rectifiers are sometimes connected in series or parallel to obtain higher voltage or current ratings. The rectifier inputs are supplied from special transformers that provide phase shifted outputs. This has the effect of phase multiplication. Six phases are obtained from two transformers, twelve phases from three transformers and so on. The associated rectifier circuits are 12-pulse rectifiers, 18-pulse rectifiers and so on...

When controlled rectifier circuits are operated in the inversion mode, they would be classified by pulse number also. Rectifier circuits that have a higher pulse number have reduced harmonic content in the AC input current and reduced ripple in the DC output voltage. In the inversion mode, circuits that have a higher pulse number have lower harmonic content in the AC output voltage waveform.

CHEPTER 2

ALTERNATOR (AUTOMOTİVE)

Alternators are used in modern automobiles to charge the battery and to power the electrical system when its engine is running.

Until the 1960s, automobiles used DC dynamo generators with commutators. With the availability of affordable silicon diode rectifiers, alternators were used instead. This was encouraged by the increasing electrical power required for cars in this period, with increasing loads from larger headlamps, electric wipers, heated rear windows and other accessories.

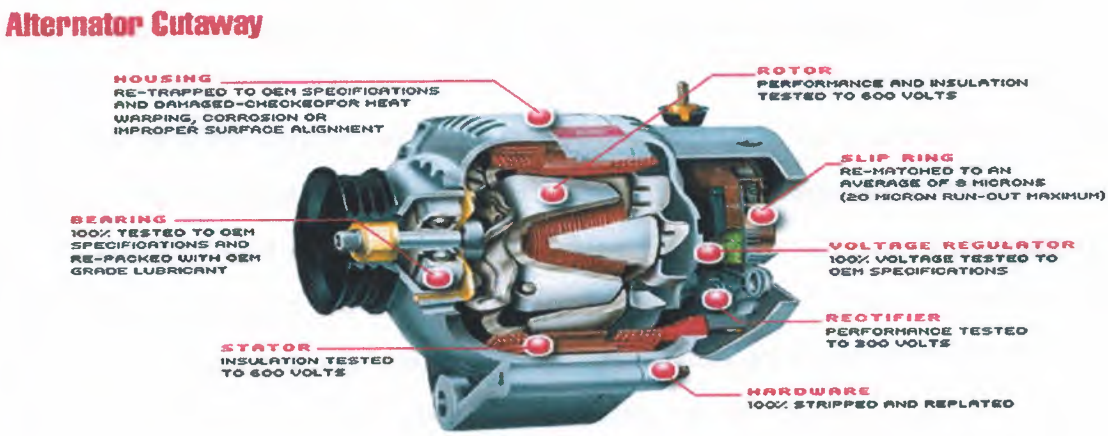

Fig. 2.1 Autoalternator cutaway

2.1 History :

Alternators were first introduced by the Chrysler Corporation on the Valiant in 1960, several years ahead of Ford and GM.

2.1.1 Ford Model T :

The first car to use an alternator was an unusual system fitted to early Model T Fords. This entirely AC system was first used solely to power the trembler coil ignition system when the engine was running. When starting, a battery was used instead – cranking the engine was entirely manual. This system was sometimes used to also provide electric lighting. Being an AC system, there was no battery in this circuit. The starting battery was removed from the car for charging, a rare event as it was only needed when starting. The generator was usually described as a magneto, although this was not an ignition magneto (even though it was used to power the ignition) as it did not provide sparks itself.

When the Model T was upgraded with electric lighting from the factory, a conventional dynamo was installed instead. This then permitted battery charging as well.

2.2 Advantages over dynamos :

Alternators have several advantages over direct-current generators. They are lighter, cheaper and more rugged. They use slip rings providing greatly extended brush life over a commutator. The brushes in an alternator carry only excitation current, a small fraction of the current carried by the brushes of a DC generator, which carry the generator's entire output. A set of rectifiers (diode bridge) is required to convert AC to DC. To provide direct current with low ripple, a three-phase winding is used and the pole-pieces of the rotor are shaped (claw-pole) to produce a waveform similar to a square wave instead of a sinusoid. Automotive alternators are usually belt driven at 2-3 times crankshaft speed. The alternator runs at various RPM (which varies the frequency) since it is driven by the engine. This is not a problem because the alternating current is rectified to direct current.

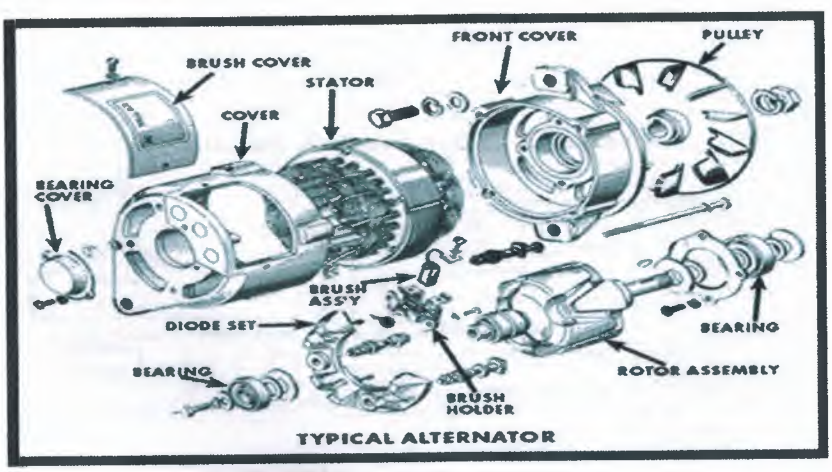

Fig. 2.2.1 autoalternator equipmant

2.3 Operation:

Despite their names, both 'DC generators' (or 'dynamos') and 'alternators' initially produce alternating current. In a so-called 'DC generator', this AC current is generated in the rotating armature, and then converted to DC by the commutator and brushes. In an 'alternator', the AC current is generated in the stationary stator, and then is converted to DC by the rectifiers (diodes).

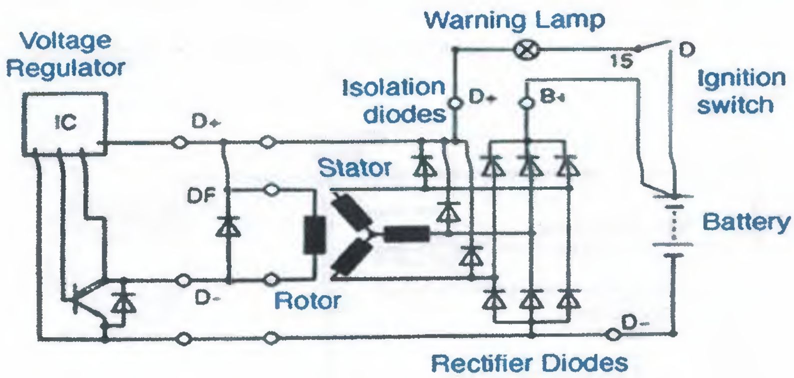

Fig. 2.3.1 Autoalternator circuit

Typical passenger vehicle and light truck alternators use Lundell or 'claw-pole' field construction. This uses a shaped iron core on the rotor to produce a multi-pole field from a single coil winding. The poles of the rotor look like fingers of two hands interlocked with each other. The coil is mounted axially inside this and field current is supplied by slip rings and carbon brushes. These alternators have their field and stator windings cooled by axial airflow, produced by an external fan attached to the drive belt pulley.

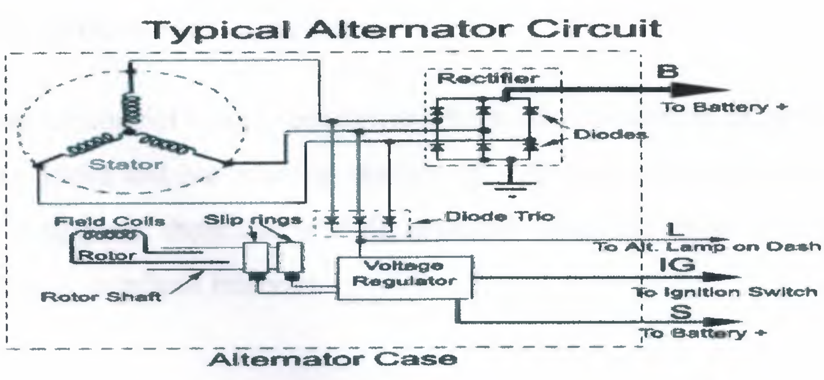

Fig. 2.3.2 Autoalternator diagram

Modern vehicles now use the compact alternator layout. This is electrically and magnetically similar, but has improved air cooling. Better cooling permits more power from a smaller machine. The casing has distinctive radial vent slots at each end and now encloses the fan. Two fans are used, one at each end, and the airflow is semi-radial, entering axially and leaving radially outwards. The stator windings now consist of a dense central band where the iron core and copper windings are tightly packed, and end bands where the windings are more exposed for better heat transfer. The closer core spacing from the rotor improves magnetic efficiency. The smaller, enclosed fans produce less noise, particularly at higher machine speeds.

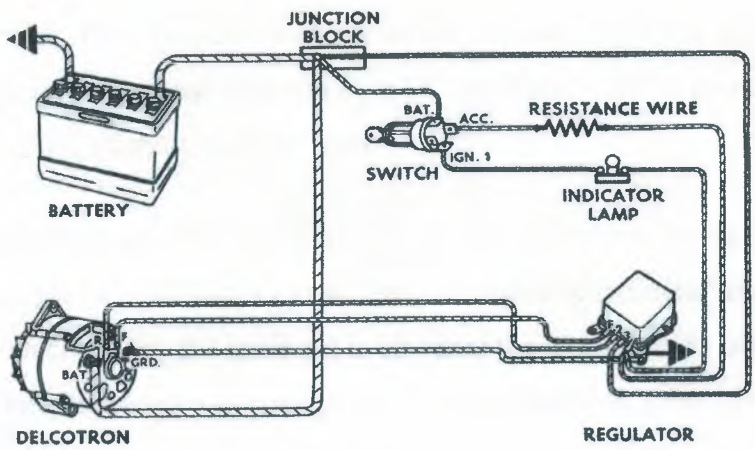

Fig. 2.3.3 Autoalternator operation diagram

Larger vehicles may have salient-pole alternators similar to larger machines.

The windings of a 3 phase alternator may be connected using either the Delta or Wye connection regime. set-up.

Brushless versions of these type alternators are also common in larger machinery such as highway trucks and earthmoving machinery. With two oversized shaft bearings as the only wearing parts, these can provide extremely long and reliable service, even exceeding the engine overhaul intervals.

2.4 Field regulation :

Automotive alternators require a voltage regulator which operates by modulating the small field current to produce a constant voltage at the battery terminals. Early designs (c.1960s-1970s) used a discrete device mounted elsewhere in the vehicle. Intermediate designs (c.1970s-1990s) incorporated the voltage regulator into the alternator housing. Modern designs do away with the voltage regulator altogether; voltage regulation is now a function of the electronic control unit (ECU). The field current is much smaller than the output current of the alternator; for example, a 70 A alternator may need only 7 A of field current. The field current is supplied to the rotor windings by slip rings. The low current and relatively smooth slip rings ensure greater reliability and longer life than that obtained by a DC generator with its commutator and higher current being passed through its brushes.

The field windings are supplied power from the battery via the ignition switch and regulator. A parallel circuit supplies the "charge" warning indicator and is earthed via the regulator.(which is why the indicator is on when the ignition is on but the engine is not running). Once the engine is running and the alternator is generating power, a diode feeds the field current from the alternator main output equalizing the voltage across the warning indicator which goes off. The wire supplying the field current is often referred to as the "exciter" wire. The drawback of this arrangement is that if the warning lamp burns out or the "exciter" wire is disconnected, no current reaches the field windings and the alternator will not generate power. Some warning indicator circuits are equipped with a resistor in parallel with the lamp that permit excitation current to flow if the warning lamp burns out. The driver should check that the warning indicator is on when the engine is stopped; otherwise, there might not be any indication of a failure of the belt which may also drive the cooling water pump. Some alternators will self-excite when the engine reaches a certain speed.

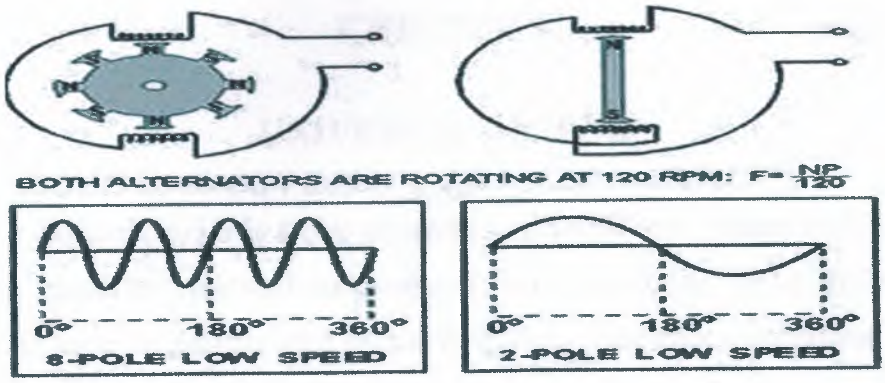

Fig. 2.4.1 Field regulation

Older automobiles with minimal lighting may have had an alternator capable of producing only 30 A. Typical passenger car and light truck alternators are rated around 50-70 A, though higher ratings are becoming more common, especially as there is more load on the vehicle's electrical system with air conditioning, electric power steering and other electrical systems. Very large alternators used on buses, heavy equipment or emergency vehicles may produce 300 A. Semi-trucks usually have alternators which output 140 A. Very large alternators may be water-cooled or oil-cooled.

In recent years, alternator regulators are linked to the vehicle's computer system and various factors including air temperature obtained from the intake air temperature sensor, battery temperature sensor and engine load are evaluated in adjusting the voltage supplied by the alternator.

Efficiency of automotive alternators is limited by fan cooling loss, bearing loss, iron loss, copper loss, and the voltage drop in the diode bridges. Efficiency reduces dramatically at high speeds mainly due to fan resistance. At medium speeds efficiency of today's alternators is 70-80%.[6] This betters very small high-performance permanent magnet alternators, such as those used for bicycle lighting systems, which achieve an efficiency around 60%. Larger permanent magnet electric machines (that can operate as motors or alternators) can achieve today much higher efficiencies. Pellegrino et al.,[7] for instance, propose not particularly expensive designs that show ample regions in which efficiency is above 96%. Large AC generators used in power stations run at carefully controlled speeds and have no constraints on size or weight. They have very high efficiencies as high as 98%.

CHEPTER 3

UNIVERSAL MOTOR

The universal motor is a type of electric motor that can operate on both AC and DC power. It is a commutated series-wound motor where the stator's field coils are connected in series or parallel with the rotor windings through a commutator. This type of electric motor can operate well on AC because the current in both the field coils and the armature (and the resultant magnetic fields) will alternate (reverse polarity) synchronously with the supply. Hence the resulting mechanical force will occur in a consistent direction of rotation, independent of the direction of applied voltage, but determined by the commutator and polarity of the field coils.

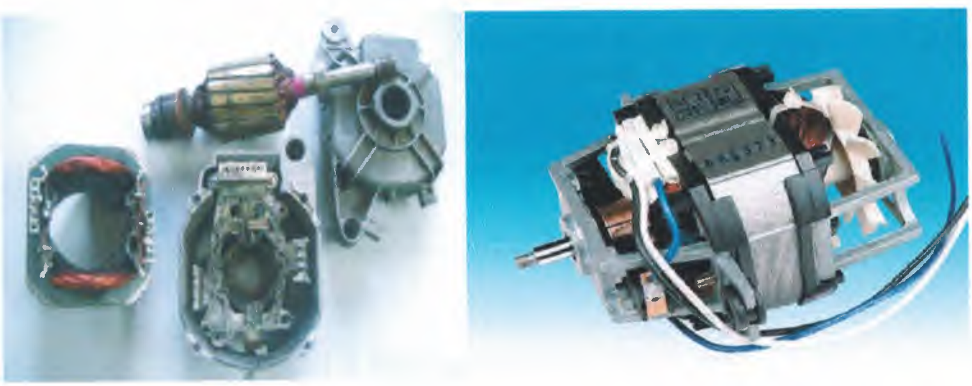

Fig. 3.1 View of universal motor

Universal motors have high starting torque, run at high speed and are lightweight and are commonly used in portable and domestic equipment.[1] They're also relatively easy to control, electromechanically using tapped coils or electronically. However, the commutator has brushes that wear, so they are much less often used for equipment that is in continuous use. In addition, partly because of the commutator universal motors are typically very noisy.

3.1 <u>Properties :</u>

When used with AC power these types of motors are able to run at a rotation frequency well above that of the mains supply, and because most electric motor properties improve with speed, this means they can be lightweight and powerful.

However, universal motors are usually relatively inefficient- around 30% for smaller motors and up to 70-75% for larger ones.

One useful property of having the field windings in series with the armature winding is that as the speed increases the back EMF naturally reduces the voltage across, and current through the field windings, giving field weakening at high speeds. This means that the motor does not inherently have a maximum speed for any particular applied voltage. Universal motors can be and are generally run at high speeds, 4000-16000 rpm, and can go over 20,000 rpm. By way of contrast, induction motors cannot turn a shaft faster than allowed by the power line frequency.

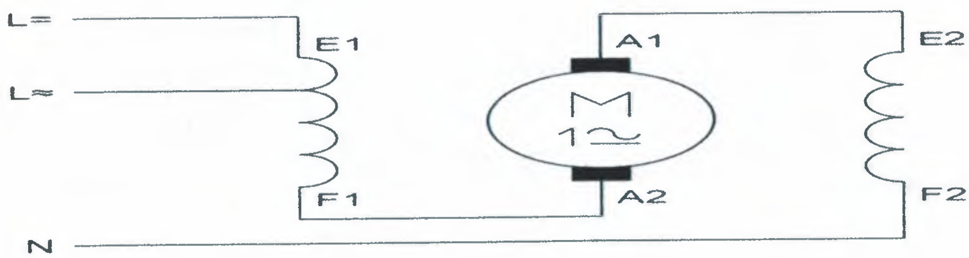

Fig. 3.1.1 Basic universal motor circuit

Universal motors's armatures typically have far more coils and plates than a DC motor, and hence less windings per coil. This reduces the inductance.

Motor damage may occur from over-speeding (running at a rotational speed in excess of design limits) if the unit is operated with no significant mechanical load. On larger motors, sudden loss of load is to be avoided, and the possibility of such an occurrence is incorporated into the motor's protection and control schemes. In some smaller applications, a fan blade attached to the shaft often acts as an artificial load to limit the motor speed to a safe level, as well as a means to circulate cooling airflow over the armature and field windings.

An advantage of the universal motor is that AC supplies may be used on motors which have some characteristics more common in DC motors, specifically high starting torque and very compact design if high running speeds are used.

A negative aspect is the maintenance and short life problems caused by the commutator, as well as EMI issues due to any sparking. Because of the relatively high maintenance commutator brushes, universal motors are used in devices such as food mixers and power tools which are used only intermittently, and often have high starting-torque demands. Continuous speed control of a universal motor running on AC is easily obtained by use of a thyristor circuit, while multiple taps on the field coil provide (imprecise) stepped speed control. Household blenders that advertise many speeds frequently combine a field coil with several taps and a diode that can be inserted in series with the motor (causing the motor to run on half-wave rectified AC).

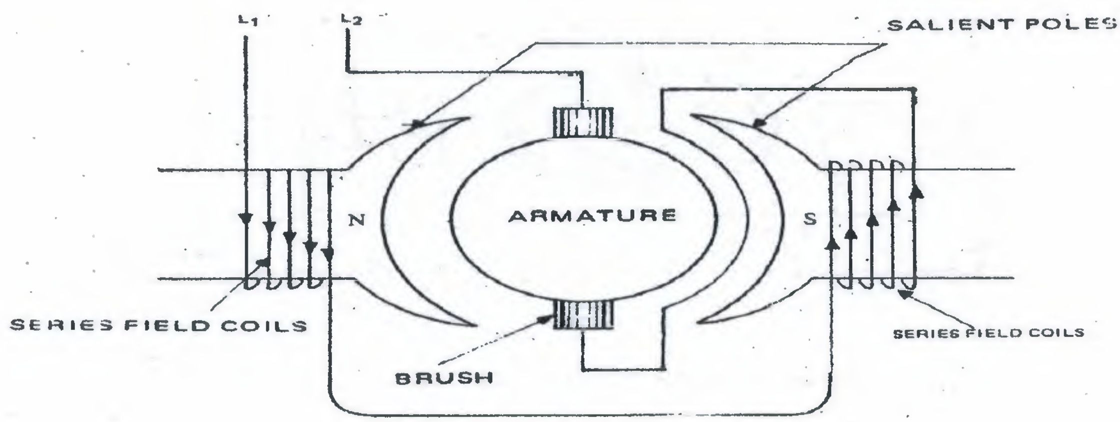

Fig. 3.1.2 Universal motor diagram

Series wound electric motors respond to increased load by slowing down; the current increases and the torque rises in proportional to the square of the current since the same current flows in both the armature and the field windings. If the motor is stalled, the current is limited only by the total resistance of the windings and the torque can be very high, and there is a danger of the windings becoming overheated. The counter-EMF aids the armature resistance to limit the current through the armature. When power is first applied to a motor, the armature does not rotate. At that instant, the counter-EMF is zero and the only factor limiting the armature current is the armature resistance. Usually the armature resistance of a motor is low; therefore the current through the armature would be very large when the power is applied. Therefore the need can arise for an additional resistance in series with the armature to limit the current until the motor rotation can build up the counter-EMF. As the motor rotation builds up, the resistance is gradually cut out.

The output speed torque characteristic is the most notable characteristic of series wound motors. The speed being almost entirely dependent on the torque required to drive the load. This suits large inertial loads as the speed will drop until the motor slowly starts to rotate and these motors have a very high stalling torque.

Not all series wound motors operate well on AC current. Motors intended for AC require laminated field cores.

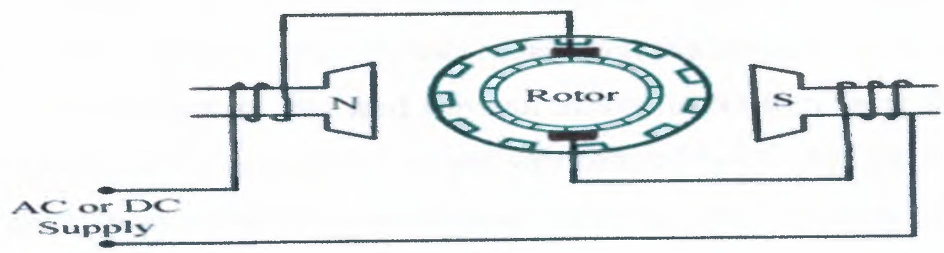

Fig. 3.1.3 Universal motor operation diagram

As the speed increases, the inductance of the rotor means that the ideal commutating point changes. Small motors typically have fixed commutation. While some larger universal motors have rotatable commutation, this is rare. Instead larger universal motors often have *compensation windings* in series with the motor, or sometimes inductively coupled, and placed at ninety electrical degrees to the main field axis. These reduce the reactance of the armature, and improve the commutation.

3.1.1 Shunt winding :

Universal motors are series wound. Shunt winding was used experimentally, in the late 19th century but was impractical owning to problems with commutation. Various schemes of embedded resistance, inductance and antiphase cross-coupling were attempted to reduce this. Universal motors, including shunt wound, were favoured as AC motors at this time as they were self-starting. When self-starting induction motors and automatic starters became available, these replaced the larger universal motors (above 1 hp) and the shunt wound.

3.2 Applications :

Operating at normal power line frequencies, universal motors are often found in a range less than 1000 watts. Universal motors also form the basis of the traditional railway traction motor in electric railways. In this application, the use of AC to power a motor originally designed to run on DC would lead to efficiency losses due to eddy current heating of their magnetic components, particularly the motor field pole-pieces that, for DC, would have used solid (un-laminated) iron. Although the heating effects are reduced by using laminated pole-pieces, as used for the cores of transformers and by the use of laminations of high permeability electrical steel, one solution available at the start of the 20th century was for the motors to be operated from very low frequency AC supplies, with 25 and 16 ⅔ Hz (the latter subsequently redesignated 16.7 Hz) operation being common. Because they used universal motors, locomotives using this design could operate from a third rail or overhead wire powered by DC. As well, considering that steam engines directly powered many alternators, their relatively low speeds favored low frequencies because comparatively few stator poles were needed.

In the past, repulsion-start wound-rotor motors provided high starting torque, but with added complexity. Their rotors were similar to those of universal motors, but their brushes were connected only to each other. Transformer action induced current into the rotor. Brush position relative to field poles meant that starting torque was developed by rotor repulsion from the field poles. A centrifugal mechanism, when close to running speed, connected all commutator bars together to create the equivalent of a squirrel-cage rotor. As well, when close to operating speed, better motors lifted the brushes out of contact.

Their high speed makes them useful for appliances such as blenders, vacuum cleaners, and hair dryers where high speed and light weight are desirable. They are also commonly used in portable power tools, such as drills, sanders, circular and jig saws, where the motor's characteristics work well. Many vacuum cleaner and weed trimmer motors exceed 10,000 RPM, while many Dremel and similar miniature grinders exceed 30,000 RPM.

Universal motors also lend themselves to electronic speed control and, as such, are an ideal choice for domestic washing machines. The motor can be used to agitate the drum (both forwards and in reverse) by switching the field winding with respect to the armature. The motor can also be run up to the high speeds required for the spin cycle.

CHEPTER 4

CONTACTOR

A contactor is an electrically controlled switch used for switching a power circuit, similar to a relay except with higher current ratings. A contactor is controlled by a circuit which has a much lower power level than the switched circuit.

Contactors come in many forms with varying capacities and features. Unlike a circuit breaker, a contactor is not intended to interrupt a short circuit current. Contactors range from those having a breaking current of several amperes to thousands of amperes and 24 V DC to many kilovolts. The physical size of contactors ranges from a device small enough to pick up with one hand, to large devices approximately a meter (yard) on a side.

Contactors are used to control electric motors, lighting, heating, capacitor banks, thermal evaporators, and other electrical loads.

4.1 Construction :

A contactor has three components. The contacts are the current carrying part of the contactor. This includes power contacts, auxiliary contacts, and contact springs. The electromagnet (or "coil") provides the driving force to close the contacts. The enclosure is a frame housing the contact and the electromagnet. Enclosures are made of insulating materials like Bakelite, Nylon 6, and thermosetting plastics to protect and insulate the contacts and to provide some measure of protection against personnel touching the contacts. Open-frame contactors may have a further enclosure to protect against dust, oil, explosion hazards and weather.

Magnetic blowouts use blowout coils to lengthen and move the electric arc. These are especially useful in DC power circuits. AC arcs have periods of low current, during which the arc can be extinguished with relative ease, but DC arcs have continuous high current, so blowing them out requires the arc to be stretched further than an AC arc of the same current. The magnetic blowouts in the pictured Albright contactor (which is designed for DC currents) more than double the current it can break, increasing it from 600 A to 1,500 A.

Sometimes an economizer circuit is also installed to reduce the power required to keep a contactor closed; an auxiliary contact reduces coil current after the contactor closes. A somewhat greater amount of power is required to initially close a contactor than is required to keep it closed. Such a circuit can save a substantial amount of power and allow the energized coil to stay cooler. Economizer circuits are nearly always applied on direct-current contactor coils and on large alternating current contactor coils.

A basic contactor will have a coil input (which may be driven by either an AC or DC supply depending on the contactor design). The coil may be energized at the same voltage as a motor the contactor is controlling, or may be separately controlled with a lower coil voltage better suited to control by programmable controllers and lower-voltage pilot devices. Certain contactors have series coils connected in the motor circuit; these are used, for example, for automatic acceleration control, where the next stage of resistance is not cut out until the motor current has dropped.

4.2 Operating principle :

Unlike general-purpose relays, contactors are designed to be directly connected to high-current load devices. Relays tend to be of lower capacity and are usually designed for both normally closed and normally open applications. Devices switching more than 15 amperes or in circuits rated more than a few kilowatts are usually called contactors. Apart from optional auxiliary low current contacts, contactors are almost exclusively fitted with normally open ("form A") contacts. Unlike relays, contactors are designed with features to control and suppress the arc produced when interrupting heavy motor currents.

When current passes through the electromagnet, a magnetic field is produced, which attracts the moving core of the contactor. The electromagnet coil draws more current initially, until its inductance increases when the metal core enters the coil. The moving contact is propelled by the moving core; the force developed by the electromagnet holds the moving and fixed contacts together. When the contactor coil is de-energized, gravity or a spring returns the electromagnet core to its initial position and opens the contacts.

For contactors energized with alternating current, a small part of the core is surrounded with a shading coil, which slightly delays the magnetic flux in the core. The effect is to average out the alternating pull of the magnetic field and so prevent the core from buzzing at twice line frequency.

Because arcing and consequent damage occurs just as the contacts are opening or closing, contactors are designed to open and close very rapidly; there is often an internal tipping point mechanism to ensure rapid action.

Rapid closing can, however, lead to increase contact bounce which causes additional unwanted open-close cycles. One solution is to have bifurcated contacts to minimize contact bounce; two contacts designed to close simultaneously, but bounce at different times so the circuit will not be briefly disconnected and cause an arc.

A slight variant has multiple contacts designed to engage in rapid succession. The first to make contact and last to break will experience the greatest contact wear and will form a high-resistance connection that would cause excessive heating inside the contactor. However, in doing so, it will protect the primary contact from arcing, so a low contact resistance will be established a millisecond later.

Another technique for improving the life of contactors is contact wipe; the contacts move past each other after initial contact on order to wipe off any contamination.

CHEPTER 5

MULTIFUNCTIONAL TIME RELAYS

MCB-8 are microprocessor-based electronic time relays. They have precisely adjustable time ranges (between 0,1 s-30 hours for MCB-7; 0,1 s-999 minutes for MCB 8; 0,5 s-30 hours for MCB-9) and up to 4 different operating modes. Wtih their thin and narrow designs, these time relays are designed for multi-purpose applications.

Fig. 5.1 View of the time delay

5.1 Technical Data :

Rated Voltage (Un) : 220 VAC, 230 VAC, 240 VAC, 24 VAC/DC
(115,127 V AC and 12 VAC/DC available upon request)
Operating Range : (0.9-1.1) x Un
Operating Frequency : 50/60 Hz.
Output Contact : 1 Changeover 8A/2000 VA (NO: 8A, NC: 6A)Cosj =1
Repetition Error : +/-0.1%
Reset Time : <=150 msec.
Ambient Temperature : -5°C ; +50°C
Dimensions : Type PK22
Protection Class : IP 20
Connection : Terminal connection, Rail-mount (Panel mount is available with the plastic adapter part.

CHEPTER 6

THE PROJECT OF CIRCUIT

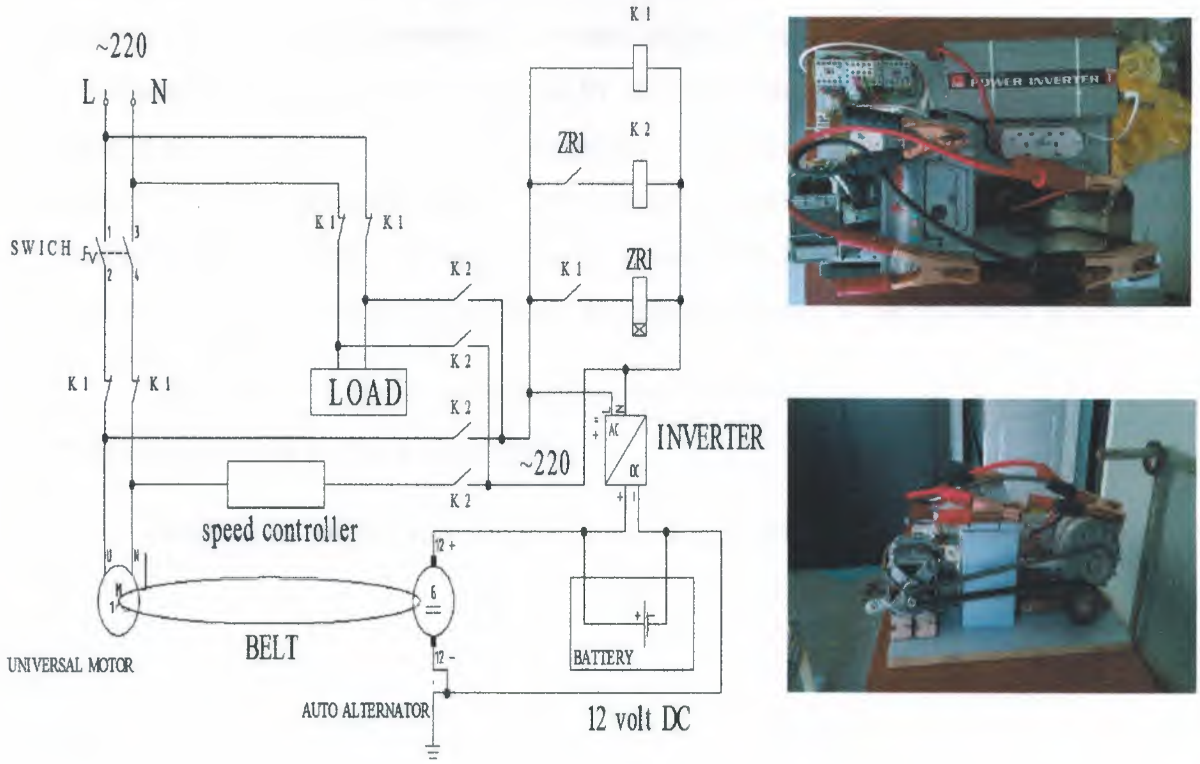

Fig. 6.1 Circuit of the Project

The system is connected to electric network. Load is connected to the mains via normally closed contact K1. When the switch is off, the engine begins to run through closed contact K1. With the help of the engine and belt, alternator rotor begins to rotate. With the operation of alternator, battery begins to charge. When ı brought the inverter switch to the on position, 12 volts from the battery, turn on the inverter output to 220 volts. When K1 contactor is 220 volt contactor contacts change the position. Motor and load are separated from the mains. When the ignition is switched off in front of the relay and time relay is activated. The relay is activated when the ignition off after a while and contactor K2 gets activated. K2 contactor contacts change the position of the motor and load. if the system load is greater than the load of the inverter a fault indicated by the inverter and moves back to the mains.

CONCLUSION

In this project the 10000 rpm revolution of a universal motor operated by the grid voltage is used and the power obtained by the help of a belt and pulleys from this motor is transferred to a dynamo. The motor pulley is smalla and the pulley connected to dynamo is larger and this is the reason why the rpm of thr dynamo is 3500. The dynamo output gives 12.5-15 Volts 80 apere hours of electricity. This energy is used to charge 12 V 60 amperehour batery. This battery is used to convert 12 V dc to 220 V ac electricity by an inverter. This electricity is connected to the universal motor as the main source. The excess energy obtained from the inverter is used to operate other systems.

This system by convertin melectrical energy to mechanical and back to electrical enargy and forming a loop to feed itself.

Similar systems are used for wind and solar generator systems.

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