PPU College Of Engineering and Technology

The Home of Competent Engineers and Researchers

Mechanical Engineering Department

Automotive Engineering Program

Bachelor Thesis

Graduation Project

Activation Of Vehicle Systems By Mobile

Work Team

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Abstract

In the last years, vehicles luxury and comfort becomes one of the most important fields in automotive industry competition.

The recent car didn't only depend on the mechanics, it now depends on the most of the available technologies in the world, and a single system may have two or more technologies in its structure to perform a specific task.

This project talks about the ability to apply telecommunication technologies on the vehicles, especially the property of dual tune multi frequency (DTMF), this technology can be used to carry out some functions in the car, and these functions will be:

* Running the engine.

* Activating the air conditioner.

* Locking or unlocking doors by activating central locking system.

* Controlling the electrical windows system to open or close.

Contents:

List of Tables

List of Figures

Chapter One:

General Introduction

1.1 Project Background.

1.2 Project Goals and Objectives.

1.3 Project Components and Concept.

1.4 Project Choice Justification.

1.5 Project Implementation Plan.

1.6 Preliminary Budget.

1.1 Project Background.

At the beginning of the 20th centuty, everything on the earth was changed, by using the internal combustion engines on the vehicles; time reduced, places become closer and making the whole life easier.

Vehicles development process didn't stop at any time, every day was coming with a new technology and features that can be added to the vehicles in order to improve the power of the engine, reducing emissions and fuel consumption and adding a great amount of comfort and luxury options.

Now, the car can be used as an office or like a special room, due to the great amount of comfort and utilities that installed in the vehicle like; DVD players, video games, internet connection and applied telecommunication technology on the car.

Cellular technology started to become useful in the 1980s and has continued to develop from then – very quickly. [1]
The idea of the vehicles that to be controlled without a human inside it, is not a new one; some of automotive companies like (Ford), uses the (Bluetooth) technology to control some functions in the car, with being in a specific range away from the car.

Some researches are existing, talking about some features in the vehicle, that to be controlled via mobile using the GSM positioning concept.

But this work uses the mobile phone itself to activate some systems in the car from any place and any time via a phone call, without distance limitations, based on "dual tune multi-frequency" technology.

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This work talks about the ability to applying telecommunication technology on the vehicles, this technology can be used to carry out some functions in the car, these functions could be:

- Running the engine.
- Activating the air conditioner.
- Locking or unlocking doors by activating central locking system.
- Closing or opening the electrical windows.

At the end of this work, it's expected that the driver can make all these functions easily by using his mobile phone.

1.2 Project Goals and Objectives.

The overall aim of the work is to finalize a design and build a device inside the vehicle for activate some systems by mobile phones. Specifically the project intends to:

1. Activation of some vehicle systems by mobile phones.
2. Build this device locally.
3. Achieving more comfort for the drivers.
4. Adding some features luxury on vehicles.
5. Applying modern technology with low cost.

1.3 Project Components and Concept.

The components required in this project are:

- Vehicle; to apply this technology on it.
- Mobile phone with the driver.
- Mobile phone in the vehicle.
- Special integrated circuit (IC).
- Digital microcontroller.

Every button in mobile excluding the green, red and arrow buttons has a special frequency called (dual-tone multi frequency "DTMF"). The "DTMF" signal is generated each time the owner presses the keypad, and producing a pair of frequencies, these frequencies will be transferred to another mobile placed in the vehicle by a phone call, which receives these frequencies and passes it using the wires of its headphone to a special integral circuit (I C); this (I C) will analyze frequencies and signals to produce different outputs depending on the input frequency from driver's phone.

Then these outputs from the (I C) will be matched to the vehicle systems and circuits, to perform the wanted tasks, like running the engine and air conditioner .... Etc.

1.4 Project Choice Justification.

This work will add a great amount of luxury and comfort for the cars and users, that is, if the driver has no more time in the morning, he can use this technology to warm up the engine without being in the car, and he can turning on the air conditioner, to adjust the climate inside the vehicle before starting his journey.

This technology also has a great advantage when the driver being away from his car, and he remembers that the car is not locked, then he can use his mobile to activate the central locking system and lock the vehicle doors and windows, or unlock them if it's needed.

All these options will be given to the driver, with a little cost.

Using the mobile to control some systems may exist in other applications, now; it's the time for applying it on the vehicles.

1.5 Work Implementation Plan

The work will be performed in two stages: the first one will be in the first semester and the other one in the second semester, the two stages will be discussed as follow:

- The first stage will focus on:

  1. Design the system.

  2. Choose the materials.

  3. Select the systems for activation.

- The second one will be devoted for:
  1. Checking the design.
  2. Building the system.
  3. Checking the safety.

1.5.1 Main Tasks and Activities

The main tasks for the first semester include:

1. Selecting the work name and problem
2. Finding the concepts and goals.
3. Scientific background on vehicles that to be controlled by mobiles.
4. Literature review and gaining.
5. Design the system.
6. Choose the systems that to be activate by mobile phone.
7. Ensure safety of the system and its efficiency.
8. Preparing the report for the first stage.

1.5.2 Time Table

The time table for the first semester is illustrated in Table 1.1.

Table 1.1: The time table for 1st semester.

Objective	Week number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Selecting project title	■	■														
Planning and Setting Project Concepts and Goals			■	■												
Establishing Scientific Background					■	■										
Literature Review				■	■	■	■	■	■	■	■					
Make a Preliminary Design for Project										■	■	■				
Choose the Material and Find it													■	■	■	
Selecting The Systems To Activate													■	■	■	
Check the Safety														■	■	■
Write the Final Report							■	■	■	■	■	■	■	■	■	■

The main tasks for the second semester include;

1. Building and installing the project and its control.
2. Test the project and its effectiveness.
3. Preparing documentation, summarizing the results and recommendation, and making presentation about the project.

Table 1.2 Time table for the 2nd semester

Objective	Week number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Collect the Material																
Build the Final Design																
Check the Safety																
Try the Device																
Recheck the Survivability																
Write the Result																
Write the Recommendation																
Final Report																

1.6 Preliminary Budget

Preliminary estimates are made for the project components as listed in table 1.3. The total estimate budget is 1300 JD

Table 1.3: Preliminary budget

Item	Estimated cost (JD)
Vehicle	700
Phone with the driver	250
Phone in the car	250
Different wires and electrical components	100
Total	1300

Chapter Two

General of "DTMF" and the Principle of Controlling It

2.1 Basics of DTMF.

2.2 The DTMF Receiver.

2.3 The Control Logic.

2.3.1 Decoder.

2.3.2 Microcontroller.

2.4 Controlled Systems.

2.4.1 Air Conditioner.

2.4.2 Ignition Switch.

2.4.3 Doors Central Locking.

2.4.4 Electrical Windows.

2.1 Basics of Dual Tone Multi- Frequency (DTMF)

More than 25 years ago the need for an improved method for transferring dialing information through the telephone network was recognized. The traditional method, Dial pulse signaling, was not only slow, suffering severe distortion over long wire loops, but required a DC path through the communications channel. A signaling scheme was developed utilizing voice frequency tones and implemented as a very reliable alternative to pulse dialing. This scheme is known as DTMF (Dual Tone Multi- Frequency), Touch-Tone™ or simply, tone dialing. As its acronym suggests, a valid DTMF signal is the sum of two tones, one from a low group (697- 941Hz) and one from a high group (1209-1633Hz) with each group containing four individual tones. The tone frequencies were carefully chosen such that they are not harmonically related and that their inter modulation products result in minimal signaling impairment (Fig. 2.1a). This scheme allows for 16 unique combinations. Ten of these codes represent the numerals zero through nine, the remaining six (*,#,A,B,C,D) being reserved for special signaling. Most telephone keypads contain ten numeric push buttons plus the asterisk (*) and octothorp (#). The buttons are arranged in a matrix, each selecting its low group tone from its respective row and its high group tone from its respective column (Fig. 2.1b).

The DTMF coding scheme ensures that each signal contains one and only one component from each of the high and low groups. This significantly simplifies decoding because the composite DTMF signal may be separated with band pass filters, into its two single frequency components each of which may be handled individually. As a result DTMF coding has proven to provide a flexible signaling scheme of excellent reliability, hence motivating innovative and competitive decoder design.

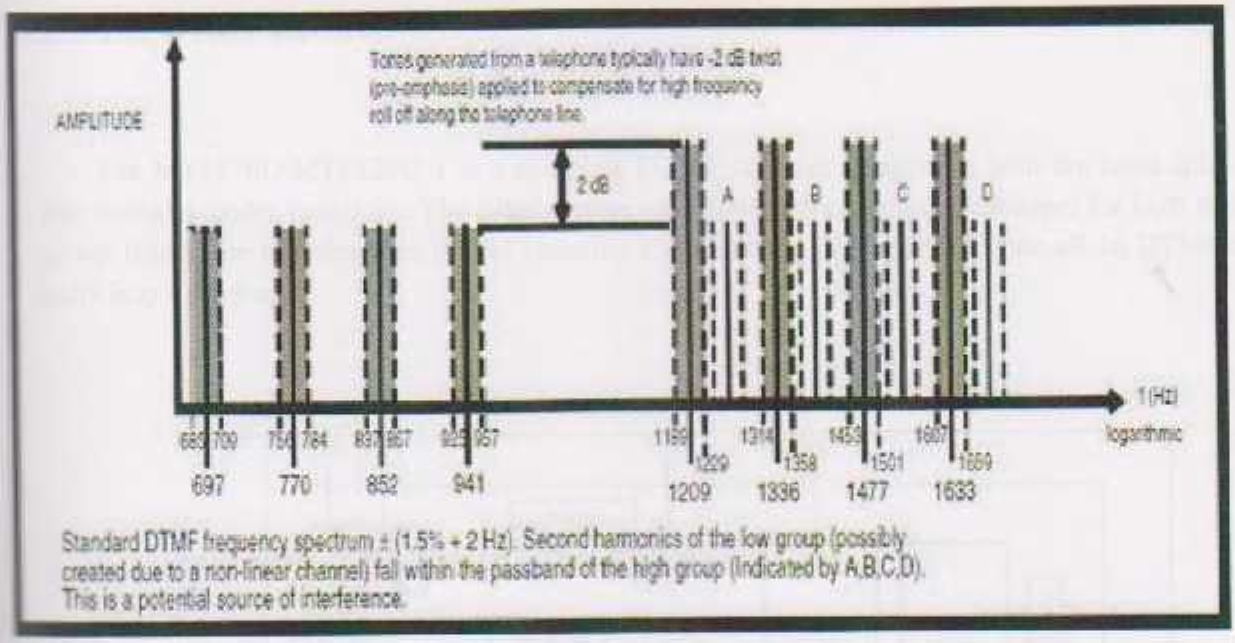


Fig. (2.1a) DTMF spectrum.

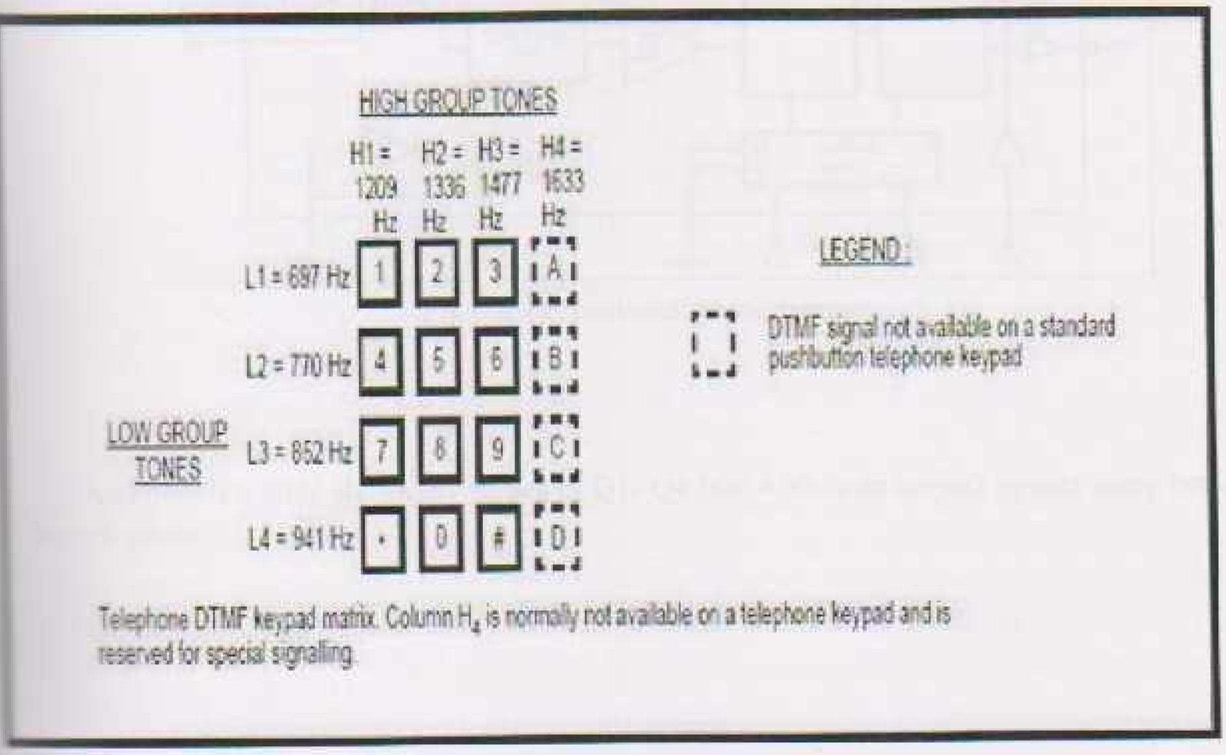


Fig. (2.1b) DTMF keypad.

2.2 The DTMF Receiver

The MT8870D/MT8870D-1 is a complete DTMF receiver integrating both the band split filter and digital decoder functions. The filter section uses switched capacitor techniques for high and low group filters; the decoder uses digital counting techniques to detect and decode all 16 DTMF tone-pairs into a 4-bit code.

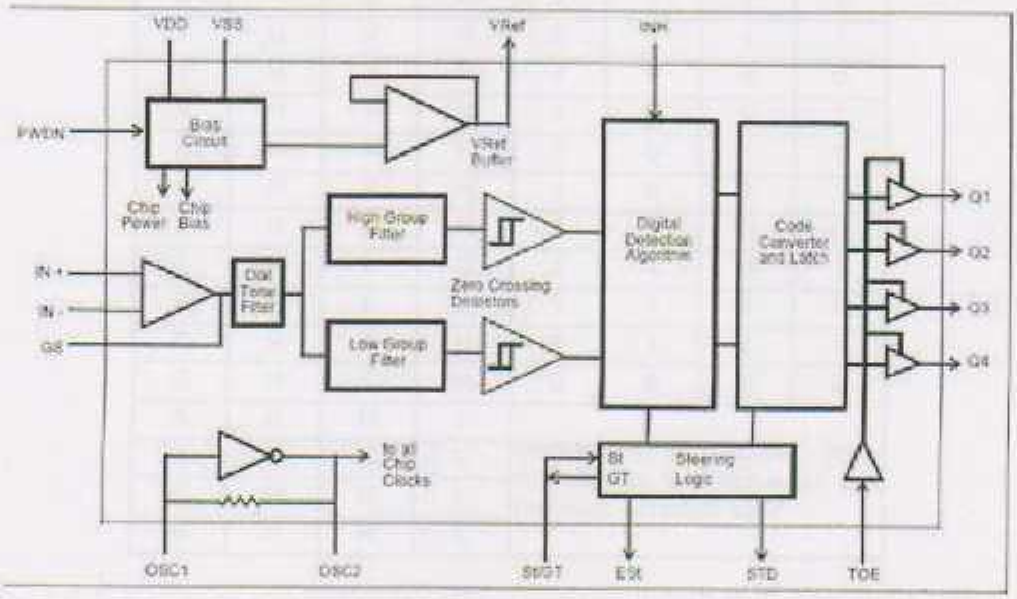


Fig.(2. 2) Functional block diagram.

And here is a table shows the values of Q1- Q4 (the 4 bit code output) against every button in the cell phone.

Table (2.1) Functional decode table.

Digit	TOE	INH	ESt	Q_4	Q_3	Q_2	Q_1
ANY	L	X	H	Z	Z	Z	Z
1	H	X	H	0	0	0	1
2	H	X	H	0	0	1	0
3	H	X	H	0	0	1	1
4	H	X	H	0	1	0	0
5	H	X	H	0	1	0	1
6	H	X	H	0	1	1	0
7	H	X	H	0	1	1	1
8	H	X	H	1	0	0	0
9	H	X	H	1	0	0	1
0	H	X	H	1	0	1	0
*	H	X	H	1	0	1	1
#	H	X	H	1	1	0	0
A	H	L	H	1	1	0	1
B	H	L	H	1	1	1	0
C	H	L	H	1	1	1	1
D	H	L	H	0	0	0	0
A	H	H	L	undetected, the output code will remain the same as the previous detected code			
B	H	H	L				
C	H	H	L				
D	H	H	L				

L: Logic low. H: Logic high.
Z: High impedance. X: Don't care.

The circuit shown in (Fig. 2.3) illustrates the use of MT8870D-1 device in a typical receiver system. It defines the input signals less than -34 dBm as the non-operate level. This condition can be attained by choosing suitable values of R1 and R2 to provide 3 dB attenuation, such that -34 dBm input signal will correspond to -37 dBm at the gain setting pin GS of MT8870D-1. As shown in the diagram, the component values of R3 and C2 are the guard time requirements when the total component tolerance is 6%.

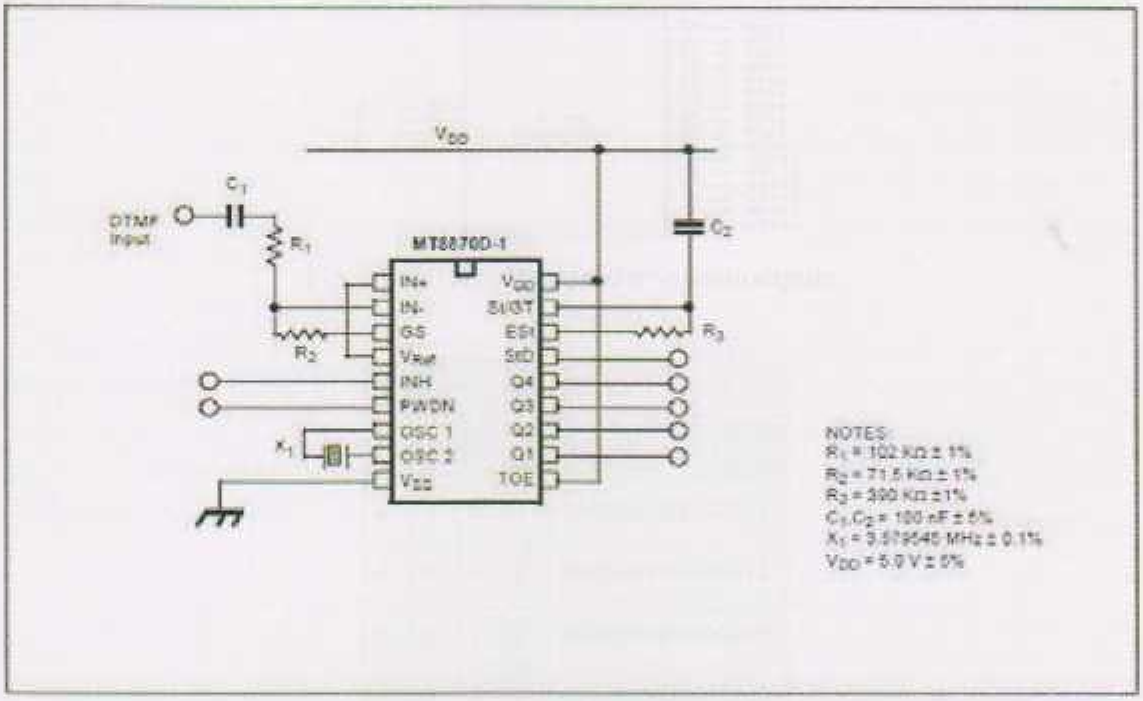


Fig. (2.3) Single ended input configuration.

2.3 The Control Logic

Control logic is a key part of a software program that controls the operations of the program. The control logic responds to commands from the user, and it also acts on its own to perform automated tasks that have been structured into the program.

2.3.1 Decoder

A decoder is a device which does the reverse of an encoder, undoing the encoding so that the original information can be retrieved. The same method used to encode is usually just reversed in order to decode.

In digital electronics this would mean that a decoder is a multiple-input, multiple-output logic circuit that converts coded inputs into coded outputs, where the input and output codes are different.

Fig. (2.4) (4 – 16) decoder inputs/outputs.

Input				Output
D	C	B	A	Q_{15} - Q_0
0	0	0	0	0000000000000001
0	0	0	1	0000000000000010
0	0	1	0	0000000000000100
0	0	1	1	0000000000001000
0	1	0	0	0000000000010000
0	1	0	1	0000000000100000
0	1	1	0	0000000001000000
0	1	1	1	0000000010000000
1	0	0	0	0000000100000000
1	0	0	1	0000001000000000
1	0	1	0	0000010000000000
1	0	1	1	0000100000000000
1	1	0	0	0001000000000000
1	1	0	1	0010000000000000
1	1	1	0	0100000000000000
1	1	1	1	1000000000000000

Table (2.2) Operating state table of (4 – 16) decoder.

2.3.2 Microcontroller

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.

A microcontroller is a highly integrated chip, which includes on a single chip, all or most of the parts needed for a controller. The microcontroller typically includes: CPU (Central Processing Unit), RAM (Random Access Memory), EPROM/PROM/ROM (Erasable Programmable Read Only Memory), I/O (input/output) – serial and parallel timers, interrupt controller. For example, Intel 8051 is 8-bit microcontroller and Intel 8096 is 16-bit microcontroller.

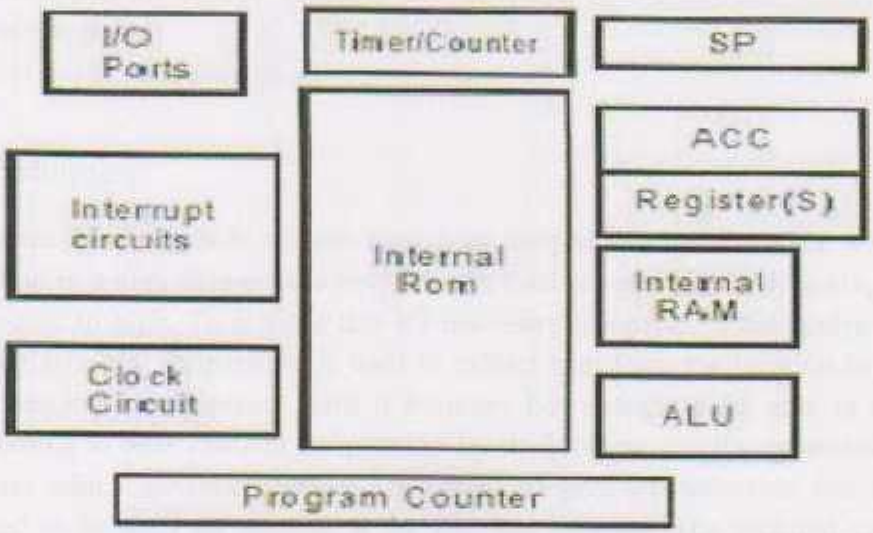


Fig. (2.5) A block diagram of microcontroller.

2.4 Controlled Systems:

2.4.1 Automotive Air Conditioning

Introduction to vehicles air conditioning:

Heating and ventilation in automotive transport is not just a function of temperature control. The safety of occupants to reduce driver fatigue, ensure good visibility and maintain comfort is a key to the successful design of such systems. A continual flow of air through the vehicle's interior reduces carbon dioxide levels, acts as a demister and prevents the buildup of the odours. Carbon dioxide in high concentrations can cause a driver to be less responsive. [2]

The modern heating, ventilating and air conditioning system (HVAC) should be able to ensure that thermal comfort and all around visibility are delivered in the extreme weather conditions experienced across the globe.

Principle of air conditioning:

It's self-evidence that heat tends to flow from high temperature to low. If we wish to provide cooling to a location in a high temperature environment then we are effectively asking heat to flow from low temperature to high. To achieve this it's necessary to operate a thermodynamic cycle in which a refrigerant at a low temperature is used to extract heat from the location to be cold. The refrigerant is subsequently compressed until it becomes hot enough to be able to reject heat to ambient. After cooling to near ambient temperature by the ambient air, it's expanded back to low pressure, a process which generates further refrigerant temperature reduction that becomes low enough to be used to be used for cooling at the required location. The required cooling is thus achieved but at the expense of the work necessary to drive the compressor.

Air conditioning in vehicles:

The automotive application places very special demands on the air conditioning systems. A typical vehicle system has a similar cooling capacity to that required for the air conditioning of a small house despite the vast difference in volumes to be cooled. The reason for this is twofold. Firstly cooling duty per unit volume is much higher for the vehicle because the heat transfer coefficients between hot ambient air and the outside surfaces are much higher due to movement of the vehicle through the air. Secondly the proportion of the enclosure consisting of glass is very high for the vehicle, a factor that makes the effect of direct solar radiation very high. On top of this a particularly demanding requirement is to cool the cabin very rapidly after the vehicle has been soaked in an ambient temperature of 40°C or higher.

Another significant way in which automotive air conditioning differs from the buildings conditioning is the question of compressor drive. In the vehicle the compressor is belt driven by the engine so that independent control over the compressor speed is not possible. This obviously has significant implications for system control and means that there can be calls for high system performance at times when compressor speeds is very low.

Components of air conditioning system:

1- Compressor:

The function of the compressor is to compress the circulate superheated refrigerant vapor around a closed loop system. Compressors vary in design, size, weight, rotational speed and direction and displacement. Also compressors can be mechanically or electrically driven. Some compressors are variable displacement and some are fixed. The compressor uses 80% of the energy used to operate an air conditioning system. This means that the type of the compressor used in the system will determine the overall efficiency of the system. This is particularly important for fuel economy and pollution.

2- Condenser:

The function of the condenser is to act as a heat exchanger to dispel the heat energy contained in the refrigerant. Superheated vapor enters the condenser at the top and subcooled liquid leaves the condenser at the bottom. The condenser must be highly efficient but as compact as possible.

The condenser is located at the front of the vehicle, where strong air flow through its core can be achieved when the vehicle is in motion. To aid the removal of the heat when the vehicle is stationary or at a low speed the condenser is fitted with a single or double fan system. Shrouds are often used to direct the air flow over the surface of the condenser. The condenser comprises a tube coil which is securely attached to fins creating a large cooling surface which facilitates heat transfer.

3- Fluid container and drier:

In the refrigerant circuit with an expansion valve, the fluid container shown in (fig. 2.6) serves as a refrigerant expansion tank and reservoir. Different amounts of the refrigerant are pumped through the circuit when operating conditions, such as the thermal load on the evaporator and condenser and compressor rpm are variable. The fluid container is integrated in the circuit in order to compensate for these fluctuations.

The drier binds chemically moisture which has entered the refrigerant circuit during installation. The drier can absorb between 6 and 12 g of water, depending on type. The amount of water that can be absorbed is temperature-dependent. The amount of water absorbed increases as the temperature drops. Abraded material from the compressor, dirt arising from installation work and similar is also deposited.

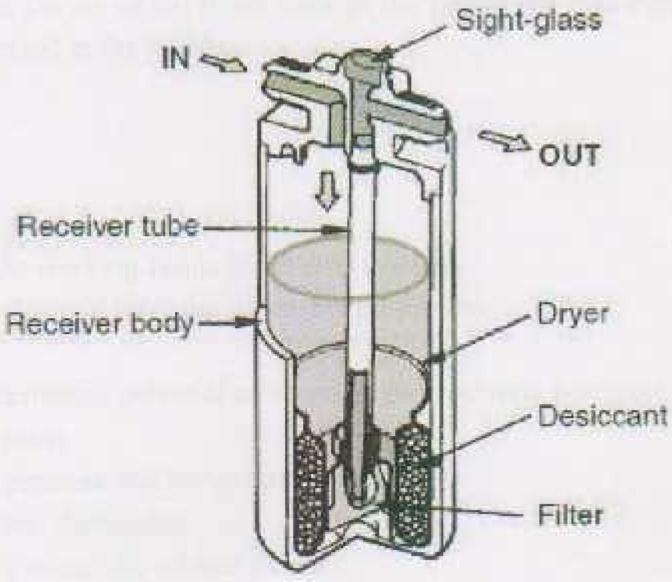


Fig (2.6) fluid container and drier.

4- Expansion valve:

To control the amount of refrigerant volume flowing through the evaporator a metering device must used. The function of the metering device is as follows:

- To separate the high pressure and low pressure side of the system.
- To meter the volume of the refrigerant.
- To ensure that there is a superheated refrigerant existed in the evaporator.

The expansion valve is the point where the refrigerant in the evaporator expands and cools down.

5- Evaporator:

The evaporator operates according to the same principle as a heat exchanger. It is an integral part of the air conditioner in the heater box. When the air conditioner is switched on, heat is extracted from the air which flows through the fins of the cold evaporator. This air is cooled, dried and cleaned in the process.

6- The Refrigerant:

Refrigerants are the working fluids at the A/C systems.
An ideal refrigerant would have the following properties:

- Zero Ozone depleting potential and zero global warming potential.
- Low boiling point.
- High critical pressure and temperature points.
- Non-toxic. Non- flammable.
- Non corrosive to metals, robber, plastics.
- Cheap to produce.

The refrigerant used now in the most of the vehicles air conditioning system is R-134a.

Operation cycle in the vehicle:

A compressor increases the pressure of the fluid in the gas phase, which increases its temperature. The gas passes through a set of coils of a heat exchanger or radiator where it cools by contact with the surrounding air under the hood of the car. Now cooler, it condenses back into a liquid phase and passes through a pressure reduction valve, cooling further.

The liquid moves through the second set of coils where it removes heat from air blown past the coils. The heat that the fluid picks up makes it evaporate back into a gas phase and then it moves toward the compressor again. The compressor is powered by a rubber belt that is turned by a pulley on the crankshaft. (Fig. 2.7) illustrates the operation cycle of the system.

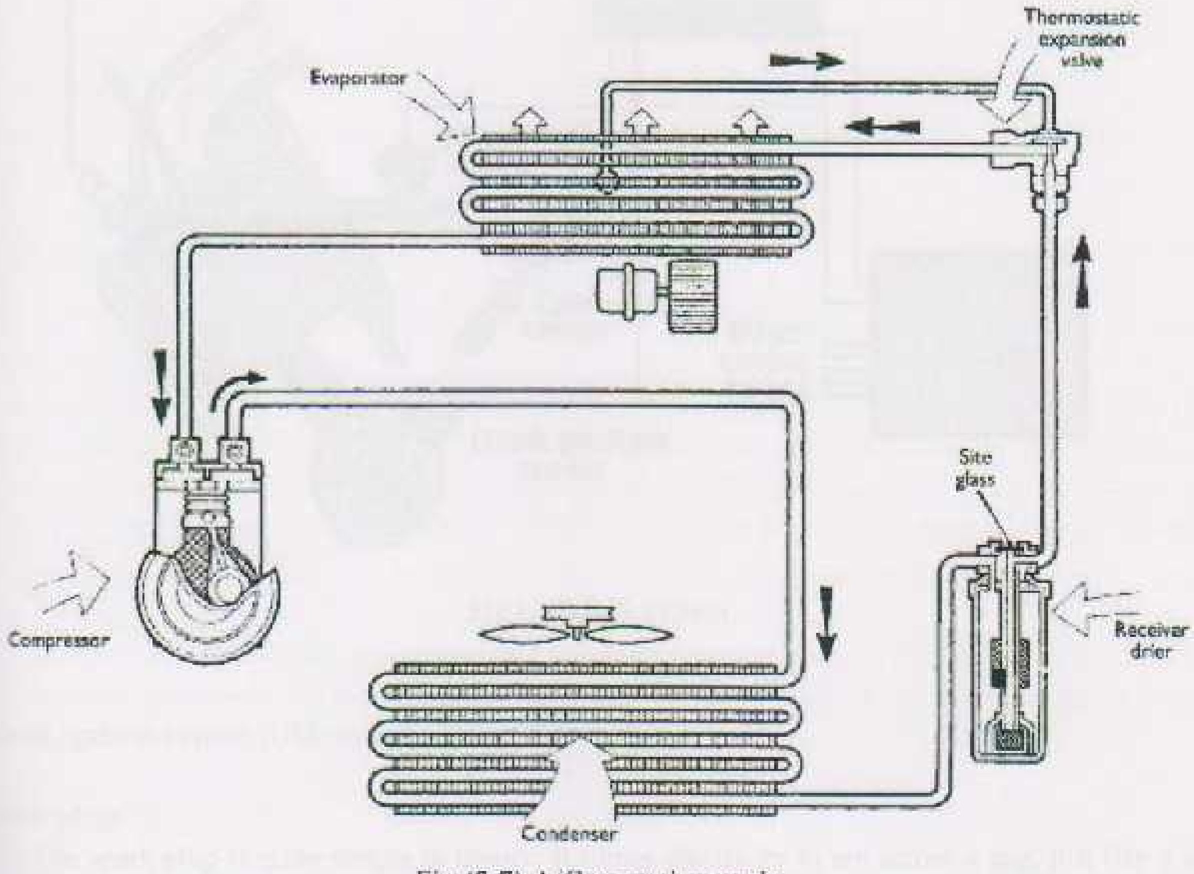


Fig.(2.7) A/C operation cycle.

2.4.2 Ignition System:

The fundamental purpose of the ignition system is to supply a spark inside the cylinder, near the end of the compression stroke, to ignite the compressed charge of air–fuel vapor.

(Fig. 2.8) shows an example of a modern ignition system which is direct ignition system (DIS).

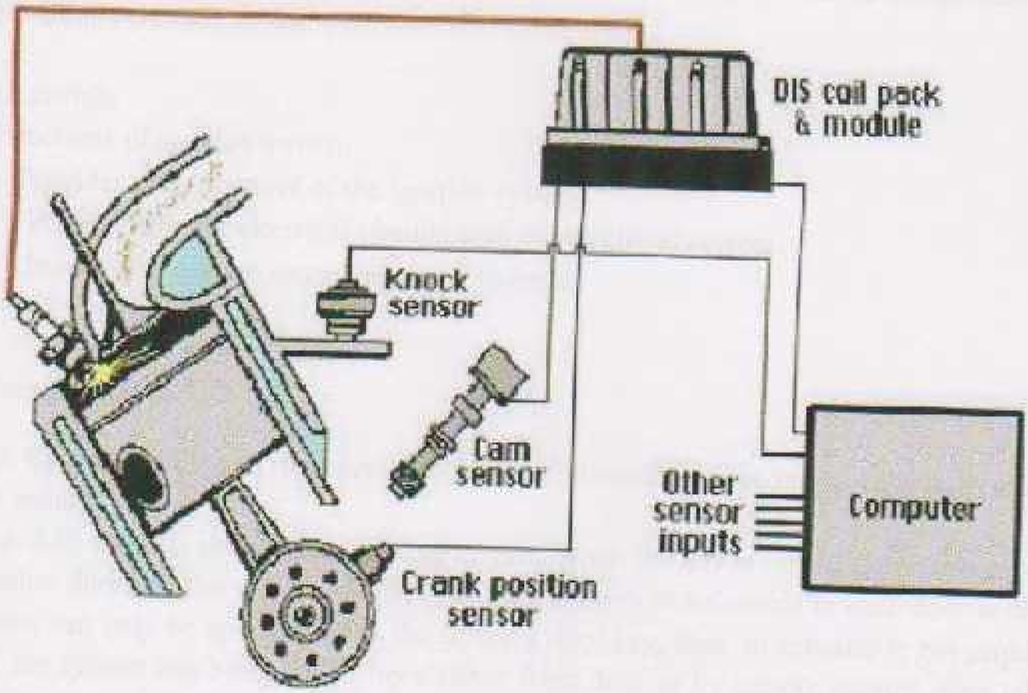


Fig.(2.8) DIS system.

Direct ignition system (DIS) main components:

Spark plugs:

The spark plug is quite simple in theory: It forces electricity to arc across a gap, just like a bolt of lightning. The electricity must be at a very high voltage in order to travel across the gap and create a good spark. Voltage at the spark plug can be anywhere from 40,000 to 100,000 volts.

Crankshaft timing sensor:

Located in the front of the crankshaft to trigger the ignition system, this sensor sends a signal that feed timing and RPM information to the DIS and computer module.

Camshaft sensor:

It is driven by the camshaft and provides information on the cylinder position for the ignition coil and fuel system.

Ignition DIS module:

It receives the signal from the crankshaft sensor and the camshaft sensor, it also receives the spark signal from the vehicle's central computer. It's major purpose is to use the information supplied to it to control the ignition coils.

Ignition coil pack:

It is comprised of multiple ignition coils, the DIS module controls these coils by means of coil leads, and the ignition coils fires two spark plugs simultaneously; one on the compression stroke and the other on the exhaust stroke.

Ignition switch:

Functions of ignition switch:

- Provides driver control of the ignition system.
- Feeding different electrical circuits with the electrical current.
- Usually also used to cause the starter to crank.

2.4.3 Central locking

The Central Locking System provides locking/unlocking of the entire vehicle from one central exterior point.

(Fig. 2.9) shows a simple door locking circuit. When the key is turned in the driver's door lock, all the other doors on the vehicle should also lock. Motors or solenoids in each door achieve this. If the system can only be operated from the driver's door key, then an actuator is not required in this door. If the system can be operated from either front door or by remote control, then all the doors need an actuator. Vehicles with sophisticated alarm systems often lock all the doors as the alarm is set.

Most door actuators are now small motors which, via suitable gear reduction, operate a linear rod in either direction to lock or unlock the doors. A simple motor reverse circuit is used to achieve the required action. (Fig. 2.10) shows a typical door lock actuator.

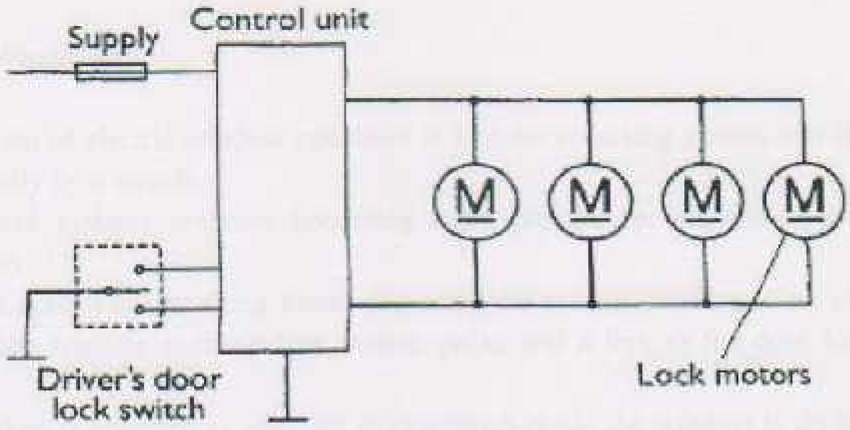


Fig. (2.9) Simple door locking circuit.

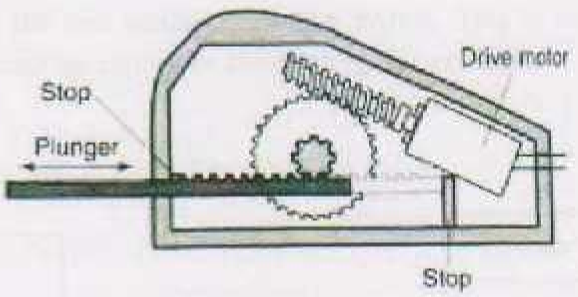


Fig. (2.10) Door lock actuator

Remote keyless system:

A keyless entry system is an electronic lock that controls access to a building or vehicle without using a traditional mechanical key. The term keyless entry system used to mean a lock controlled by a keypad located at the door that requires pressing a predetermined numeric code for entry.

The term remote keyless system (RKS), or more commonly just as keyless entry, refers to a lock that uses an electronic remote control as a key which is activated by a handheld device or automatically by proximity. [5]

Keyless remotes contain a short-range radio transmitter, and must be within a certain range, of the car to work. When a button is pushed, it sends a coded signal by radio waves to a receiver unit in the car, which locks or unlocks the door.

2.4.4 Electrical Windows:

The basic form of electric window operation is a motor reversing system that is operated either by relays or directly by a switch.
More sophisticated systems are now becoming more popular for reasons of safety as well as improved comfort.

Usually this system not working alone, the complete system consists of an electronic control unit containing the window motor relays, switch packs and a link to the door lock and sun-roof circuits.

When a window is operated in one-shot or one touch mode the window is driven in the chosen direction until either the switch position is reversed, the motor stalls or the ECU receives a signal from the door lock circuit. The problem with one-shot operation is that if a child, for example, should become trapped in the window there is a serious risk of injury. To prevent this, the back-off feature is used.

A circuit for electric windows is shown in (Fig. 2.11). There are connections to other systems such as door locking and the rear window isolation switch. This is commonly fitted to allow the driver to prevent rear window operation for child safety, for example.

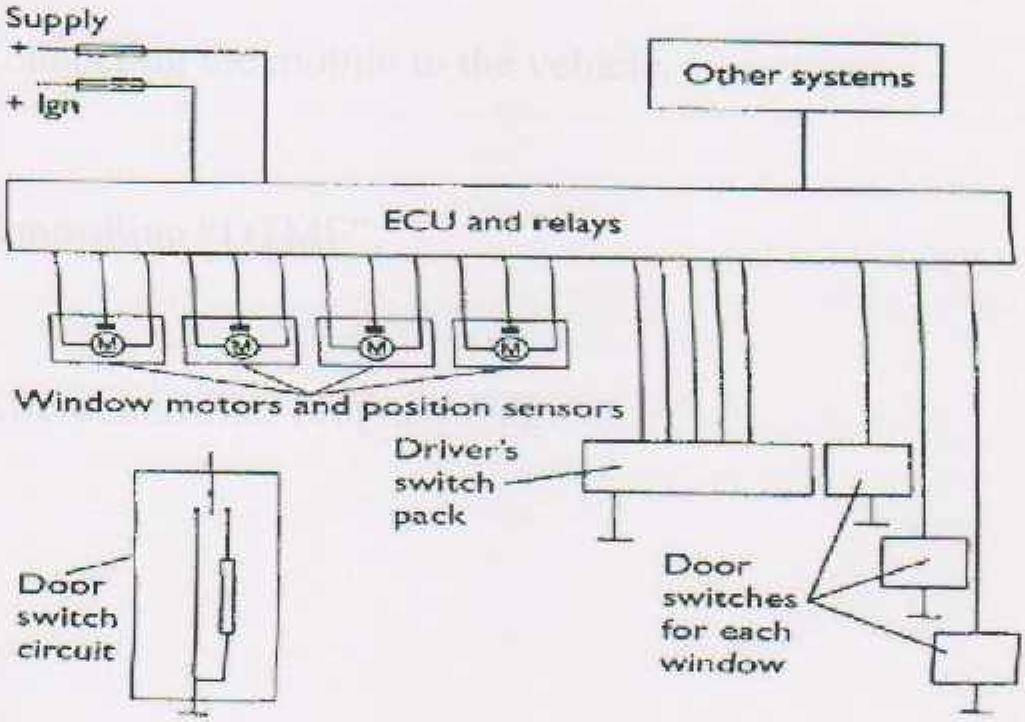


Fig. (2.11) Electric window control circuit.

Chapter Three:

Principle of Work

3.1 Connecting the mobile to the vehicle.

3.2 Controlling "DTMF".

3.3 Microcontroller Programming.

3.1 Connecting the mobile to the vehicle:

(Fig. 3.1) shows the flow of processes in the system to activate one device or more in the vehicle.

This system uses two mobile phones, one with the driver and the other placed inside the car. Each one of these mobiles contains a valid "SIM" card.

The mobile inside the vehicle has an activated "Answer Machine" option, once the driver dials the number of the "SIM" inside the car, the two mobiles will be connected to each other.

The mobile inside the vehicle is attached with a headphone wires, just the wires needed here, the negative terminal of the wires connected to the earth and the positive one is connected to an integral circuit (IC) which is responsible for receiving "DTMF" frequencies. This integrated circuit is "CM 8870".

Now, the mobile with the driver is completely connected with the internal system of the controlling device, and waiting for orders.

3.2 Controlling "DTMF":

After the signals of "DTMF" have been received by the mobile inside the car, then these signals will be resend to the "CM 8870" circuit, which specialized of determining these frequencies. This piece reading each frequency alone, and then producing (4-bit) values for each button presented in the mobile. As explained in chapter two.

After that, the (4-bit) values leave the circuit (CM 8870) to enter (4*16) decoder which convert these values into (16) values, through determining the entering (4-bit) values.

Now, each button in the mobile has a unique constant value comes from the decoder.

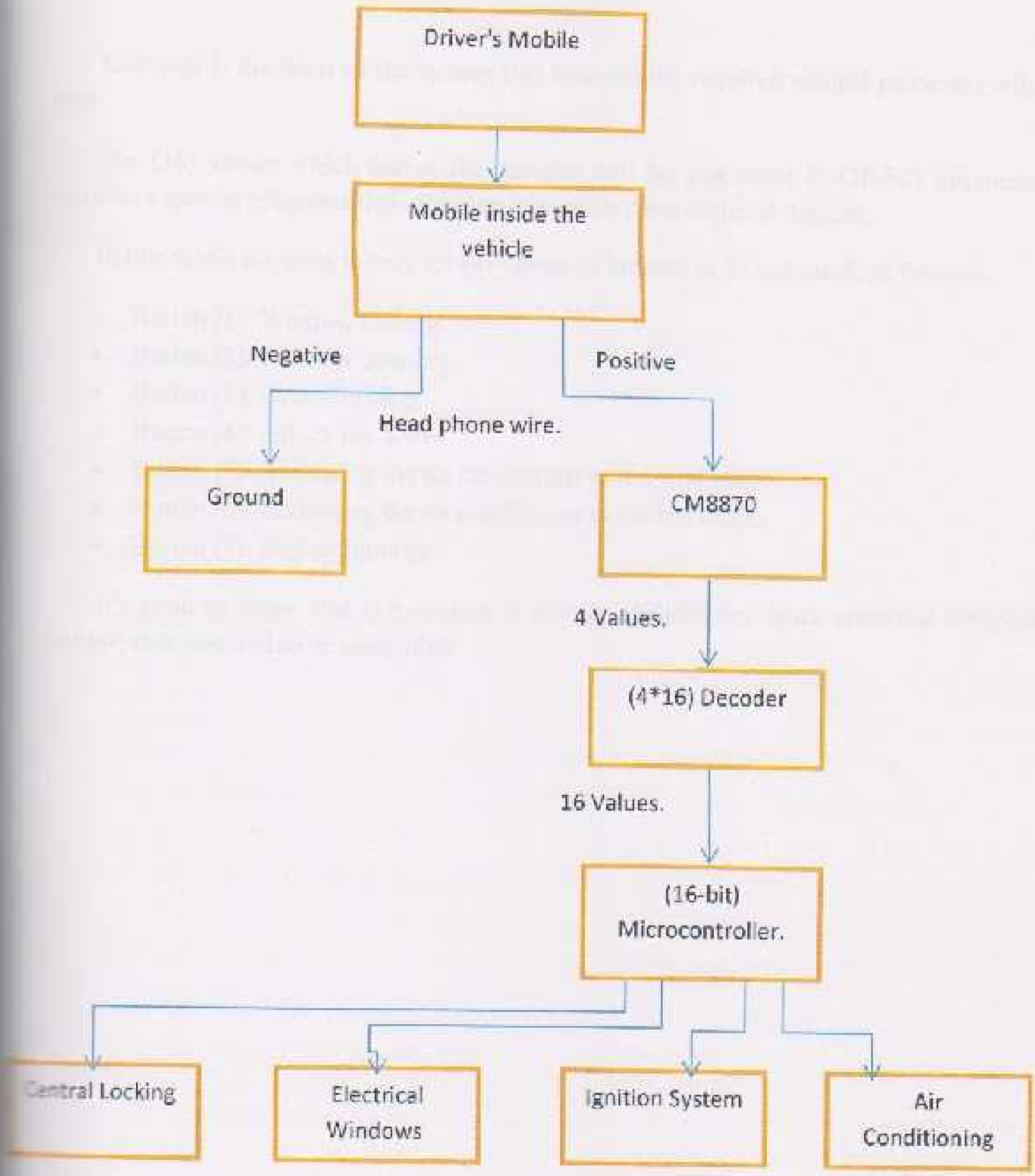


Fig. (3.1) Flow of processes.

3.3 Microcontroller Programming:

This step is the heart of the system that because the required control processes will be performed here.

The (16) values which leaves the decoder will be processed in (16-bit) microcontroller, which includes a special programs that allowing it to control the required devices.

In this work, the need is only for (9) values or buttons to be activated, as follows:

- Button (1): Window closing
- Button (2): Window opening.
- Button (3): Doors locking.
- Button (4): unlock the doors.
- Button (5): Activating the air conditioner at the cold mode.
- Button (6): Activating the air conditioner at the hot mode.
- Button (7): Engine running.

It's good to know that this system is able to include any other electrical component inside the vehicle that required to be controlled.

Chapter Four:

Design Process

4.1 Introduction.

4.2 Mobile used.

4.3 DTMF decoder building.

4.4 Microcontroller description.

4.5 Vehicle used.

4.6 Central locking wiring diagram and principle of controlling it.

4.7 Windows wiring diagram and principle of controlling it.

4.8 Air conditioning wiring diagram and principle of controlling it.

4.9 Ignition system and principle of controlling it.

4.1 Introduction:

In this chapter the principles of design will be introduced, by explaining the steps of building the system in order to fulfill the objectives needed.

These objectives will be:

- Starting the engine.
- Opening/closing the windows.
- Locking/unlocking the doors.
- Controlling the air conditioning system.

These objectives should be done by cell phone controlling.

In order to build the complete design of this project, a test board contains a model of the electrical and electronic components were built, to install it on the vehicle when this model tested and gives the requirements.

This test board is shown in figure (4.1).

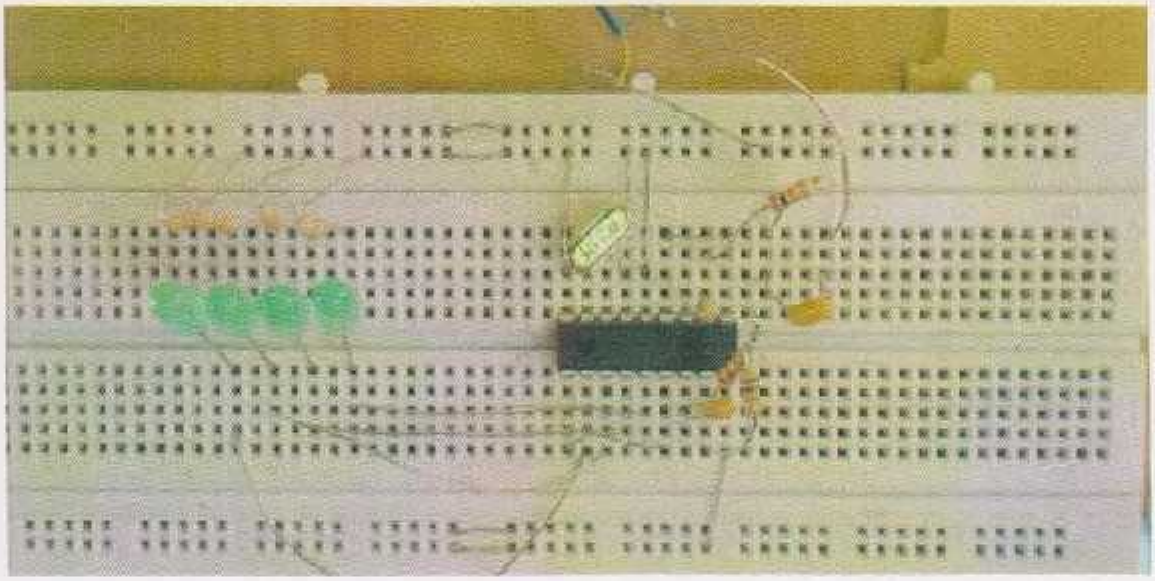


Fig. (4.1): The test board.

4.2 Mobile used:

This mobile should be able to receive a phone call from another mobile outside the model, and give a signal through its headphone wires to the (IC) depending on the DTMF received from the external mobile.

Fig. (4.2) shows the mobile used here is nokia 1616.

Fig. (4.2): Mobile used in the project.

This mobile used for the following reasons:

- Can receive the DTMF signals.
- Have a headphone exit.
- Have the ability of auto answer.
- Low cost.

The mobile inside the vehicle will be supplied with the power through a charger *connected to the cigarettes lighter.*

4.3 DTMF decoder building:

The (CM 8870) is a complete DTMF receiver integrating both the band split filter and digital decoder functions. The filter section uses switched capacitor techniques for high and low group filters; the decoder uses digital counting techniques to detect and decode all 16 DTMF tone-pairs into a 4-bit code.

The (CM 8870) is a special integral circuit concerns with receiving the dual tune multi frequency (DTMF) signals, and used in many applications such as: receiving systems in telecommunication service providers, mobile radio applications, credit card systems, personal computers, remote control, and telephone answering machines.

This (IC) offers a small size, low power consumption, and high performance. In order to use this (IC) as a DTMF receiver it should be connected to with some resistances and capacitors to save it and to allow good processing as shown in the figure (4.3) below.

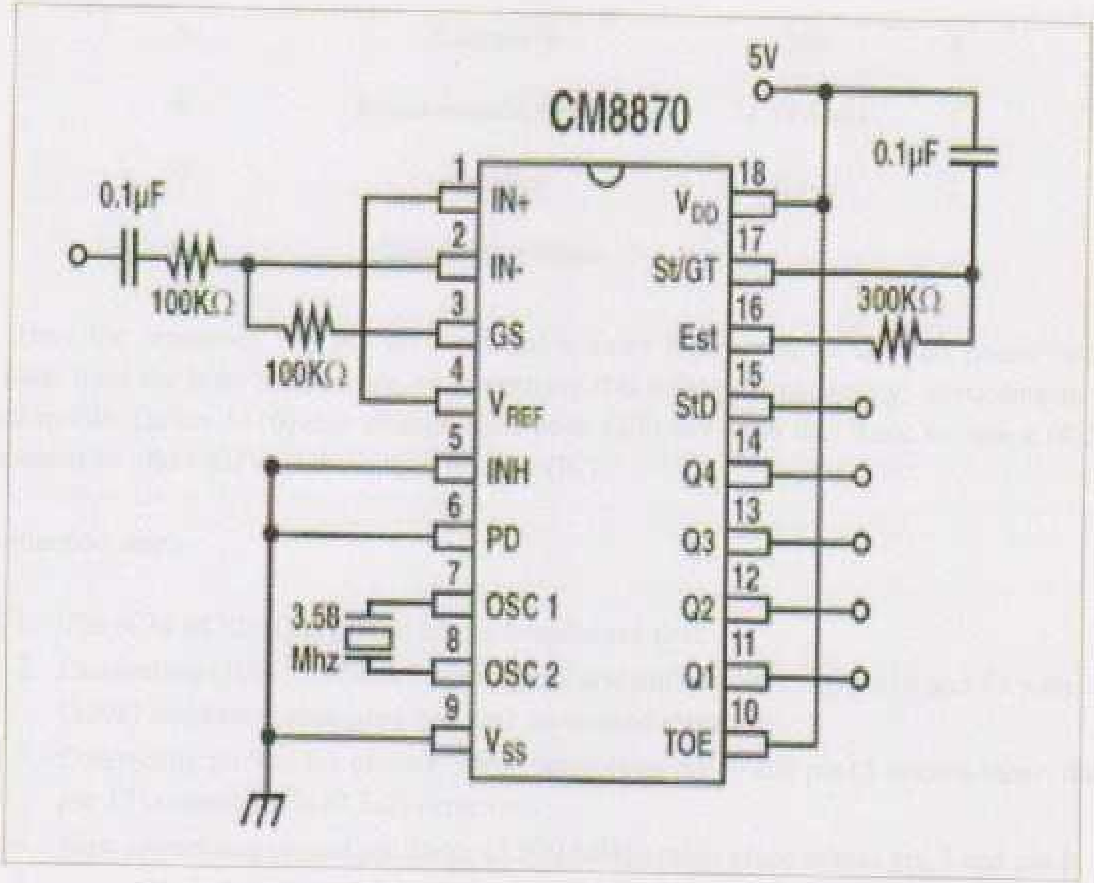


Fig. (4.3): Connection of capacitors and resistances with the (IC).

And this is the meanings of the symbols, and the magnitudes:

Prt.No	Description	Spec.	Qty (Nos.)
1	MT8870		
2	Resistor-1	R	1
3	Resistor-2	100k	1
4	Resistor-3	330k	1
5	Resistor-4	22k	4
6	Piezo-electric Crystal	3.57 MHz	1
7	capacitor	0.1uf	2
8	Connecting Wires	-	-

Here the resistance (R) has no fixed value since it depends on the cell phone output voltage from the head phone wire, so measuring this voltage is necessary, according to the used mobile (nokia 1616) this voltage have been (100 mV) and that leads to use a (4.7 k) resistance to allow the signal to move into the (IC).

Connection steps:

1. The (CM 8870) IC is placed on the breadboard first.
2. Connecting (100k) resistance across pin2 and pin3, connecting pin16 and 17 with (330k) resistance, then pin4 and pin1 connected together.
3. Connecting pin9 to the ground, while connecting pin10 and pin15 to each other, then pin 17 connected via (0.1uf) capacitor.
4. Now connecting crystal oscillator (3.579 MHZ) takes place across pin 7 and pin 8.
5. Connecting 4 (22 k) resistances in parallel with pins (11-14).
6. Connecting the voltage source (+5 V) to pin18.
7. Connecting the head phone positive wire with (0.1uf) capacitor and with it in series the (4.7k) resistance then connecting it to pin2.
8. Connecting the negative wire of the head phone to the ground.

Testing of the circuit:

For testing this circuit 4 LEDs needed with 4 (300 ohm) resistances, the LEDs connected via resistors R11 to R14 at pins 11 through 14, respectively, indicate the output of the (IC).

The tune- pair DTMF (dual tune multi frequency) generated by pressing the telephone is covered into binary values internally in the (IC), the binary values are indicated by glowing of LEDs at the outputs of the (IC).

LED 1 represents the lowest significant bit (LSB) and LED 4 represents the most significant bit (MSB). So, when you dial a number, say, 5, LEDs 1 and 3 will glow, which is equal to 0101. Similarly, for each number dialed in the mobile, the corresponding LEDs will glow. Thus, a non-defective (IC) should indicate proper binary values corresponding to the decimal number pressed in the mobile keypad.

The next table shows the status of LEDs on pressing keys on the mobile keypad:

Table (4-1): Status of the LEDs when pressing a key in the mobile.

Key No.	LED 1	LED 2	LED 3	LED 4
1	OFF	OFF	OFF	ON
2	OFF	OFF	ON	OFF
3	OFF	OFF	ON	ON
4	OFF	ON	OFF	OFF
5	OFF	ON	OFF	ON
6	OFF	ON	ON	OFF
7	OFF	ON	ON	ON
8	ON	OFF	OFF	OFF
9	ON	OFF	OFF	ON
0	ON	OFF	ON	OFF

Notes: 1- LEDs blinks momentarily whenever any key is pressed.

2- ON = 1, while OFF = 0.

4.4 Microcontroller description:

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office machines, power tools and other systems.

By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes, mixed signal microcontrollers are common.

Microcontroller selection:

A 16f877 pic microcontroller, shown in figure (4.4), used in this project, this particular microcontroller were chosen for the following features:

1- Low-power.

2- High-speed Flash/EEPROM (Electrically Erasable Programmable Read-Only Memory) technology.

3- Fully static design.

4- Wide operating voltage range (2.0V to 5.5V).

5- Commercial and Industrial temperature ranges.

6- Low cost.

Fig. (4.4): the Microcontroller used in this project.

In some systems the CPU is a limit to the highest and sometimes the lowest CPU clock frequency, so the clock needs to be stable enough to guarantee timing requirements are met according to the design and the specification.

Oscillator circuit is used for providing a microcontroller with a clock. Clock is needed so that microcontroller could execute a program or program instructions.

Many types of oscillators used in microcontrollers, the type used for this project is quartz crystal oscillator, which is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time, to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers.

The frequency of each crystal remains stable at a variety of temperatures and pressures and in the presence of many different materials and chemicals, making it ideal for operations that require precise timing under many circumstances.

The crystal oscillator used in this project for the microcontroller is an external (SJK) with 4 MHz frequency.

Microcontroller programming:

first of all, this system should be safe, so that only the vehicle's owner who will have the ability to control his vehicle, and to fulfill this purpose a security system where built in the microcontroller passed on a password protection.

when the owner calls his vehicle, he must enter the right password to log in to the system, if he enters the right password he will get an accepting tone, after that the owner will listen to tone every time he presses a number, to ensure that the process in progress.

If the owner wants to end the call, he must press (#) to log out of the system, and that to make the password return to the set point, otherwise the system will accept any call later from anybody else.

The following flow chart shows the flow of the processes inside the microcontroller:

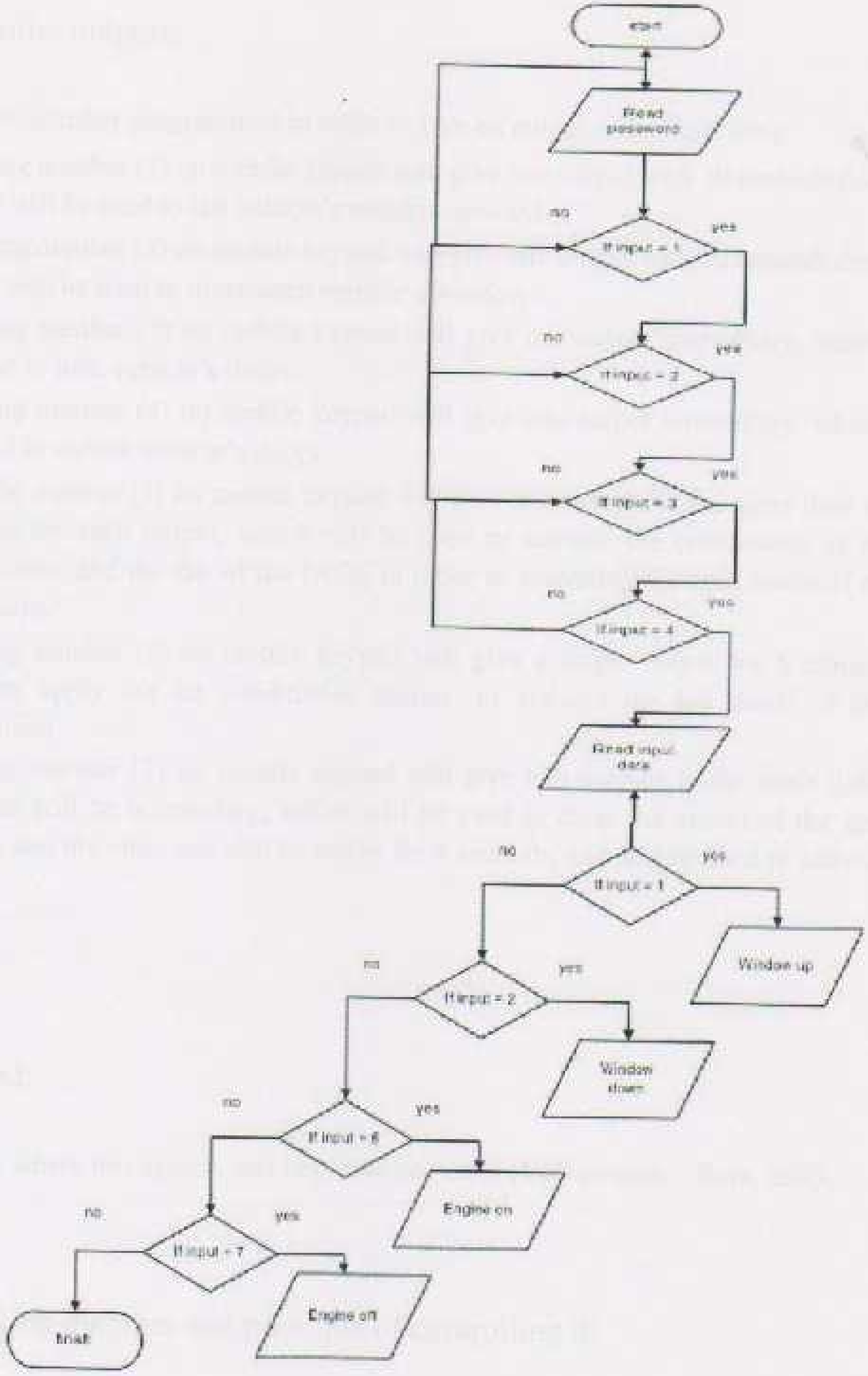


Chart (4.1): flow of processes inside the microcontroller.

Microcontroller outputs:

The microcontroller programmed in order to give an output as the following:

- Pressing number (1) on mobile keypad will give one output with 10 seconds duration, which will be used to left vehicle's window upward.
- Pressing number (2) on mobile keypad will give one output with 10 seconds duration, which will be used to downward vehicle's window.
- Pressing number (3) on mobile keypad will give one output momentary, which will be used to lock vehicle's doors.
- Pressing number (4) on mobile keypad will give one output momentary, which will be used to unlock vehicle's doors.
- pressing number (5) on mobile keypad will give two outputs at the same time with 5 minutes for each output, which will be used to activate the compressor of the air conditioner, and the fan of the (AC), in order to activating the cold mode of the air conditioner.
- Pressing number (6) on mobile keypad will give a single output for 5 minutes, in order to apply the air conditioner blower, to activate the hot mode of the air conditioner.
- pressing number (7) on mobile keypad will give two outputs at the same time, the first one will be momentary, which will be used to close the circuit of the ignition switch, and the other one will be active for 4 seconds, and will be used to activate the starter.

4.5 Vehicle used:

The vehicle where this system was implemented on is (Volkswagen – Bora, 2005, 1600cc).

4.6 Central locking diagram and principle of controlling it:

This System provides locking/unlocking of the entire vehicle from one central exterior point.

The mechanism depends on a small DC motor which, via suitable gear reduction, operates a linear rod in either direction up and down to lock or unlock the doors, by changing motor polarity.

When the actuator moves the latch up, it connects the outside door handle to the opening mechanism. When the latch is down, the outside door handle is disconnected from the mechanism so that it cannot be opened.

This system is quite simple, a small electric motor turns a series of gears that serve as a reduction, the last gear drives a rack and pinion gear set that is connected to the actuator rod, and the rack converts the rotational motion of the motor into the linear motion needed to move the lock.

An important thing about this mechanism is that while the motor can turn the gears and move the latch, if you move the latch it will not turn the motor.

A normal central locking system can be activated directly by the ignition key or by remote control from specified distance.

In this project, the system should be activated by the mobile with the driver to dial a number which is responsible for opening or closing the doors automatically through a phone call, and then the mobile inside the vehicle will respond through the answering machine and passing the suitable (DTMF) signals to the integrated circuit (MT8870).

The (IC) receives the signal; analyze it, and producing a (4-bit) values special for the number dialed by the driver. These values transferred to the decoder which becomes a (16-bit) value after leaving the decoder.

Now, the signal enters the microcontroller, processed, and then the controller according to the content program decides which system should be activated or deactivated.

An order from the microcontroller transferred to the central locking system through a wire connects between the microcontroller and the main relay in the system, especially in the same location where the ignition signal wire connected with the relay or at the door locking switch as shown in figure (4.5).

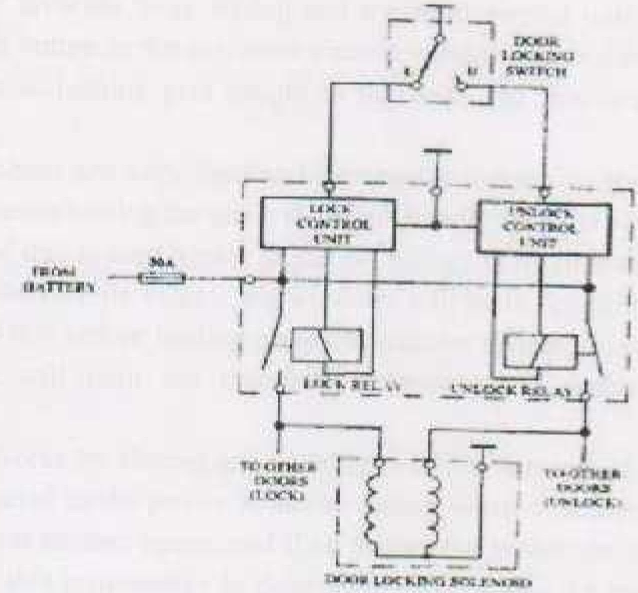


Fig. (4.5): Door locking/unlocking circuit.

4.7 Electric windows wiring diagram and principle of control it.

In an electric window system, a D.C. permanent magnet motor is normally used to operate each window, and a three-position rocker switch changes the polarity for providing up-and-down motion of the window. Four main window switches, one for each window are installed on the driver's panel, and an isolation switch is also added to disconnect the supply to the rear windows,   two relays control the current to each motion and are powered by a common feed.

An important feature of power windows is that they cannot be forced open; the worm gear in the drive mechanism takes care of this, many worm gears have a self-locking feature because of the angle of contact between the worm and the gear, the worm can spin the gear, but the gear cannot spin the worm. friction between the teeth causes the gears to bind.

A gearbox forms the drive between the motor and the window glass and amplifies the torque sufficiently to undertake upward motion of the window, which is more difficult than the downward motion. The gearbox drives either a flexible rack or acts directly on to the window winding mechanism similar to a manual system.

The wiring of the electric windows runs throughout the car, sometimes it's very simple to wire the car, as each window has its own control. However, the driver's side door often has controls for all the windows in a car, which requires wiring to run throughout the car.

This simply involves more wiring and a central control unit that processes the electric signals for each button in the car, most electric windows have a feature that stops them from going up when something gets caught in the way, and this is a safety feature that keeps people safe.

The mechanisms are very similar in manual windows as that of power windows, but instead of the motor turning the gears the crank handle does the work.

Activating of this system begins as the car battery that sends the power to the ignition; so that when you turn on the vehicle the windows will be in operation, from the ignition a wire runs to the fuse box before leading on to the window switch, this is essential in the case of a fault, the fuse will burn out therefore preventing any major costly repairs to larger components.

The switch works by closing and opening two different sets of wire circuits, and then the wires are redirected to the power windows motor, when a user pushes the switch one way, one set closes and another opens, and if he pushes the switch the other way the opposite sets open and close, this is necessary in determining which way the motor should run. As shown in figure (4.6).

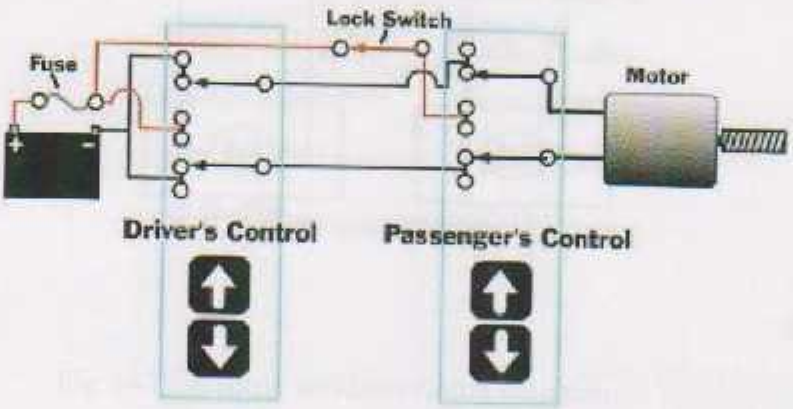


Fig. (4.6): Changing the direction of the window (up/down).

The driver's door module monitors all of the switches, for instance, if the driver presses his window switch, the door module closes a relay that provides power to the window motor and activate the system for closing or opening.

In this project, it's needed to control the window of the driver, a signal from the microcontroller given to the switch of the window of the driver, this signal causes the circuit to close, and then the motor start rotating to rise or setting down the glass. As shown in the figure (4.7).

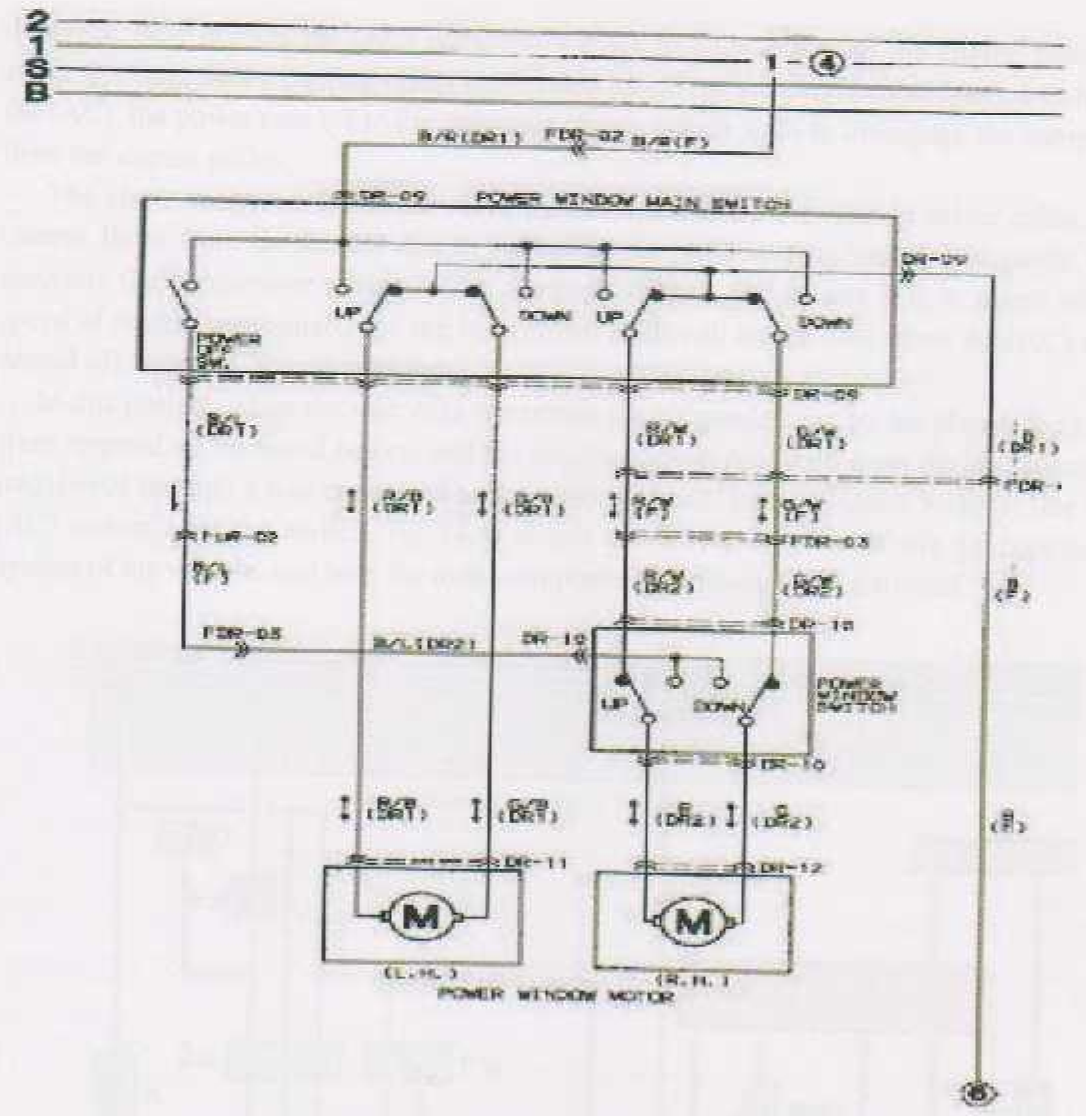


Fig. (4.7): Electric windows circuit diagram.

4.8 Air conditioning wiring diagram and principle of controlling it:

Two types of air conditioning systems are available on vehicles; automatically controlled system and the other system is manually controlled.

The system installed on the vehicle of this project is a manual type.

The (AC) Compressor is driven by the engine through the belt and pulley. As the engine starts to rotate, the pulley rotates the compressor shaft and starts compressing the refrigerant. The (A/C) clutch is a mechanism to control the connection of the compressor to the engine.

The (AC) magnetic clutch works on the principle of electromagnetism. When the (AC) is turned on, the electromagnetic clutch energizes and produces a strong magnetic field. This magnetic field attracts the (AC) compressor rotor to engage it with the engine pulley and starts working, thus a cooling effect is obtained inside the passenger cabin. As we switch off the (AC), the power cuts off to the magnetic clutch, which leads to disengage the compressor from the engine pulley.

The electromagnetic clutch activated by an air conditioner switch in driver cabin, when current flows from the battery due to switching the (AC) system "on" the magnetic clutch connects the compressor pulley to the compressor shaft and causes it it to rotate with the speed of engine crank shaft, and the compressor shaft will be released when the (AC) switch turned off, then (AC) stops working.

In this project, when the user asks to operate the air conditioner by his phone, the system were respond as discussed before, and the required signal produced from the microcontroller transferred through a line connected to the air conditioner relay common with the line of the (AC) switch after the switch, fig. (4.8) shows the wiring diagram of the air conditioning system of the vehicle, and how the main components connected and activated.

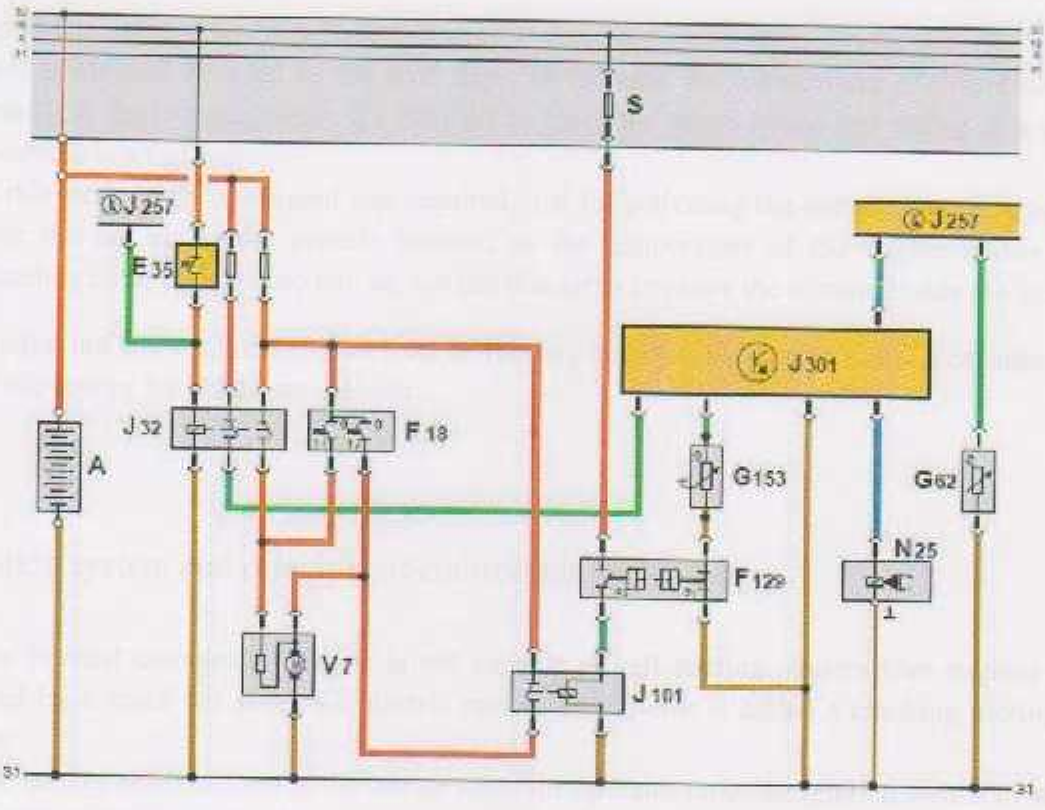


Fig. (4.8) Wiring diagram of the (AC) system.

Where: E35: air conditioner switch. J32: air conditioner relay.

V7: radiator fan. F18: radiator fan thermo switch.

Another option available for the user, that he can activate hot or cold mode at different weather conditions.

a) Cold mode:

This mode may be required in summer days, for cooling the inside volume of the vehicle before start travelling, or when a car is parked under the sun, so it's difficult to use it with its polluted inside air, and hot furniture temperature.

To activate this mode, it was needed to have two signals from the microcontroller; one of them was taken to the (AC) fan switch, for activating the system. And the other signal connected to the magnetic clutch, in order to activate the compressor, which forces the refrigerant to recirculate in the cooling cycle.

The cold mode will be chosen by default from the driver previously, as the air conditioner normally would be activated at this mode in the summer days.

b) Hot mode:

This mode will be used in the cold days, to increase the temperature of driver cabin, especially in the morning when it's difficult to leave the warm house and sitting in a very cold vehicle in a fast way.

In this mode; only one signal was required, just for activating the hot air blower, in order to pass the hot air to the vehicle interior, as the temperature of the engine makes the surrounding air to become too hot, so, we use this air to improve the climate inside the car.

In both modes, hot and cold, the engine must be running before activating any mode, because it's the source of the energy for the air conditioner.

4.9 Ignition system and principle of controlling it.

The internal combustion engine is not capable of self-starting. Automotive engines are cranked by a small but powerful electric motor. This motor is called a cranking motor, or starter.

The battery sends current to the starter when the operator turns the ignition switch to start; this causes a pinion gear in the starter to mesh with the teeth of the ring gear, thereby rotating the engine crankshaft for starting.

In conventional way of starting the engine, the key with the driver is used, to offer some measure of security to engine operation and starting, rotating of the switch is used to control the engine and starter motor.

There are typically three separate switches options in the ignition switch assembly, off, on, and start positions. As shown in figures (4.9, a, b, c).

Fig. (4.9, a): Off position.

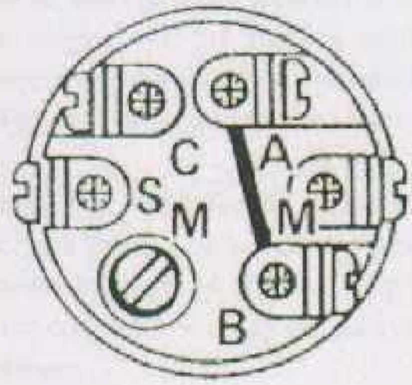


Fig. (4.9, b): On position.

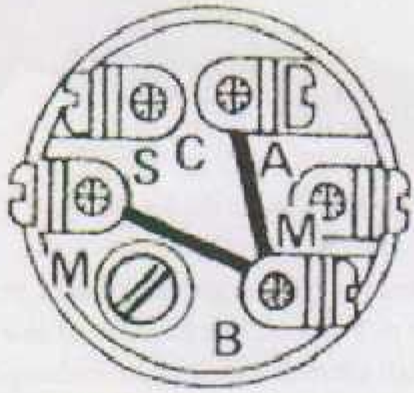


Fig. (4.9, c): Start position.

Where: A/I: Accessory or Ignition. S: Start.
B: Battery. M: Engine chassis or battery negative.

The two M terminals are the poles of an isolated switch which are only connected in the (Off) position. These terminals are used to connect the ignition kill circuit to ground, Fig. (4.9, a).

The B terminal with +12-volts from the battery is connected to the A (or I) terminal, supplying battery voltage to all the accessory loads and to the engine ignition. This is the (On) or (run) position, Fig. (4.9, b).

The B terminal is connected to the A and S terminals, supplying battery voltage to the engine ignition and accessory loads, and to the engine starter solenoid. This is the (start) position, Fig. (4.9, c).

In modern vehicles starting system, in order to achieve more security, a key contains a certain code used to start the engine, and the engine will not running until a matching between the code included at the key, and the corresponding code that presents in the vehicle (ECU), then the engine will start after turning the key if the codes are the same.

It's very difficult for us to know the correct code that will make the engine running. So, to overcome the problem of the code in this project, the ignition code will be extracted from the key, and then installed in an external chip, shown in figure (4.10), this chip be integrated with the DTMF system inside the vehicle, and the code will be ready for the system any time it's needed. This will help to get rid of code problems.

Fig. (4.10): The chip which contains the ignition code.

Now, when the driver asked to start the engine, the number responsible for this task were dialed in his phone, a signal was transferred and analyzed in the system, and then processed though the microcontroller to produce two outputs to make the engine run.

The first output were taken to the circuit responsible for the ignition switch. To feed the related electrical circuits with a current and keeping them working as the engine is running. As shown in the figure (4.11).

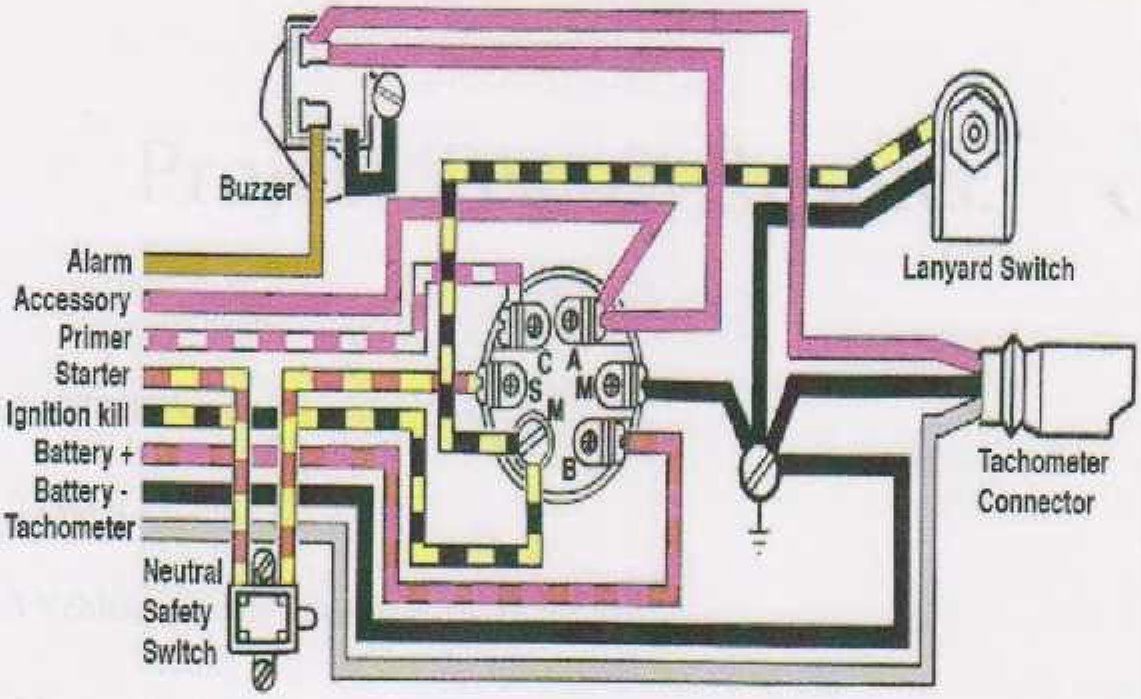


Fig. (4.11): Systems depending on the ignition key.

The other output was taken to the starter, to mesh with the fly wheel and start rotating the engine as shown in figure (4.12). This signal duration must be limited, for about five seconds, to avoid starter wearing and damage when it's rotating with the engine after starting.

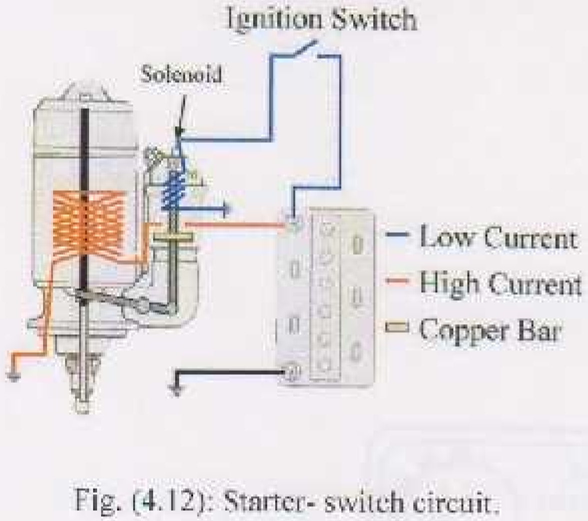


Fig. (4.12): Starter- switch circuit.

Chapter Five:

Project Test & Results.

5.1 (DTMF) System testing:

The DTMF system built and tested out of the vehicle, by using light emitted diodes (LEDs) to check that the system responds correctly to the order required by the driver.

The number of the mobile used in the system was dialed, and after the automatically answering system started, the password of the system was entered. At that moment the system was in connection with the driver mobile and able to accept any entry from the external mobile.

After that, the response of the system was checked by entering each individual number which is responsible for activating vehicle systems from the external mobile, and noticing how (LEDs) will respond to it.

As the (LEDs) been observed, the system was record great results, the suitable (LED) emitted as a specified number dialed through the external mobile, and for the required period. This means that the system was able to be installed in the vehicle.

5.2 Power circuit

The signals produced by (DTMF) system were not able to activate any relay connected with vehicle systems. So, a special circuit consists of transistors and resistances were built in order to produce the suitable current and voltage outputs which required for activating the relays.

5.3 Vehicle systems testing:

Before installing the (DTMF) system on the vehicle, vehicle systems were checked. The test showed that the available vehicle has no central locking actuators, and the air conditioner was invalid, because it used in a previous graduation project.

Some problems were encountered when trying to run the engine, but it's been fixed, and the engine was ready for this project.

The motor of the electric window at driver's side did not exist, so, the window at the passenger side was chosen for this project.

5.4 Project testing:

After the tests for (DTMF) system and for the vehicle systems gave good results, the (DTMF) system was installed to the required vehicle systems as described in chapter four.

The (DTMF) system was connected to the ignition system and to the electric window, and the external mobile became in contact with the mobile in the vehicle by a phone call, then the whole system was ready for the orders.

The number responsible for activating the ignition system was dialed, processed through (DTMF) system, and then the engine ran as required. Another number for turning off the engine was entered and the engine stalled.

Tow numbers responsible for moving the glass up and down, these numbers were dialed consequently, and then the window gave the desired movement.

5.5Results:

- The system was built completely.
- The system was tested successfully.
- This system able to be implemented on other vehicle systems with good expected results.

5.6Recommendations:

- This system can be applied on other vehicle systems.
- More safety considerations need to be integrated with kind of systems.

PIC code:

```
char Pass_Flag=0;
char Pass[4;[
char Pass_cunt=0;
char dtmf()
}
char x=0;
char out=0;
x=portd;
switch(x(
}
case 17:out=1;break;
case 18:out=2;break;
case 19:out=3;break;
case 20:out=4;break;
case 21:out=5;break;
case 22:out=6;break;
case 23:out=7;break;
case 24:out=8;break;
case 25:out=9;break;
case 26:out=10;break;

case 27:out=11;break;
case 28:out=12;break;



x=0;
return out;
{
{
void main ()
}
Pass[0]=1;
Pass[1]=2;
Pass[2]=3;
Pass[3]=4;

trisa=0;
trisb=0;
trisc=0;
trisd=0b00011111;

porta=0;
portb=0;
portc=0;
portd=0;
Sound_Init(&PORTC, 0;(

while(1(
}
if(Pass_flag==0(
}
if(Pass_cunt==0&&Pass[0]==dtmf())Pass_cunt=1;
else if(Pass_cunt==1&&Pass[1]==dtmf())Pass_cunt=2;
```

```
else if(Pass_cunt==2&&Pass[2]==dtmf())Pass_cunt=3;
else
if(Pass_cunt==3&&Pass[3]==dtmf()){Pass_cunt=4;Pass_flag=1;Sound_Play(880,
1000{ ;{
else Pass_cunt=0;
{
else if(Pass_flag==1(
}
    if(dtmf()==1){Sound_Play(1000,
1000);RB0_bit=1;delay_ms(10000);RB0_bit=0{;
else if(dtmf()==2){Sound_Play(1000,
1000);RB1_bit=1;delay_ms(10000);RB1_bit=0{;

else if(dtmf()==3){Sound_Play(1000,
1000);RB2_bit=1;delay_ms(1000);RB2_bit=0{;
else if(dtmf()==4){Sound_Play(1000,
1000);RB3_bit=1;delay_ms(1000);RB3_bit=0{;

else if(dtmf()==5){Sound_Play(1000,
1000);RB4_bit=1;RB5_bit=1;delay_ms(50000);RB4_bit=0;RB5_bit=0{;

else if(dtmf()==6){Sound_Play(1000,
1000);RB6_bit=1;RB7_bit=1;delay_ms(3000);RB7_bit=0{;

else if(dtmf()==12){Sound_Play(1000, 1000);Pass_cunt=0;Pass_flag=0{;

{

{


{
```

Volkswagen Golf IV 2001 to 2004

Key to circuits

Diagram 1: Information for wiring diagrams

Diagram 2: Starting and charging, airbag and radio with CD player

Diagram 3: Central locking, electric windows and mirrors

Diagram 4: Central locking control unit and interior lights, horn, fuel tank filler flap release, typical radiator fan, diagnostic connector supply, cigarette lighter and 12V socket

Diagram 5: ABS, heater blower, heated rear window, wash/wipe, brake lights and reversing lights

Diagram 6: Headlights, licence plate lights, taillights and side lights, rear fog light, hazard warning lights and direction indicators

Diagram 7: Headlight leveling, lighting rheostat, front fog lights, gas discharge headlights, gas discharge headlight range control

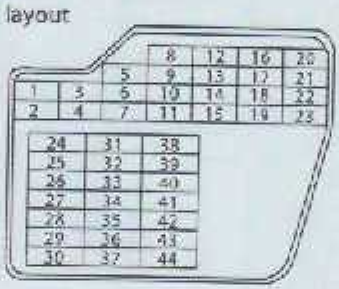
Diagram 8: Instrument panel, glove box light, interior lights not convenience system

Key to symbols

- Bulb
- Switch
- Fuse/fusible link and current rating
- Multiple contact switch (ganged)
- Resistor
- Variable resistor
- Connecting wires
- Item no.
- Pump/motor
- Earth point and location
- Wire joint
- Solenoid actuator
- Diode
- Light emitting diode (LED)
- Wire colour (brown with black tracer)
- Screened cable

Dashed outline denotes part of a larger item, containing in this case an electronic or solid state device.
Connectors:
- Unspecified connector, pin 2.
T75/1 - Connector T75, pin 1.

Fuse box layout



Earth points

E1	Battery earth	E8	Driver's door earth 3	E15	Passenger's door earth 2
E2	Gearbox earth	E9	Lower left A pillar	E16	Passenger's door earth 3
E3	Airbag earth	E10	Lower right A pillar	E17	LH engine compartment
E4	Centre of the dashboard	E11	Lower left B pillar	E18	Front cross member
E5	Radio earth 2	E12	Lower right B pillar	E19	Instrument panel earth
E6	Radio earth 1	E13	Steering column		
E7	Driver's door earth 2	E14	LH luggage compartment		

Key to circuits

Diagram 1	Information for wiring diagrams
Diagram 2	Starting and charging, airbag and radio with CD player
Diagram 3	Central locking, electric windows and mirrors
Diagram 4	Central locking control unit and interior lights, horn, fuel tank filler flap release, typical radiator fan, diagnostic connector supply, cigarette lighter and 12V socket
Diagram 5	ABS, heater blower, heated rear window, wash/wipe, brake lights and reversing lights
Diagram 6	Headlights, licence plate lights, taillights and side lights, rear fog light, hazard warning lights and direction indicators
Diagram 7	Headlight leveling, lighting rheostat, front fog lights, gas discharge headlights, gas discharge headlight range control
Diagram 8	Instrument panel, glove box light, interior lights not convenience system

Fuse table

Battery fuse holder

Fuses	Rating	
F162	50A	Glow pin heating
F163	50A	Engine management
F164	40A	Radiator fan
F176	110A	Interior
F177	110A	Alternator (90A)
	150A	Alternator (120A)
F178	30A	ABS (pump)
F179	30A	ABS
F180	30A	Radiator fan

Relay plate fuses

Fuses	Rating	
F37	30A	Central locking, electric windows
F111	15A	Convenience system
F144	15A	Convenience system

Main fuse box

Fuses	Rating	Circuit protected
F1	10A	Glove box light, electric mirrors
F2	10A	Indicators, hazard lights, headlight adjusters
F3	5A	Fog light relay, lighting rheostat
F4	5A	Licence plate lights
F5	7.5A	Air conditioning, heater blower convenience system, sunroof CCS, electric mirrors, radiator fan, heated seats diagnostic connector
F6	-	Not used
F7	10A	Reversing lights
F8	5A	Mobile phone
F9	5A	ABS
F10	15A	Engine management (petrol)
	5A	Engine management (diesel)
	10A	Radio
F11	5A	Automatic transmission, instrument panel
F12	7.5A	Alarm, mobile phone, diagnostic connector
F13	10A	Brake lights, ABS, engine management
F14	10A	Central locking, interior lights
F15	5A	Automatic transmission, instrument panel, ABS
F16	10A	Air conditioning, radiator fan
F17	-	Not used
F18	10A	RH headlight (main beam), instrument panel
F19	20A	LH headlight (main beam)
F20	15A	Headlight range control, RH headlight (dipped beam), RH gas discharge headlight
F21	15A	LH headlight (dipped beam), LH gas discharge headlight
F22	5A	RH sidelights, instrument panel
F23	5A	LH sidelights, instrument panel
F24	20A	Wash/wipe
F25	20A	Air conditioning, heater blower engine management
F26	25A	Heated rear window
F27	15A	Rear window wiper
F28	15A	Fuel pump
F29	15A	Engine management (petrol)
	10A	Engine management (diesel)
F30	20A	Sunroof
F31	20A	Brake servo, automatic transmission
	5A	4 wheel drive unit (4 motion)
F32	10A	Injectors (petrol)
	30A	Engine management
F33	20A	Wash/wipe
F34	10A	Engine management
F35	30A	12V socket
F36	15A	Fog lights, instrument panel
F37	10A	Engine management
F38	15A	Central locking, filler flap
F39	15A	Indicators, gas discharge headlights
F40	20A	Horn
F41	15A	Cigarette lighter
F42	25A	Radio
F43	10A	Engine management
F44	15A	Heated seats

H33091

Diagram 2

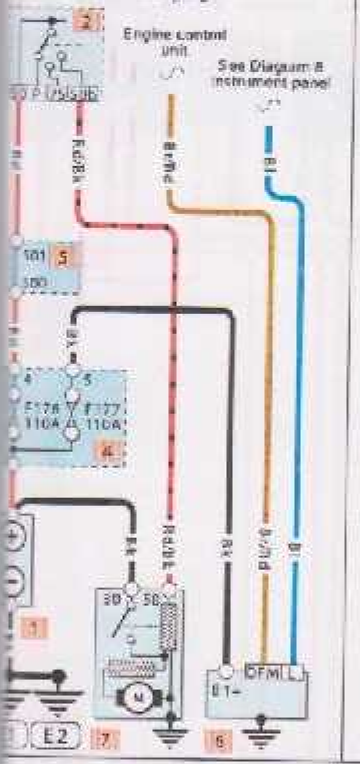
Wire colours

Bk	Black	Or	Orange
Bl	Blue	Rd	Red
Br	Brown	Vi	Violet
Gr	Grey	Wh	White
Gn	Green	Ye	Yellow

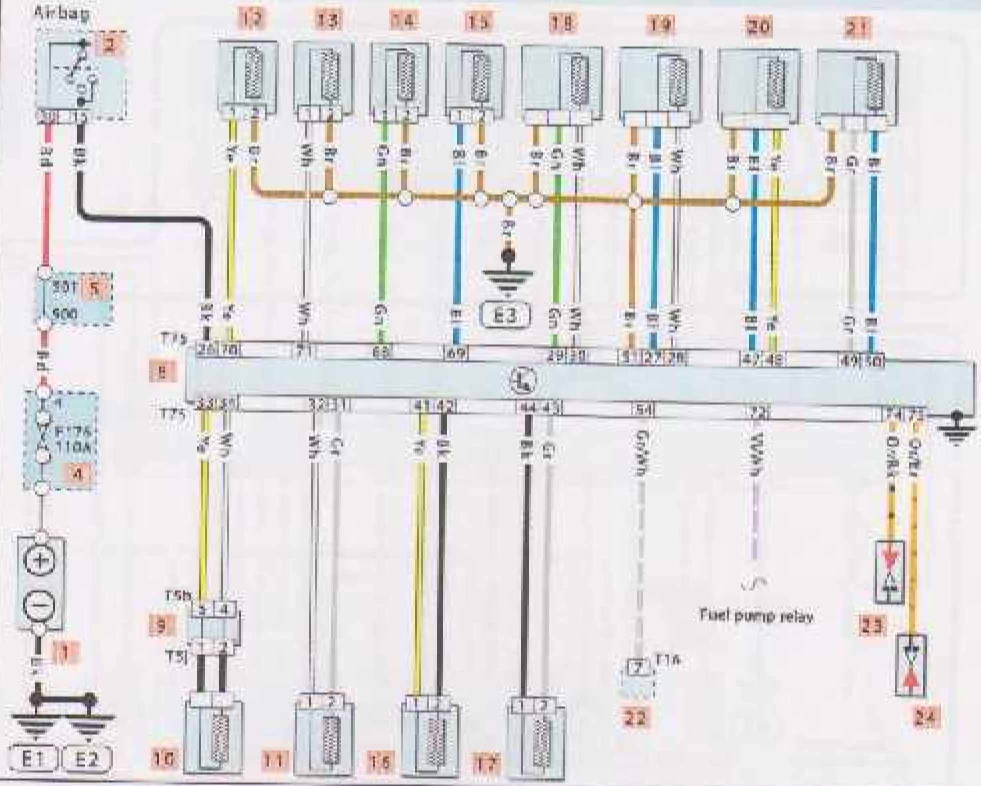
Key to items

1 Battery
2 Ignition switch
3 Main fuse box
4 Battery fuse box
5 Relay plate
6 Alternator
7 Starter motor
8 Airbag control unit
9 Steering wheel clock spring
10 Driver's airbag
11 Passenger's airbag
12 Driver's crash sensor
13 Passenger's crash sensor
14 RH rear crash sensor
15 LH rear crash sensor
16 Driver's seatbelt tensioner
17 Passenger's seatbelt tensioner
18 Driver's side airbag
19 Passenger's side airbag
20 Driver's curtain airbag
21 Passenger's curtain airbag
22 Diagnostic connector
23 High bus connection
24 Low bus connection
25 Radio
26 Amplifier
27 CD player
28 Aerial
29 RH front speaker
30 RH front tweeter
31 LH front speaker
32 LH front tweeter
33 RH rear speaker
34 RH rear tweeter
35 LH rear speaker
36 LH rear tweeter
37 Remote control switches

Starting and charging



Airbag



Radio with CD player

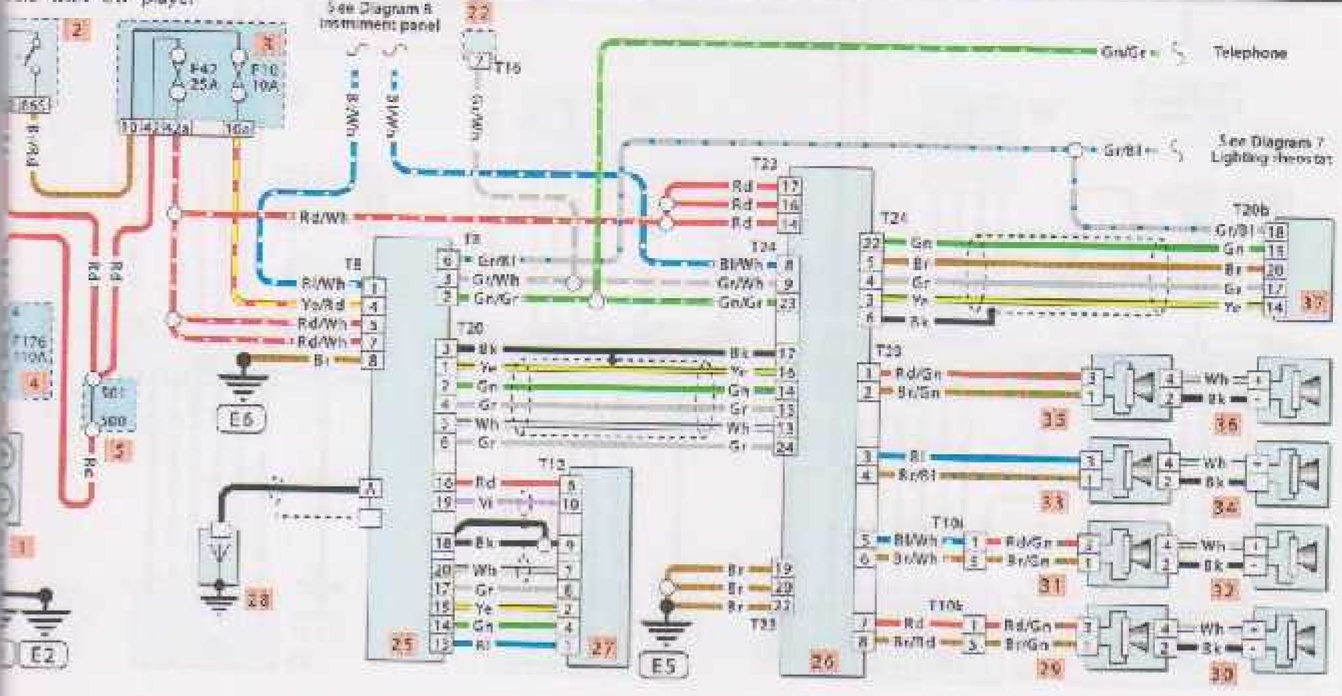


Diagram 3

Wirer colours

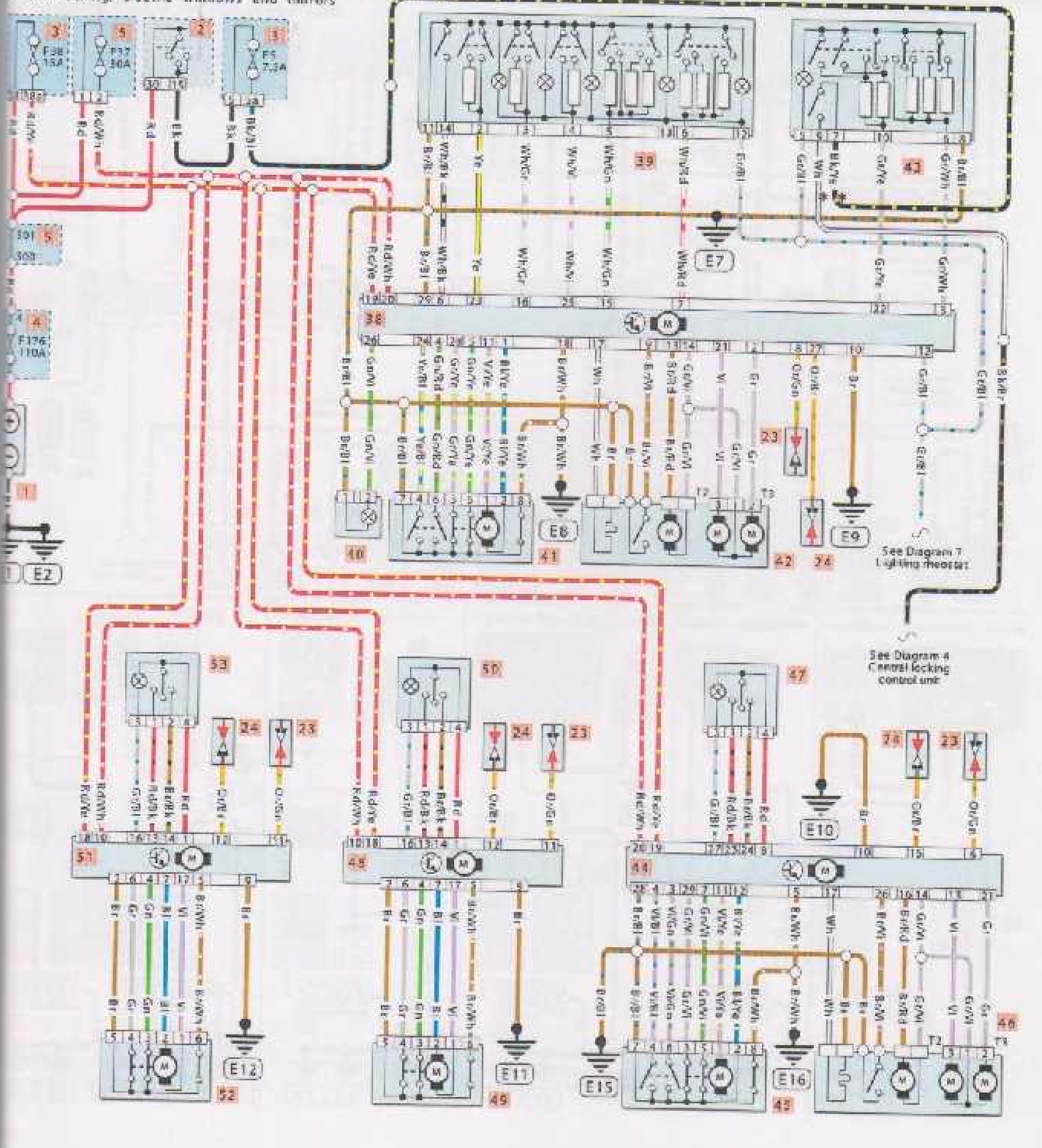
Bk	Black	Or	Orange
Bl	Blue	Rd	Red
Br	Brown	Vi	Violet
Gr	Grey	Wh	White
Gn	Green	Ye	Yellow

Key to items

1 Battery
2 Ignition switch
3 Main fuse box
4 Battery fuse box
5 Relay plate
23 High bus connection
24 Low bus connection
38 Driver's door unit with window motor
39 Driver's electric window switch unit
40 Central locking warning light
41 Driver's door locking unit
42 Driver's mirror heater and motors
43 Mirror adjustment switches
44 Passengers's door unit with window motor
45 Passenger's door locking unit
46 Passenger's mirror heater and motors
47 Passenger's electric window switch
48 LH rear door unit with window motor
49 LH rear door locking unit
50 LH rear electric window switch
51 LH rear door unit with window motor
52 LH rear door locking unit
53 LH rear electric window switch

* Separate heater only

Central locking, electric windows and mirrors



Wirer colours

Bk	Black	Or	Orange
Bl	Blue	Rd	Red
Br	Brown	Vi	Violet
Gr	Grey	Wh	White
Gn	Green	Ye	Yellow

- Separate heater only
- Without separate heater
- Golf only
- Bora only

Key to items

1 Battery
2 Ignition switch
3 Main fuse box
4 Battery fuse box
5 Relay plate
9 Steering wheel clock spring
22 Diagnostic connector
23 High bus connection
24 Low bus connection
54 Central locking control unit
55 Electric sunroof
56 Sunroof switch
57 Tailgate central locking motor
58 Boot lid release motor
59 Luggage compartment light switch
60 Luggage compartment light
61 Tailgate switch
62 Driver's door warning light
63 Passenger's door warning light
64 Driver's mirror light
65 Driver's mirror light switch
66 Passenger's mirror light
67 Passenger's mirror light switch
68 RH rear reading light
69 LH rear reading light
70 Front interior light
71 Bonnet switch
72 Central locking aerial
73 Boot lid release button
74 Boot release key switch
75 Switch in boot lock
76 Horn relay
77 Horn switch
78 Horns
79 Fuel tank filler flap release switch
80 Fuel tank filler flap release motor
81 12V socket
82 Cigarette lighter
83 Radiator fan switch
84 Radiator fan

Diagram 4

MTS H31507

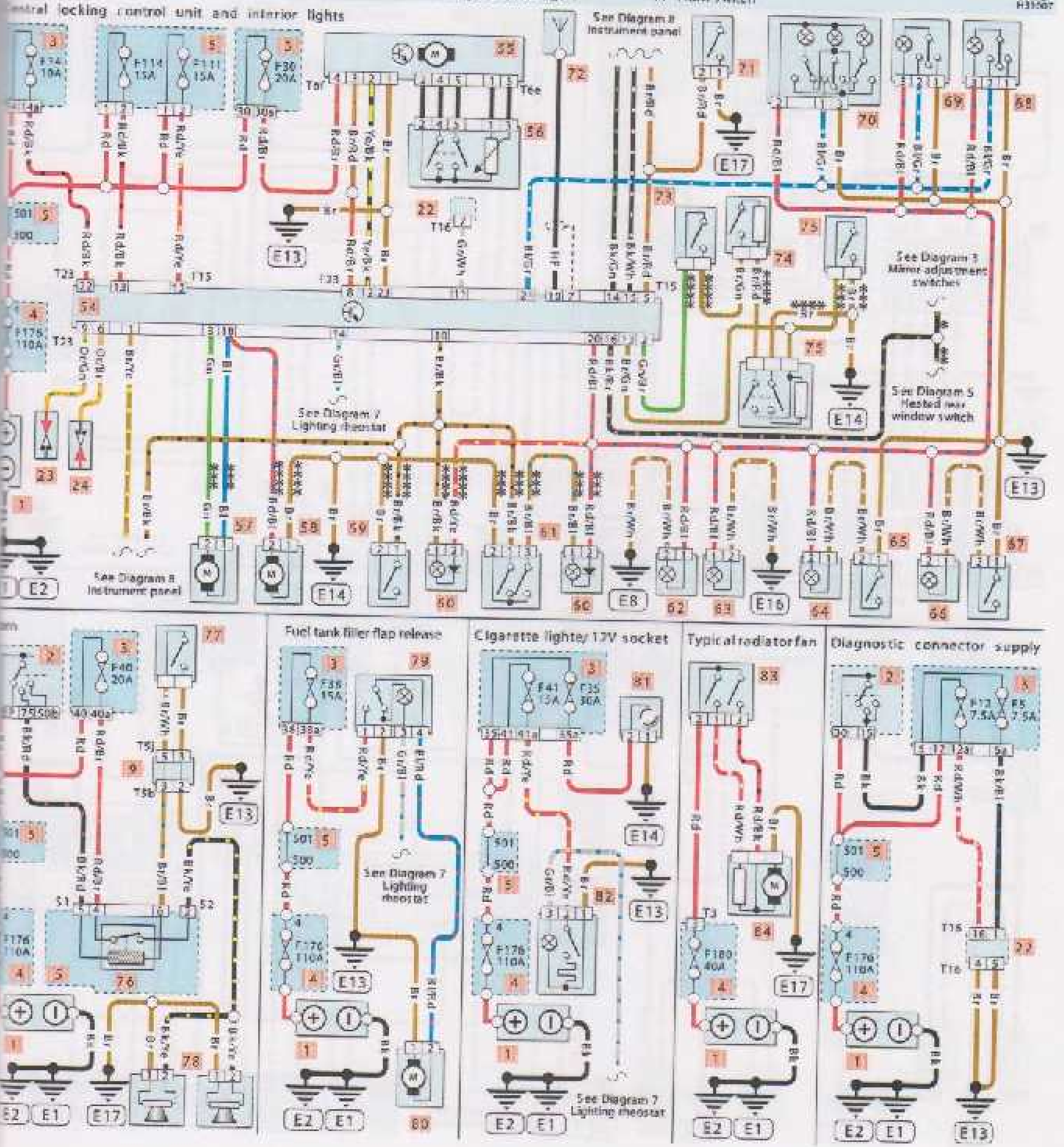


Diagram 5

Wirer colours

Bk	Black	Or	Orange
Bl	Blue	Rd	Red
Br	Brown	Vi	Violet
Gr	Grey	Wh	White
Gn	Green	Ye	Yellow

Key to items

1 Battery
2 Ignition switch
3 Main fuse box
4 Battery fuse box
5 Relay plate
23 High bus connection
24 Low bus connection
85 ABS control unit
86 Traction control switch
87 Steering angle sensor
88 LH front wheel speed sensor
89 LH rear wheel speed sensor
90 RH front wheel speed sensor
91 RH rear wheel speed sensor
92 ESP sensor
93 Brake pressure sensor
94 X contact relay
95 Blower controls
96 Blower motor
97 Resistor pack
98 Air recirculation flap motor
99 Heated rear window switch
100 Heated rear window
101 Rear wiper motor
102 Washer pump
103 Wash wipe relay
104 Windscreen wiper motor
105 Intermittent wiper control
106 Wash/wipe switch
107 Brake light switch
108 LH rear light cluster
  a) brake light
  b) reversing light
109 RH rear light cluster (as 108)
110 High level brake light
111 Reversing light switch

a Golf only

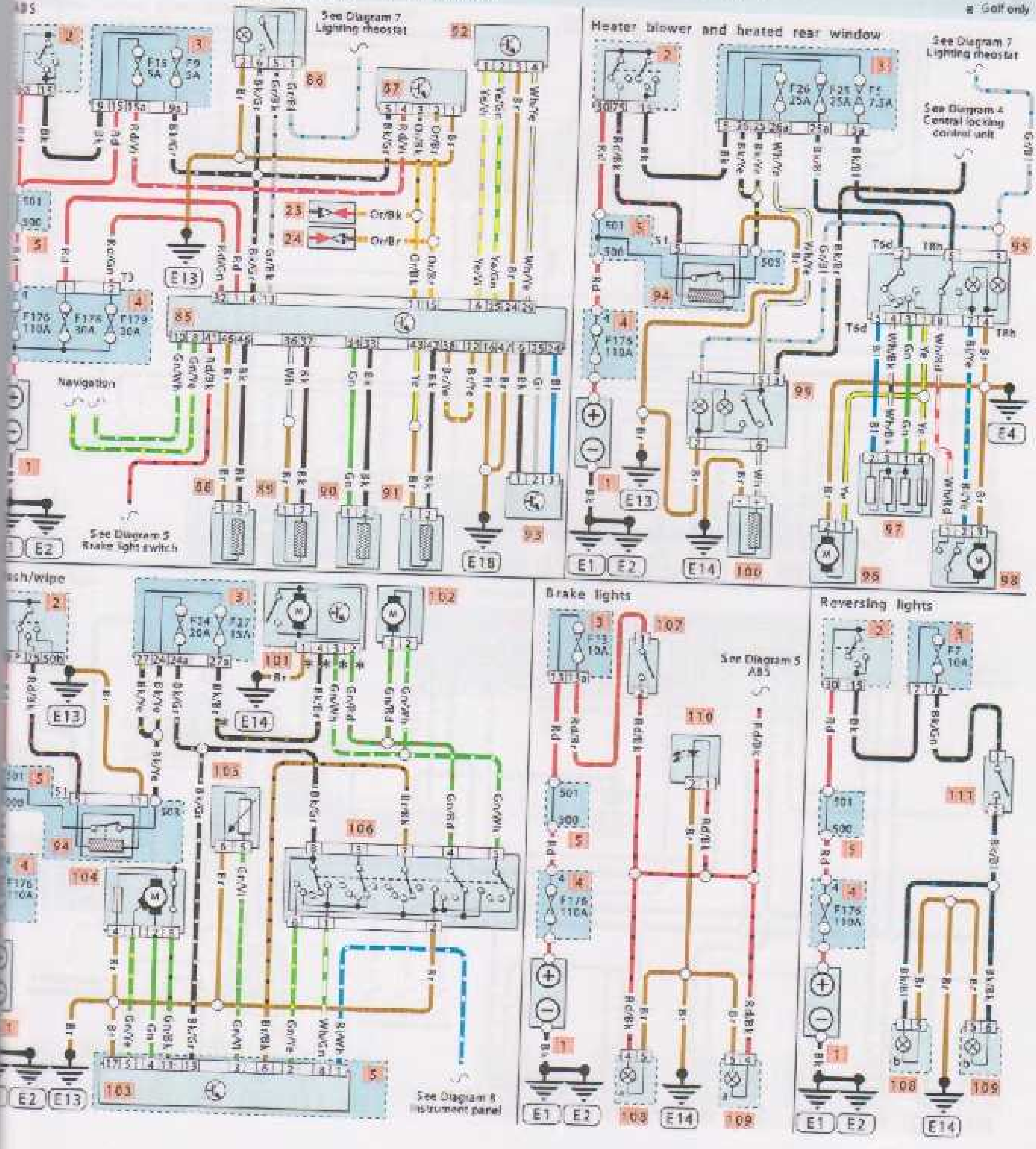


Diagram 6

Wirer colours

Bk	Black	Or	Orange
Bl	Blue	Rd	Red
Br	Brown	Vi	Violet
Gr	Grey	Wh	White
Gn	Green	Ye	Yellow

MTS

Key to items

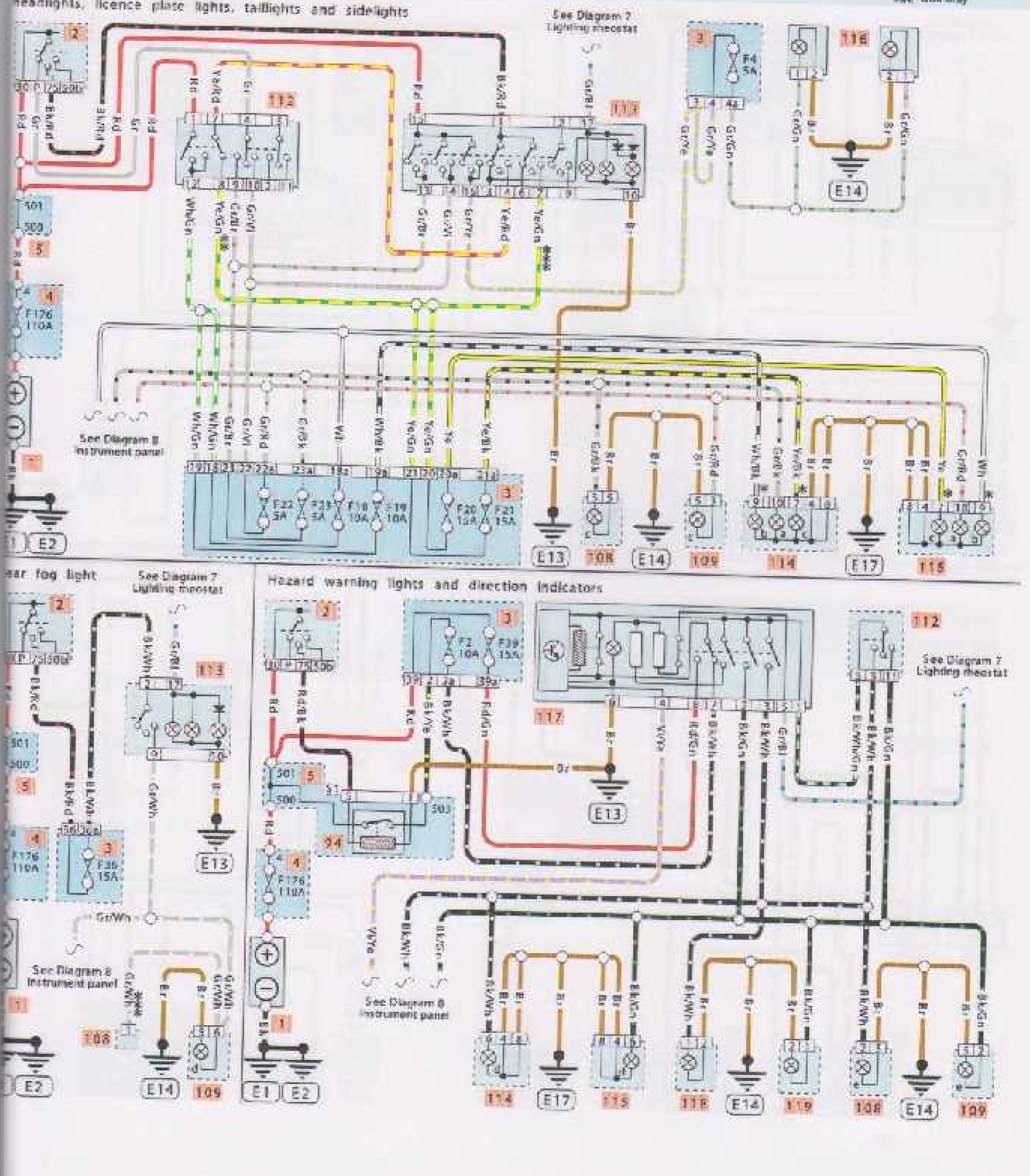
1 Battery
2 Ignition switch
3 Main fuse box
4 Battery fuse box
5 Relay plate
94 X contact relay
108 LH rear light cluster
- c) tail light
- e) direction indicator

109 RH rear light cluster
- c) tail light
- d) fog light
- e) direction indicator

112 LH multifunction stalk
113 Light switch
114 LH headlight cluster
- a) sidelight
- b) main beam
- c) dipped beam
- d) direction indicator

115 RH headlight cluster (as 114)
116 Licence plate lights
117 Combined hazard warning light switch and indicator relay
118 LH side indicator
119 RH side indicator

* Bora fitted with dual filament bulbs wiring remains the same
** Bora only
*** Golf only



Wire colours

Bk	Black	Or	Orange
Bl	Blue	Rd	Red
Br	Brown	Vi	Violet
Gr	Grey	Wh	White
Gn	Green	Ye	Yellow

Key to items

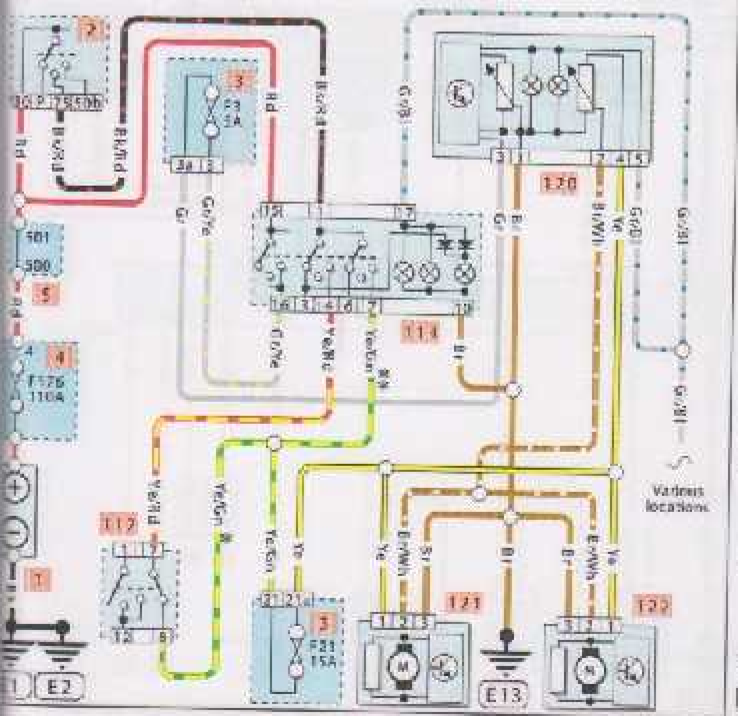
1 Battery
2 Ignition switch
3 Main fuse box
4 Battery fuse box
5 Relay plate
94 X contact relay
112 LH multifunction stalk
113 Light switch
114 LH headlight cluster (+ fog light)
115 RH headlight cluster (as 114)
120 Headlight range switch and lighting rheostat
121 LH headlight motor
122 RH headlight motor
123 Front fog light relay
124 LH gas discharge starter
125 LH gas discharge control unit
126 LH gas discharge bulb
127 RH gas discharge starter
128 RH gas discharge control unit
129 RH gas discharge bulb
130 Range control unit
131 LH range control motor
132 RH range control motor
133 LH front vehicle level sensor
134 LH rear vehicle level sensor

Diagram 7

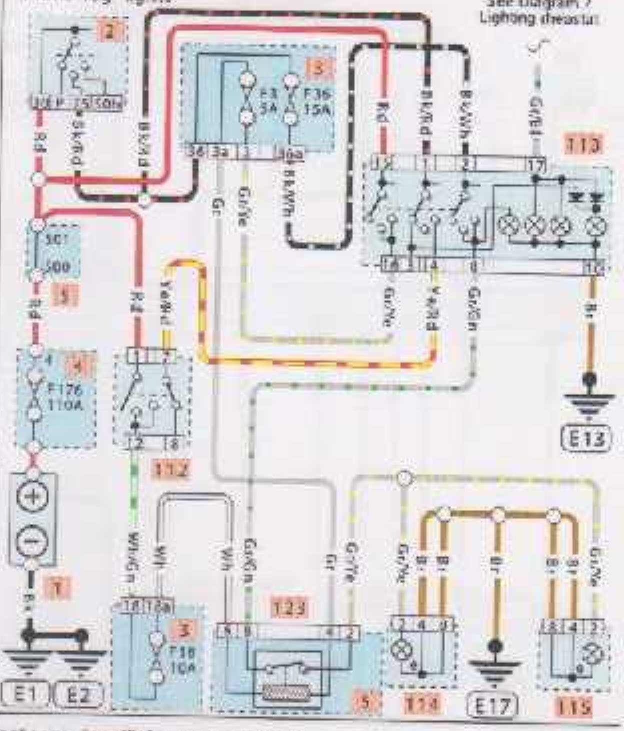
* Bora only
** Golf only

MTS
H32216

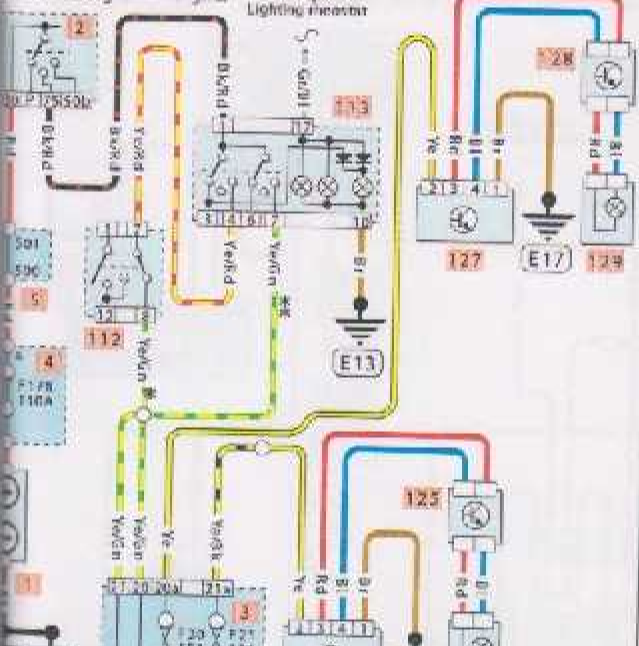
Headlight leveling, lighting rheostat



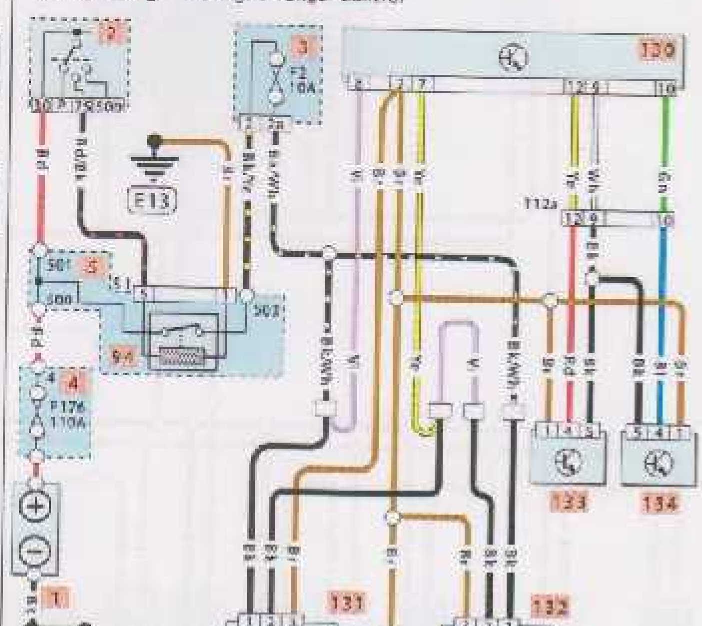
Front fog lights



Gas discharge headlights



Gas discharge headlight range control



Wirer colours

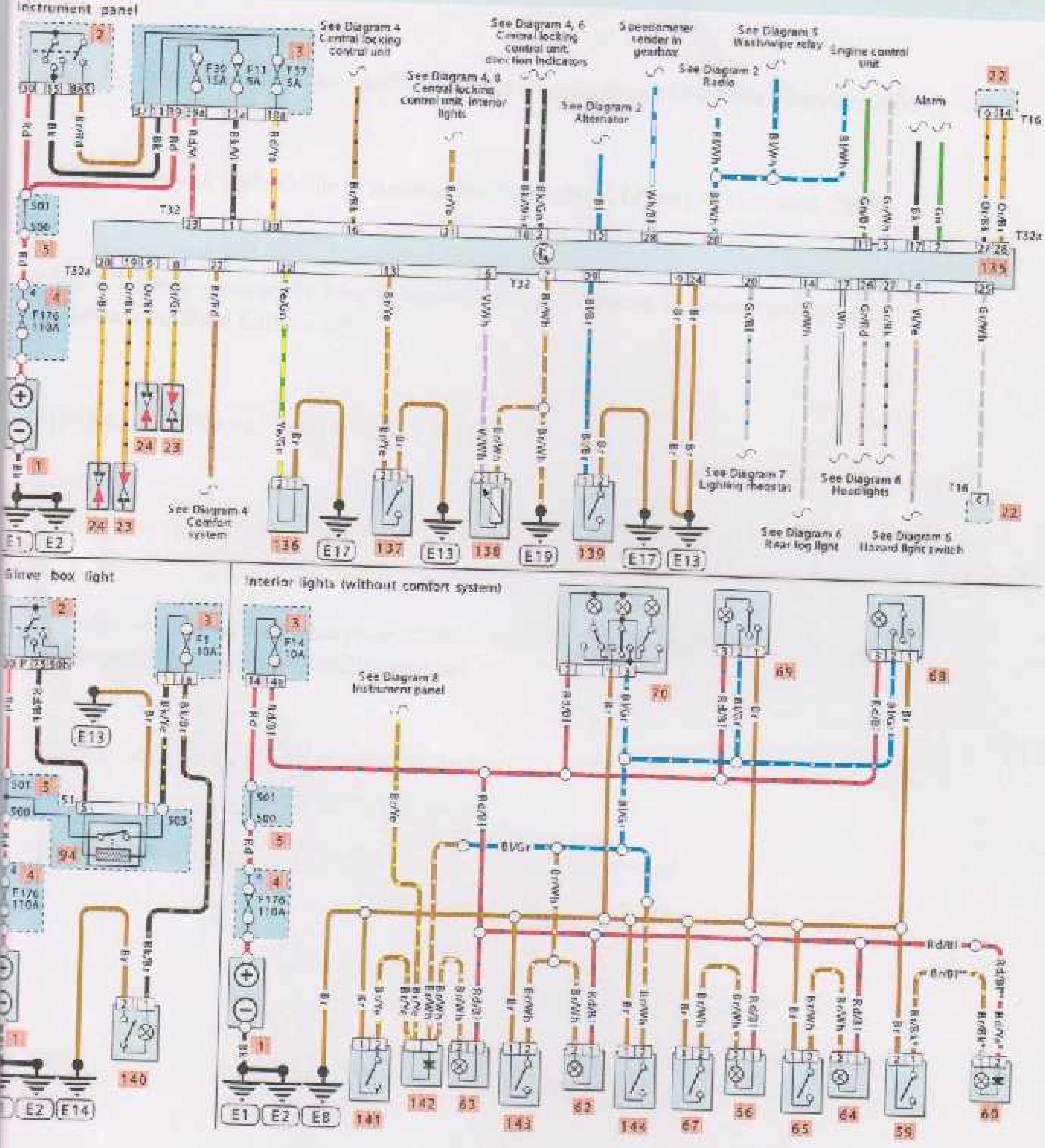
Bk	Black	Or	Orange
Bl	Blue	Rd	Red
Br	Brown	Vi	Violet
Gr	Grey	Wh	White
Gn	Green	Ye	Yellow

MTS * Bora only ** Golf only

Key to items

Diagram 8

1 Battery
2 Ignition switch
3 Main fuse box
4 Battery fuse box
5 Relay plate
22 Diagnostic connector
23 High bus connection
24 Low bus connection
59 Luggage compartment light switch
60 Luggage compartment light
62 Driver's door warning light
63 Passenger's door warning light
64 Driver's mirror light
65 Driver's mirror light switch
66 Passenger's mirror light
67 Passenger's mirror light switch
68 RH rear reading light
69 LH rear reading light
70 Front interior light
94 X contact relay
135 Instrument panel
136 Brake pad wear sender
137 Handbrake switch
138 Windscreen wash level sensor
139 Brake fluid level sensor
140 Glove box light
141 Passenger's door switch
142 Diode
143 Drivers door switch
144 RH rear drivers door switch



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