AUTOMATIC BATTERY CHARGER

Abstract

In this study, charger is designed for 12V sealed lead-acid batteries. The designed device consists of a circuit which performs charging, a circuit displaying battery charge level during or resting state of charging (may change according to requirements), a circuit controlling charging time and that displays charging data on battery an LCD. Main charger circuit is voltage controlled (when adjusted charge value equals charge value on battery, charging is terminated). Battery charge level is displayed by leds. The difference between minimum voltage value and maximum voltage value is divided 10 equal cells and a led is lit for each single cell (leds being lit on bar mode or dot mode may vary according to design). Control circuit with LCD is used to adjust charging duration and to choose battery to be charged. Battery type and left time are displayed on screen during charging, charging stops when the time is up.

In the front panel of charger there are 5 buttons, LCD and 12 leds. Buttons are open/close, reset, up, down and ok buttons. Data on charging is written on LCD during charging. First, battery list is written, battery to charged is chosen. Then time adjustments are done by the help of up, down and ok buttons. Battery type to charged and left time displayed on screen during charging. Charging stops when the time is up. Reset button is used when charging accuracy is to be readjusted. 10 of leds are used to show charging level. One of remaining leds is used to show working the device(power) and other one is used to show charging.

Design is simulated by proteus simulation software, and then prototype circuit is set up. Solutions were brought to problems that were noticed during tests. Software in the design was developed by PicBasicPro. PIC16F877 which is the most advanced microcontroller nowadays, design is open for further development. Each of three desinged circuit is suitable for single use and different purposes.

Özet


**Introduction**

The aim of project is to design automatic battery charger. The features of devices are as follows. The device is appropriate for 12V sealed lead-acid batteries, since these batteries are chosen because of usage frequencies. Besides, the device appropriate for different current values which are 1.2 Ah, 4 Ah, 7Ah and 12Ah. The device has monitor -is consisted ten leds- which shows its charging level and LCD which shows left time and battery which are chosen during charging and five buttons to adjust.

In this part, information is given about of batteries in order to grasp better understanding of the designed circuits.

**1. Battery**

Battery is an electrical device which is a combination of several electrochemical cells, used to convert stored chemical energy into electrical energy or vice versa. As most of you may have seen, there are some writings such as 12V, 60Ah, 255A in addition to its trademark.

12V: Battery voltage. (this value gives information on how many cells the battery contains. Since, a cell is 2 Volt, 12Volt means it contains 6 cells)

60Ah: Signifies battery capacity which means the amount of current the battery can give in stated voltage for an hour constantly.

255A: It defines maximum current amount which could be safely taken from the battery.

**1.1. Battery Types**

Batteries can be categorized in several different aspects. We will categorize them in terms of the materials used to build. In this categorization, there are 4 types; Sealed Lead-Acid Battery(SLA), Nickel-Cadmium(Ni-Cd) Battery, Nickel-Metal Hydride(Ni-Mh) Battery, Lithium-Ion(Li-ion) Battery. These four types differentiate in terms of capacity, cost, area of usage. We selected sealed lead-acid battery since it is most commonly used in our country, is inexpensive and is high capacitated.

**1.1.2. Sealed Lead-Acid Battery**

A sealed lead acid battery is an electrical storage device that was a reversible chemical reaction to store energy[1]. It uses a combination of lead plates on grids and an electrolyte
consisting of a diluted sulphuric acid to convert electrical energy into potential chemical energy and vice versa. As can be understood from the definition, main property of the sealed lead-acid battery is its electrodes are lead and uses sulphuric acid as electrolyte.

Sealed Lead-Acid batteries are used in various places. The most common usage is in emergency lighting in case of power failure. They are also used to power electric motors in diesel-electric submarines and nuclear submarines. In most areas of usages, 12 Volt sealed lead-acid batteries is used. That is way we choose them.

### 1.1.3. Battery Voltage

There is much confusion about “battery voltage” because a battery has more than one voltage. There are some general voltages ranges for six-cell (12 Volt) lead batteries.

- **Open-circuit (quiescent) of full charge**: 12.6V to 12.8V
- **Open-circuit at full discharge**: 11.8V to 12.0V
- **Loaded at full discharge**: 10.5V [2]

Besides values I mentioned, there is a term called float voltage. Float voltage refers to the constant voltage that is applied continuously to cell to maintain the cell in a fully charged condition. With a 12V sealed lead-acid battery to float voltage is in the range of 13.5V-13.8V. Another term, nominal voltage is the voltage value written on the battery. These voltage values vary according to shape, size and trademark of the battery.

### 1.1.4. Battery Current

Charging current for batteries must be chosen between one over ten (1/10) and one over twenty (1/20) of the battery capacity, but closer to one over ten.

In introduction part, some information about batteries is given. The aim is to make you understand why we chose 12 Volt sealed lead-acid batteries and to give a brief information on the current and voltage values we will use in circuits.

### 1.1.5. Advantages of Sealed Lead-Acid Battery

They are low cost, reliable, over 140 years of development, robust, tolerant to abuse, tolerant to overcharging, low internal impedance, indefinite shelf life if stored without electrolyte, wide range of sizes and capacities available, the world's most recycled product. They can deliver very high currents and can be left on trickle or float charge for prolonged periods.[3]

### 1.2. Charger Types

#### 1.2.1. Unregulated Transformer-Based Charger

These are the absolute cheapest chargers around. They consist of a wall mount transformer and a diode. The transformer is designed to deliver 13 to 14 volts over a reasonable current range. The biggest problem with this approach is that when the current tapers off, the voltage raises to 15, 16, 17, even 18 volts. At these high voltages electrolysis of the water in the battery starts in. These must not be left to trickle or float charge a battery, they must be disconnected when the battery is fully charged. This is not a problem with flooded batteries as long as you check the water periodically and refresh it. Sealed lead acid batteries can recycle the generated gasses as long as they are being overcharged at less than C/3. However, leaving the battery to be overcharged even at C/10 will corrode the plates if left on for weeks at a time. The transformer is so designed as to limit the current while the battery is in absorption mode. As the battery voltage rises the current decreases to top off the
battery. Because the transformer is used to control the current and voltage these chargers are typically heavy and get hot [4].

1.2.2. Taper chargers

Another cheap way to charge a sealed lead acid battery is called a taper charge. Either constant voltage or constant current is applied to the battery through a combination of transformer, diode, and resistance. The unregulated chargers mentioned above are taper chargers. A better, and not very expensive, alternative is a regulated taper charger. These don't let the voltage climb higher than the trickle charge voltage, so they can be also be used to maintain a battery. They won't damage the battery if left on charge too long, and they don't change their charging characteristics if the line voltage should change.

Regulated taper chargers are very useful when you need a 12V or 24V battery backup. A taper charger in parallel with the battery, in parallel with the load makes an effective battery back-up. You should take care to ensure that the taper charger is designed to give continuous current equal to the load plus some left over for battery charging. It is also important that the current limit of the taper charger is the voltage-cut-back method, and not the hiccup method or other PWM methods.

There are two ways to make a regulated charger. The first is to use a transformer and a simple voltage regulation circuit. This has the disadvantages of weight and heat, but it is still inexpensive. The second uses a modern switching power supply in a wall mount or desk mount package. These low power high frequency switchers are surprisingly cheap, efficient, and small. They are rapidly taking over the overnight charging requirement in consumer equipment[4].

1.2.3. Constant current chargers

A more sophisticated and not much more expensive charger uses an electric circuit to control the charging current. This method is useful for recovering batteries that have suffered from extensive storage without charging, but is capable of overcharging a battery if there is not some voltage limiting function, usually from the transformer. For this reason these chargers are limited to slow charging[4].

1.2.4. Constant Voltage Chargers (Taper plus current limit)

A circuit that is set for the maximum allowable charge voltage, but has a current limit to control the initial absorption current can produce a very nice charger. This type of charger can both charge at a reasonable rate and maintain the battery at full charge without damage. Not all constant voltage chargers are made equal, however, because the maximum voltage is a function of temperature. A temperature compensated charger is a little more expensive, and should be used where the temperature varies significantly from room temperature[4]

Methods and Experiments

The circuits which are designed are told in this part. The designed circuits are as follows:

✓ Main charger circuit
✓ 10led monitor circuit using LM3914
✓ Control circuit with LCD and PIC16F87
2.1. Voltage-Controlled Main Charger Circuit

![Circuit diagram of main charger circuit](image)

*Figure-2.1.1: Circuit diagram of main charger circuit*

Before moving on to the main charger circuit, common property of all charger circuits is told. It is to transform AC voltage values coming from network to DC voltage values. We want to explain this transformation by giving information about circuit components and theirs area of usages. The block diagram of this transformation is given below.
Transformer: Transformers step down high voltage AC mains to low voltage AC. In this step our voltage is still AC.

Rectifier: A bridge rectifier is an arrangement of four diodes in a bridge configuration that provides the same polarity of output voltage for either polarity of input voltage. Rectifier converts AC to DC but the DC output is varying.

Smoothing capacitor: Smoothing capacitors smooths the DC from varying greatly to a small ripple.
**Regulator:** Regulator eliminates the ripple by setting DC output to a fixed voltage.

![Figure-2.1.6: Function of regulator](image)

### 2.1.1. Used Components and Working Principles of Main Charger Circuit

Transformer, bridge rectifier and smoothing capacitor are used in main charger circuit to obtain DC voltage. LM723 is used as voltage regulator with external transistor which is MJE3055 to obtain controlled charge.

The reasons which we use these components are as follows:

**18V Transformer:** Our battery voltage is 12V plus 3V regulator drop plus 1.4V rectifier drop (2 diodes) plus 10% safety. \[12 + 3 + 1.4 + (12 \times 0.1) = 17.6V \sim 18V\]

This safety means as follows: The physical behaviour of electricity is from high voltage to low. We want the current to flow from the transformer to battery. In the opposite situation the current will flow from the battery to transformer. The transistor in our circuit will not let this happen. But, neither the battery will be charged.

Power of the 18V transformer is related to current of the battery to be charged. For example, the current of a 10watt transformer is 0.55 amper from the equation current equals to power/voltage. As I said before the charging current is approximately 1/10 and 1/20 of battery capacity but closer to 1/10. So, 0.55 times 10 equals to 5.5 and 0.55 times 20 equals to 11. And since it will be closer to 5.5, 10watt is sufficient for 7A battery. Here is a table for related values of watts and compares. Since current limitation is handle by regulator, it is not dangerous to use higher powers. But using lower power will not be sufficient to charge to battery. Some power values of transformer is given in below:

<table>
<thead>
<tr>
<th>BATTERY</th>
<th>TRANSFORMER</th>
</tr>
</thead>
<tbody>
<tr>
<td>12V, 1.3Ah</td>
<td>3W 2x9V</td>
</tr>
<tr>
<td>12V, 2.2Ah</td>
<td>4W 2x9V</td>
</tr>
<tr>
<td>12V, 4Ah</td>
<td>6W 2x9V</td>
</tr>
<tr>
<td>12V, 7Ah</td>
<td>10W 2x9V</td>
</tr>
</tbody>
</table>

*Table-2.1.1: Battery type and transformer values*

**LM723 Voltage Regulator:** The reason for LM723 as voltage regulator was its output voltage and output current value ranges. Output voltage is adjustable from 2V to 37V and output currents in excess of 10A are possible by adding external transistors. As we mentioned before, the current required to charge a battery is 10 percent of its ampere capacity. So, this voltage regulator is sufficient for us.
Figure-2.1.7: LM723 and pin diagram[5]

D1 is called power led. This led is connected between AC input and DC output of bridge rectifier. It enables us to tell both there is an AC input from transformer to bridge rectifier. Meaning transformer works and there is a DC output from bridge rectifier meaning bridge rectifier works.

LM723 (Figure.2.1.7) and its connections: All of these connections are made in the LM723 datasheet. MJE3055 is used as external transistor along with LM723 to provide desired current. In LM723 voltage pins are 12, 11 and 7 pins. Pin number 12 is positive voltage. Pin numbers 12 and 11 which are connected connects to DC voltage at the output of smoothing capacitor. Pin number 7 is connected to ground. Pins numbers 1, 14 and 8 are not connected as expressed in datasheet.

In this integrated circuit, pin number 2 is current limit, pin number 3 is current sense. Pin number 3 is connected to positive pole of the battery. By this connection, voltage regulator obtains charge current and controls this current during charging. Pin number 2 supplies source current over the resistance 1.5Ω in order to make a reference point to limit the current. This pin also is connected to transistor[6] emitter. The collector of transistor is connected to positive voltage.

A capacitor is connected between pin numbers 13 and 4, by looking from the datasheet. Pin number 4 is called inverting input. It gets reference voltage which is due to 10K pot. This voltage obtained from 10K pot is actually is charging voltage. Before charging, output voltage should be adjusted until it matches the charging voltage. The charging voltage should be set 2.3-2.4V per 2V cell. So, a 12V battery(6cells of 2V) is charged at 6x2.3=13.8V

LM723 determines charging condition comparing datas from pin numbers 2, 3 and reference voltage. By combining pins numbers 9 and 10 by making current control for transistor to be triggered, it supplies voltage output over led yellow. Voltage to the base pin put the transistor in transmission. Led yellow which is called charge led is lit while charging.
We were able to obtain a controlled charging. The current will be cut-off automatically when battery voltage equals to the voltage we adjusted with pot. The circuit has been tested and the successful results were gained in charging 12V 7A batteries.

2.2. 10led monitor circuit using LM3914

This circuit is designed to observe battery charge condition. This monitor circuit is designed for 12V batteries. For higher voltage values, the integrated circuit does not work. There are ten LEDs on it. LM3914(Figure 2.2.1) integrated circuit is used in this circuit. LM3914 integrated circuit is a LED-driven voltmeter.

Figure 2.2.1: LM3914 and pin diagrams[7]

Figure 2.2.2: Block diagram of monitor circuit
When looked at the datasheet, the leds are connected to 1,18,17,16,15,14,13,12,11,10 in accordingly. Besides, pin numbers 2 and 8 are connected to ground, pin number 3 is connected positive voltage. Pins numbers 4 and 6 are connected pot in order to make a minimum adjustment. This pot is also connected to ground (First pin of pot is connected to pin number 6, second pin of pot is connected to number 4 and third pin of pot connected to ground). Pin number 5 is input signal and connected to pot in order to make a maximum adjustment. The pot also is connected positive voltage (First pin and second pin of pot is connected to positive voltage and third pin of pot connected topin number 5). Pin number 7 which is reference output as mentioned in LM3914 datasheet is connected top in number 6.

In LM3914, pin number 9 is used to choose either dot or bar mode. In order to make this choice, jumper is put between pin number 9 and +voltage. Monitor is on bar mode, when jumper is connected. When jumper is removed, that is when pin number 9 is disconnected is a dot mode.

The diode is used to or event reverse polarity.

Voltage ratio between comparators is equal. Minimum acting point is adjusted by P1(10k). By this process of adjustment led which is connected number 1 is lit up for minimum voltage value. Maximum acting point of monitor circuit is adjusted by P2(50k). In this case led which is connected top in number 10 is lit up during adjustment process. The minumum and maximum values which circuit will measure is applied accordingly. The adjustment is made with P1 and P2. Difference between two measured voltage is divided into
ten equal pieces inside LM3914. To understand working principle of the circuit it is necessary to look into pins and inner structure of LM3914.

It is chosen 11.44V for minimum value when it is out of charge and 13.8V for maximum value when it is fully charged during charging.

It is chosen 11.85 V for minimum value when it is out of charge and 12.65 for maximum value when it is fully charged after or before charging (in resting state).

2.3. Control Circuit With LCD And PIC16F877A

This circuit has been designed to make controlled charge. The circuit should be used to adjust the charging period. Datas are shown in LCD panel. A list of batteries is on the LCD. Using down button, battery which will be charged will be selected and after this will be pushed on OK button. Then charge time will be adjusted in manual way. First, hour configuration will be made. Down and up buttons are used to start counting up and down. While counting to stop the process up or down button can be pressed. When ok button is pushed, hour is configured. The same process can be made for minute configuration. After adjusting the charging time, the ok button will be pushed and the charging process will be started. During charge process LED is on. At the end of charging process, charge is cut down and LED is off. When reset button is pushed all the configurations will be cancelled and the process returns to beginning.

2.3.1. Used Materials and Connections

4 x 20 LCD Panel: A (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly. LCDs therefore need a light source and are classified as passive displays. Some types can use ambient light such as sunlight or room lighting. There are many types of LCDs that are designed for both special and general uses. They can be optimized for static text, detailed still images, or dynamic, fast-changing, video content.

There are different types LCDs which are sold in the markets. Some examples are 1x8, 2x8, 2x16, 4x16. The first number shows number of rows and second number shows number of characters in a row. In this circuit, 4x20 liquid crystal display (LCD) is used because of its properties. The 4x20 LCD is enough to write four different batteries name in the screen.
Figure-2.3.2: Control Circuit Diagram

Figure-2.3.3: LM044L (LCD) in Proteus[8]

<table>
<thead>
<tr>
<th>LCD Pins</th>
<th>Function of pins</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vss, Ground, Logic Vss, Logic Ground</td>
</tr>
<tr>
<td>2</td>
<td>Vcc, +5 Volt, Logic Vcc, Logic Power</td>
</tr>
<tr>
<td>3</td>
<td>VLc, VBias, Bias, Contrast</td>
</tr>
<tr>
<td>4</td>
<td>RS, Register Select</td>
</tr>
<tr>
<td>5</td>
<td>R/W, Read/Write</td>
</tr>
<tr>
<td>6</td>
<td>E, Enable, Strobe</td>
</tr>
<tr>
<td>7-14</td>
<td>D0-D7 (DATAinputs)</td>
</tr>
<tr>
<td>15*</td>
<td>Led+, A, Backlight+, Backlight Anode (LCD Panel Light(+5 Volt))</td>
</tr>
<tr>
<td>16*</td>
<td>Led-, K, Backlight-, Backlight Cathode (Ground)</td>
</tr>
</tbody>
</table>

*Some display, there are no pins 15 ve 16.
**VL_c** (Contrast): Pin number 3, contrast input, are connected with ground with a 2.5k resistor (10k, 20k can be). If the resistor value increases, contrast decreases or vice versa. If we want to change adjustment of contrast, we connect pin 3 with a trimpot (usually 2.5k). In this circuit, pin number 3 is connected with ground.

RS (Register Select): If RS (pin number 4) is 0 (connected with ground), LCD can take information from microcontroller (PIC). If RS is 1 (connected with 5V), data storage (veri saklayıcı) is chosen.

R/W (Read/Write): If R/W (pin number 5) is 0 (connected with ground), LCD is in writing OK. This OK is used to be written data on LCD.

Data Pins: Data pins (pin number 7-14) are connected with any Port of microcontroller. They are used to send command or data to LCD as 4 bits form or 8 bits form.

E (enable): It is the pin which transfers real data between LCD and pins. First this pin is introduced to the microcontroller by the help of program code. After introduction, PIC provides enable pulse to the this pin (not more than 230 nanoseconds) when PIC sends data. Enable and Register Select pins are connected with any pin of any port. They are defined in program code.

**PIC16F877A:**

In this circuit PIC16F877 is used as microcontroller although we studied on PIC16F84 last semester. PIC16F84 has 1Kword memory, PIC16F877 has 8Kword memory. So, the most important reason to choose it its memory. Also, as designing circuit the possibility of development is considered. PIC16F877 and pins is shown in Figure 2.3.3. Pins’ description is given in appendix.

When using PIC, PortA and PortE are empty, because these ports can be used for analog input. When the design is improved these ports can be used, too. Furthermore to use these ports as input/output, extra commands are needed. Also, this situation may cause errors. In the circuit, first, second and third bits of PortB are used as control bits. RB0 bit is empty,
in case it can be used for interrupt in future works. The other bits of PortB are used as data bits. In this circuit, LCD is controlled in 4-bit OK. PortD is chosen for buttons.

In this circuit, PIC evaluates datas which came from buttons and then sends datas to LCD. MCLR (pin number 1) is connected with a button to reset circuit. Also, an LED is connected with RC0 (zeroth bit of PortC) to show charge.

**Crystal and Capacitors:** A square signal is needed to run commands in program memory. This signal is called “clock signal”. There are 2 pins, OSC1/CLKIN(pin number 13) and OSC2/CLKOUT(pin number 14), to use as clock signal input. The clock signal is obtained from different type oscillators. In this circuit, oscillators which are made using crystal and capacitors are used. This type oscillator is used when timing is important. In Circuits which crystal oscillators are used, we pay importance while determining capacitors value. Table.1 shows which capacitor is used in which frequency.

<table>
<thead>
<tr>
<th>Oscillator type</th>
<th>Frequency</th>
<th>Capacitor value</th>
</tr>
</thead>
<tbody>
<tr>
<td>XT</td>
<td>500 KHz</td>
<td>20-68 pF</td>
</tr>
<tr>
<td></td>
<td>1 MHz</td>
<td>15-68 pF</td>
</tr>
<tr>
<td></td>
<td>2 MHz</td>
<td>15-47 pF</td>
</tr>
<tr>
<td></td>
<td>4 MHZ</td>
<td>15-33 pF</td>
</tr>
</tbody>
</table>

*Table-2.3.1: Crystal Oscillator Frequency and Capacitor Values*

If capacitors values is higher than values in Table.2.3.1, square waves distort. In this situation, PIC does not work. Circuit diagram of oscillator is shown in Figure.2.3.4. In this circuit, C1 and C2 value are equal to each other.

*Figure-2.3.5: Crystal and capacitors connections*
2.3.2. Flow Chart of The Program

Start

Define PIC16FB77

TRISD= INPUT
TRISB,C=OUTPUT

ADCON1=7

Define LCD_DREG, DBIT
Define LCD_EREG, EBIT
Define LCD_RSREG, RSBIT
Define LCD_RWREG, RWBIT
Define LCD_BITS
Define LCD_LINES

7th bit of PortD=OK
6th bit of PortD=DOWN
5th bit of PortD=UP

HOUR, MINUTE as BYTE

Clear

Write "AKU SARJ
DEVRESI" in first line of LCD

Delay 1000 ms

Clear

Display battery list
to screen, cursor "*"
in first line of LCD
Write battery list to LCD, cursor "*" in second line

OK=0

no

DOWN=0

yes

Delay 50 ms

no

DOWN=0

yes

no

Clear

yes

Write battery list to LCD, cursor "*" in third line
Write battery list to LCD, cursor ** on fourth line

Delay 50 ms

OK = 0

DOWN = 0

no

Clear

yes
GOSUB AYAR

Delay 60000 ms

Write battery type (first battery of the list) and left time in LCD

Delay 200 ms

Write battery type (first battery of the list), period of charging in LCD

yes

Clear

HIGH PORTC.0

OK=0

Clear

MINUTE=MINUTE-1

MINUTE=255

yes

MINUTE=59

HOUR=HOUR-1

HOUR=255

yes

LOW PORTC.0

Write charged completed in LCD

Delay 2000 ms

8
GO SUB AYAR

Delay 60000 ms

Write battery type (second battery of the list) and left time in LCD

Delay 200 ms

Write battery type (second battery of the list), period of charging in LCD

yes

MINUTE=255

yes

MINUTE=59

yes

HOUR=HOUR-1

HOUR=255

no

HIGH PORTC.0

yes

LOW PORTC.0

no

MINUTE=MINUTE-1

OK=0

Clear

Clear

Write charged completed in LCD

Delay 2000 ms
GOSUB AYAR

Delay 60000 ms

Write battery type (third battery of the list) and left time in LCD

Delay 200 ms

Write battery type (third battery of the list), period of charging in LCD

yes

Clear

HIGH PORTC.0

OK=0

Clear

LOW PORTC.0

Write charged completed in LCD

Delay 2000 ms

MINUTE=MINUTE-1

MINUTE=255

yes

MINUTE=59

HOUR=HOUR-1

HOUR=255

yes

yes

HOUR=255

LOW PORTC.0

delay completed in LCD

Delay 2000 ms
GOSUB AYAR

Clear

Write battery type (fourth battery of the list) and left time in LCD

Delay 60000 ms

MINUTE=MINUTE-1

MINUTE=255

yes

MINUTE=59

HOUR=HOUR-1

HOUR=255

yes

LOW PORTC.0

Write charged completed in LCD

Delay 2000 ms

Delay 200 ms

Write battery type (fourth battery of the list) and period of charging in LCD

GOSUB AYAR

yes

Clear

HIGH PORTC.0

MINUTE=MINUTE-1

MINUTE=255

yes

MINUTE=59

HOUR=HOUR-1

HOUR=255

yes

LOW PORTC.0

Write charged completed in LCD

Delay 2000 ms

Delay 60000 ms
Delay 50 ms

OK=0

no

OK=0

yes

10

UP=0

no

yes

MINUTE=MINUTE+1

MINUTE=60

yes

MINUTE=0

no

DOWN=0

Clear

Write hour and minute variables in LCD to adjust time

Delay 100 ms
10

Delay 50 ms

OK=0

Clear

Write time of charge in LCD

Delay 1000 ms

RETURN
2.3.3. Program Code:

As a summary, Pic is evaluated datas which comes from buttons. Then datas are send to LCD by the help of program. Program code is written in PicBasicPro.

;Sample Title
****************************************************************
* Name    :ABC.BAS                                      *
* Author  : [select VIEW...EDITOR OPTIONS]                    *
* Notice  : Copyright (c) 2010 [select VIEW...EDITOR OPTIONS] *
*        : All Rights Reserved                  *
* Date    : 23.03.2010                                 *
* Version : 1.0                                       *
* Notes   :
*        :                                                   *
****************************************************************

;In this part, DEVICE definitons and config information are given. The commands which are started @, are assembly commands in fact. The @ sign provide to use these commands in pic pasic code.

;Configuration bits are used to determine rules which PIC obeys when voltage is applied to pic. For example, if XT oscillator was used as oscillator, this condition must be written Pic. Rules which are determined by configuration bits are oscillator type, condition of watchdog timer(ON/OFF), condition power-on-reset (when voltage is applied to pic, condition of code protect(ON/OFF).

@ DEVICE pic16F877                                          'Define Device
@ DEVICE pic16F877, WDT_oFF                       'Watchdog Timer OFF
@ DEVICE pic16F877, PWRT_OFF                    'Power on timer OFF
@ DEVICE pic16F877, PROTECT_ON           'Code protect ON
@ DEVICE pic16F877, XT_OSC                          'XT oscillator is used

;This command is used to cancel analog-digital converter.
ADCON1=7

;In this part, inputs/outputs are defined.
TRISA=%00000000     'PORTA output
TRISB=%00000000      'PORTB output
TRISC=%00000000      'PORTC output
TRISD=%11100000      'Last threebits of PORTD input
TRISE=%00000000      'PORTE output

;In this part, necessary definitions are written to use LCD.
DEFINE LCD_DREG PORTB              'To which port is LCD data pins connected?
DEFINE LCD_DBIT 4                  'From which bit do LCD data pins start?
DEFINE LCD_EREG PORTB  'To which port is LCD Enable Pin connected?  
DEFINE LCD_EBIT 3  'To which bit is LCD Enable Pin connected?  
DEFINE LCD_RSREG PORTB  'To which port is LCD RS Pin connected?  
DEFINE LCD_RSBIT 1  'To which bit is LCD RS Pin connected?  
DEFINE LCD_RWREG PORTB  'To which port is LCD RW Pin connected?  
DEFINE LCD_RWBIT 2  'To which bit is LCD RS Pin connected?  
DEFINE LCD_BITS 4  'Is LCD connected as 4 bit or 8 bit?  
DEFINE LCD_LINES 4  'How many lines can be written to LCD?  

;In this part, variables’ names and types are defined. Symbol is used for Port pins.
SYMBOL OK=PORTD.7  'OK buttons is connected seventh bit of PORTD
SYMBOL UP=PORTD.6  'UP buttons is connected sixth bit of PORTD
SYMBOL DOWN=PORTD.5  'DOWN buttons is connected fifth bit of PORTD
HOUR VAR BYTE
MINUTE VAR BYTE

;All ports are assigned as zero in the beginning.
PORTA=%0000000000
PORTB=%0000000000
PORTC=%0000000000
PORTD=%0000000000
PORTE=%0000000000

;All variables are assigned as zero.
CLEAR

;NOTE1: $80: adress of first line first character
;       $C0: adress of second line first character
;       $94: adress of third line first character
;       $D4: adress of fourth line first character

;In this part, AKU SARJ DEVRESİ is written in first line in LCD. After 1000 milisecond,
LUTFEN SARJ EDiLECEK is written in first line, ," AKUYU SECİNiZ " in second line.

BASLA:
  LCDOUT $FE,1  'Clear the display
  LCDOUT $FE,$80," AKU SARJ DEVRESİ"
  LCDOUT $FE,$C0," 
  LCDOUT $FE,$94," 
  LCDOUT $FE,$D4," 
  pause 1000
  LCDOUT $FE,1
  LCDOUT$FE,$80,"LUTFEN SARJ EDiLECEK"
  LCDOUT $FE,$C0," AKUYU SECİNiZ "
  LCDOUT $FE,$94," 
  LCDOUT $FE,$D4," 
  pause 1000
;NOTE2: The 200 milisecond delay is needed to be ready LCD to use. 1000 milisecond delay is used to appear writings in display more time.

ATLA:
    LCDOUT $FE,1
    LCDOUT $FE,$80,"1. 12 v 1.2 amp *
    LCDOUT $FE,$C0,"2. 12 v 4 amp 
    LCDOUT $FE,$94,"3. 12 v 7 amp 
    LCDOUT $FE,$D4,"4. 12 v 12 amp 

;********************************************************

;BEKLE subroutines control whether press OK and DOWN button or not. First, OK button is controlled. If OK button is pressed, program goes to AKU subroutines. If DOWN button is not pressed, DOWN button is controlled. If DOWN button is pressed, program goes to ATLA subroutines. In this subroutine, Cursor sign ‘*’ is shifted bottom line. Also, Alist of battery is written LCD in this subroutine. If DOWN button is not pressed, the program returns beginning of the same subroutine. This process is repeated four times. If no button is pressed until last time, the program return to “ATLA” subroutine.

BEKLE1:
   IF OK=0 THEN AKU1
   IF DOWN=0 THEN
   PAUSE 50
   WHILE DOWN=0
   WEND
   GOTO ATLA1
   ENDIF
   GOTO BEKLE1

ATLA1:
    LCDOUT $FE,1
    LCDOUT $FE,$80,"1. 12 v 1.2 amp 
    LCDOUT $FE,$C0,"2. 12 v 4 amp *
    LCDOUT $FE,$94,"3. 12 v 7 amp 
    LCDOUT $FE,$D4,"4. 12 v 12 amp 

BEKLE2:
   IF OK=0 THEN AKU2
   IF DOWN=0 THEN
   PAUSE 50
   WHILE DOWN=0
   WEND
   GOTO ATLA2
   ENDIF
   GOTO BEKLE2
ATLA2:
    LCDOUT $FE,1
    LCDOUT $FE,$80,"1. 12 v 1.2 amp "
    LCDOUT $FE,$C0,"2. 12 v 4 amp 
    LCDOUT $FE,$94,"3. 12 v 7 amp *
    LCDOUT $FE,$D4,"4. 12 v 12 amp 

BEKLE3:
    IF OK=0 THEN AKU3
    IF DOWN=0 THEN
        PAUSE 50
        WHILE DOWN=0
            WEND
        GOTO ATLA3
    ENDIF
    GOTO BEKLE3

ATLA3:
    LCDOUT $FE,1
    LCDOUT $FE,$80,"1. 12 v 1.2 amp "
    LCDOUT $FE,$C0,"2. 12 v 4 amp 
    LCDOUT $FE,$94,"3. 12 v 7 amp *
    LCDOUT $FE,$D4,"4. 12 v 12 amp *

BEKLE4:
    IF OK=0 THEN AKU4
    IF DOWN=0 THEN
        PAUSE 50
        WHILE DOWN=0
            WEND
        GOTO ATLA
    ENDIF
    GOTO BEKLE4

;-------------------------------------
;In AKU subroutines, program goes to AYAR to adjust hour and minute by using buttons.
;After adjustment, program return to back. Battery type, time of charging is written first and second line of LCD. Then OK button is controlled. If the button is pressed, it means that charge starts and zeroth bit of PortC is assigned high, Led is on. In charging period, battery type and left time is written in LCD. At the end of charge period, zeroth bit of PortC is low, led is off.

;-----------------------------

;In AKU subroutines, program goes to AYAR to adjust hour and minute by using buttons. After adjustment, program return to back. Battery type, time of charging is written first and second line of LCD. Then OK button is controlled. If the button is pressed, it means that charge starts and zeroth bit of PortC is assigned high, Led is on. In charging period, battery type and left time is written in LCD. At the end of charge period, zeroth bit of PortC is low, led is off.
AKU1:
    GOSUB AYAR
    LCDOUT $FE,1
    LCDOUT $FE,$80,"AKU: 12 v 1.2 amp   
    LCDOUT $FE,$C0,"SARJ SURESi:",DEC2 HOUR,:",DEC2 MINUTE
    LCDOUT $FE,$94,"OK TUSUNA BASARAK"
    LCDOUT $FE,$D4,"SARJI BASLATINIZ"
    PAUSE 200
JEK1:
    IF OK=0 THEN
    HIGH PORC.0

TOM1:
    LCDOUT $FE,1
    LCDOUT $FE,$80,"          AKU  
    LCDOUT $FE,$C0,"    12 v 1.2 amp  
    LCDOUT $FE,$94,"   KALAN SURE"
    LCDOUT $FE,$D4,"   
    PAUSE 60000
    MINUTE=MINUTE-1
    IF MINUTE=255 THEN
    MINUTE=59
    HOUR=HOUR-1
    IF HOUR=255 THEN
    LOW PORC.0
    LCDOUT $FE,1
    LCDOUT $FE,$80,"   SARJ iSLEMi"
    LCDOUT $FE,$C0,"   TAMAMLANDI"
    LCDOUT $FE,$94,"   
    LCDOUT $FE,$D4,"   
    pause 2000
    GOTO BASLA
    ENDFI
    GOTO TOM1
    ENDFI
    GOTO TOM1
    ENDI
    GOTO JEK1

AKU2:
    GOSUB AYAR
    LCDOUT $FE,1
    LCDOUT $FE,$80,"AKU: 12 v 4 amp   
    LCDOUT $FE,$C0,"SARJ SURESi:",DEC2 HOUR,:",DEC2 MINUTE
JEK2:
   IF OK=0 THEN
   HIGH PORTC.0
TOM2:
   LCDOUT $FE,1
   LCDOUT $FE,$80,"   AKU   
   LCDOUT $FE,$C0,"   12 v 4 amp   
   LCDOUT $FE,$94,"   KALAN SURE" 
   LCDOUT $FE,$D4,"   ,DEC2 HOUR,":" ,DEC2 MINUTE  
   PAUSE 60000  
   MINUTE=MINUTE-1  
   IF MINUTE=255 THEN  
   MINUTE=59  
   HOUR=HOUR-1  
   IF HOUR=255 THEN  
   LOW PORTC.0  
   LCDOUT $FE,1  
   LCDOUT $FE,$80,"   SARJ iSLEMi"  
   LCDOUT $FE,$C0,"   TAMAMLANDI"  
   LCDOUT $FE,$94,"   "  
   LCDOUT $FE,$D4,"   "  
   pause 2000  
   GOTO BASLA  
   ENDIF  
   GOTO TOM2  
   ENDIF  
   GOTO TOM2  
   ENDIF  
   GOTO JEK2

AKU3:
   GOSUB AYAR  
   LCDOUT $FE,1  
   LCDOUT $FE,$80,"AKU: 12 v 7 amp   "  
   LCDOUT $FE,$C0,"SARJ SURESi: ",DEC2 HOUR,": ",DEC2 MINUTE  
   LCDOUT $FE,$94,"OK TUSUNA BASARAK"  
   LCDOUT $FE,$D4,"SARJI BASLATINIZ"  
   PAUSE 200 
JEK3:
   IF OK=0 THEN  
   HIGH PORTC.0
TOM3:
  LCDOUT $FE,1
  LCDOUT $FE,$80," AKU "
  LCDOUT $FE,$C0," 12 v 7 amp "
  LCDOUT $FE,$94," KALAN SURE"
  LCDOUT $FE,$D4," " ,DEC2 HOUR,"." ,DEC2 MINUTE
  PAUSE 60000
  MINUTE=MINUTE-1
  IF MINUTE=255 THEN
    MINUTE=59
    HOUR=HOUR-1
  IF HOUR=255 THEN
    LOW PORTC.0
  LCDOUT $FE,1
  LCDOUT $FE,$80,"  SARJ iSLEMi"
  LCDOUT $FE,$C0,"  TAMAMLANDI"
  LCDOUT $FE,$94,"  
  LCDOUT $FE,$D4,"  
  pause 2000
  GOTO BASLA
  ENDIF
  GOTO TOM3
  ENDIF
  GOTO TOM3
  ENDIF
  GOTO JEK3

AKU4:
  GOSUB AYAR
  LCDOUT $FE,1
  LCDOUT $FE,$80,"AKU: 12 v 12 amp  "
  LCDOUT $FE,$C0,"SARJ SURESı:" ,DEC2 HOUR,"." ,DEC2 MINUTE
  LCDOUT $FE,$94,"OK TUSUNA BASARAK"
  LCDOUT $FE,$D4,"SARJI BASLATINIZ"
  PAUSE 200
  JEK4:
  IF OK=0 THEN
    HIGH PORTC.0
  TOM4:
  LCDOUT $FE,1
  LCDOUT $FE,$80,"  AKU "
  LCDOUT $FE,$C0," 12 v 12 amp "
  LCDOUT $FE,$94,"  KALAN SURE"
  LCDOUT $FE,$D4," " ,DEC2 HOUR,"." ,DEC2 MINUTE
PAUSE 60000
MINUTE=MINUTE-1
IF MINUTE=255 THEN
MINUTE=59
HOUR=HOUR-1
IF HOUR=255 THEN
LOW PORTC.0
LCDOUT $FE,1
LCDOUT $FE,$80," SARJ İSTEMİ"
LCDOUT $FE,$C0," TAMAMLANDI"
LCDOUT $FE,$94," "
LCDOUT $FE,$D4," "
pause 2000
GOTO BASLA
ENDIF
GOTO TOM4
ENDIF
GOTO TOM4
ENDIF
GOTO JEK4

AYAR:
PAUSE 50
WHILE OK=0
WEND
TUR1:
IF OK=0 THEN MINBIR
IF UP=0 THEN
HOUR=HOUR+1
IF HOUR=99 THEN HOUR=0
ENDIF
IF UP=0 THEN
HOUR=HOUR-1
IF HOUR=255 THEN HOUR=99
ENDIF
LCDOUT $FE,1
LCDOUT $FE,$80,"LUTFEN SARJ SURESİNİ"
LCDOUT $FE,$C0," SEÇİNİZ."
LCDOUT $FE,$94," ",DEC2 HOUR," ",DEC2 MINUTE
LCDOUT $FE,$D4," "

PAUSE 100
GOTO TUR1
MINBIR:
    PAUSE 50
    WHILE OK=0
    WEND
TUR2: IF OK=0 THEN CIK
    IF UP=0 THEN
        MINUTE=MINUTE+1
        IF MINUTE=60 THEN MINUTE=0
    ENDIF
    IF DOWN=0 THEN
        MINUTE=MINUTE-1
        IF MINUTE=255 THEN MINUTE=59
    ENDIF

    LCDOUT $FE,1
    LCDOUT $FE,$80,"LUTFEN SARJ SURESİNİ"
    LCDOUT $FE,$C0," SEÇİNİZ ",
    LCDOUT $FE,$94," ,DEC2 HOUR,",:",DEC2 MINUTE
    LCDOUT $FE,$D4," 
    PAUSE 100
    GOTO TUR2

CIK:
    PAUSE 50
    WHILE OK=0
    WEND
    LCDOUR $FE,1
    LCDOUT $FE,$80," SARJ SURESİ"
    LCDOUT $FE,$C0," AYARLANDI ",
    LCDOUT $FE,$94," ,DEC2 HOUR,",:",DEC2 MINUTE
    LCDOUT $FE,$D4," 
    PAUSE 1000
    RETURN
END
Results and Discussions

3.1. Calibration and Simulations of Designed Circuits

3.1.1. Calibration and Simulation Main Charger Circuit: The circuit was runned in simulation program (Proteus Isis), the following figures are taken from this program. Transformers do not work in this program so we applied DC voltage to simulate the circuit.

*Figure-3.1.1.1: In this figure, you can see that the charge led is lit up after DC voltage applied.*
**Calibration of Circuit:** Battery voltage is adjusted with pot. This value is obtained from datasheet. The other way to obtain battery voltage is to measure fully charged battery.

*Figure-3.1.1.2: Minimum voltage value which is calibrated with pot*

*Figure-3.1.1.3: Maximum voltage value which is calibrated with pot*
After we measured minimum and maximum values, we saw that the 10k pot is sufficient to charge 12V batteries.

![Figure-3.1.1.4: Output voltage to 13.8V to charge 12V batteries](image)

We adjusted the output voltage to 13.8V to charge 12V batteries. As we mentioned before, the value can change depend on trademark, shape, size of the battery.

**Simulation of Circuit:**

We can not observe to charge battery during time in simulation program. But, we tested the circuit by connected variable batteries instead of 12V sealed lead-acid batteries.

![Figure-3.1.1.5: The circuit works for battery voltage values below 13.8V. This means that the charging process goes on until the battery voltage equals to the voltage we adjusted with pot.](image)
3.1.1.6: The circuit does not work for battery voltage values above 13.8V. This means that the current cuts-off automatically when battery voltage equals to the voltage we adjusted with pot.

We were able to obtain a controlled charging. The current will be cut-off automatically when battery voltage equals to the voltage we adjusted with pot. The circuit has been tested and the successful results were gained in charging 12V 7A batteries.

3.1.2. Calibration and Simulation 10led monitor circuit

The circuit was run in simulation program (Proteus Isis), the following figures are taken from this program.

**Calibration of Circuit:** Minimum acting point is adjusted by P1 (10k). By this process of adjustment led which is connected top in number 1 is lit up for minimum voltage value. Maximum acting point of monitor circuit is adjusted by P2 (50k). In this case led which is connected top in number 10 is lit up during adjustment process. These adjustments are done more one time. The minimum and maximum values which circuit will measure is applied accordingly. The adjustment is made with P1 and P2. Voltage ratio between comparators is equal. Difference between two measured voltage is divided into ten equal pieces inside LM3914. To understand working principle of the circuit it is necessary to look into pins and inner structure of LM3914.
Figure-3.1.2.1: Adjustment of minimum acting point

Figure-3.1.2.2: Adjustment of maximum acting point (in bar mode)
Simulation of Circuit:

Some Examples: For these examples, it is chosen 11.8V for minimum value when it is out of charge and 13.8V for maximum value when it is fully charged.

Figure-3.1.2.3: Three leds are lit up for 12.3 V

Figure-3.1.2.4: Five leds are lit up for 12.7V
Figure-3.1.2.5: Seven leds are lit up for 13.2 V

Figure-3.1.2.6: Eight leds are lit up for 13.5 V

This circuit provide us to see charge level during charging and after charging according to minimum and maximum voltage adjustments.
3.1.3. Simulation of LCD Circuit

Figure-3.1.3.1: Beginning of the simulation

Figure-3.1.3.2: After 1000 ms
Figure-3.1.3.3: After 1000 ms

Figure-3.1.3.4: After battery was chosen

Figure-3.1.3.5: After hour adjustment was done
Figure-3.1.3.6: After time (hour and minute) adjustment was done

Figure-3.1.3.7: Beginning of the charging

Figure-3.1.3.8: After 1 minute passed

Figure-3.1.3.9: End of the charging time
When running test we encountered same problems. First was the overheating of the transistor when charged in high currents. Heatsink is sufficient up to 12 Ah and 12 Ah batteries.

Another problem was the dangerous that may occur during a short circuit. A battery can deliver 100 and above amperes during a short, so it can cause serious damage or even fires when something goes wrong with the charger. In order to prevent this we will put a fuse behind the regulator in the lead going to the battery. The fuse on the charger is about two times the maximum current we will be charging with.

### 3.2. Combined Circuits

#### 3.2.1. First Design

It is very simple way. This design includes main charger circuit and monitor circuit. Two of them are connected directly to battery. The features of first design are as follows. It is voltage controlled. The current is cut-off automatically when battery voltage equals to the voltage we adjusted with pot. It has 10 led to show charge level. Also, it is cheap design.

![Figure-3.2.1.1: Block diagram of first design](image)

#### 3.2.2. Second Design

This design includes all designed circuits. Monitor circuit is connected directly to battery. Charger circuit and control circuit are connected to relay. Also, relay is connected to battery.

![Figure-3.2.2.1: Block diagram of second design](image)
Power Supplies for PIC and Relay:

**LOW AC VOLTAGE FROM TRANSFORMER**

**RECTIFIER**

**SMOOTHING**

**PIC 16F877**

**7805 (5 VOLT REGULATOR)**

**7812 (12 VOLT REGULATOR)**

**RELAY**

*Figure-3.2.2.2: Block Diagram of Power supplies*

**Lm7812 and 7805 Series Voltage Regulator:** A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents [10].

*Figure-3.2.2.3: Lm7812 and 7805 pin diagram in Proteus*
**Relay:** A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism, but other operating principles are also used.[11]

**How to Control A relay from Pic controller:**

![Reference circuit 1](image1)

As it is seen on Figure.3.2.2.4 and Figure.3.2.2.5, the relays are connected to Port pins of the PIC bc1329, bc107 transistors. When the transistor gets cut off, a reverse EMF may occur and the transistor may be defected. To overcome this unwanted situation, 1N4007 diodes are connected between the supply and the transistor collectors.

![Reference circuit 2](image2)
Figure-3.2.2.6: Ares schematic of second design

Summary

The features of the circuits designed are as follows:

- Appropriate for 12V sealed-lead acid batteries
- Appropriate for current values 12Ah and below 12Ah
- Voltage or time controlled (it depends on design)
  - If it is voltage controlled, Interrupts the current when battery is charged
  - If it is time controlled, Interrupts the current when time is up
- Has ten leds which shows charge level during charging or after/before charging (in resting state)
- Has buttons to choose battery type and adjust charge time
- Has LCD to show left time and battery type which chosen to be charged
References

[8] Datasheet of LM044L
[10] Datasheet of LM78XXX
[22] Lecture notes of ECE 246, ECE 347, ECE 425