Clock Kit Project V.2

Clock Kit Project

Our project will be the assembly of a digital clock. This little device will tell you the time, date, day of the week and even the temperature! It uses many of the parts and circuits we have discussed in class (resistors, switches, LEDs, thermistors, light sensitive resistors).

Assembly Instructions

This is a very difficult assembly project, especially because we are using lead free solder and the instructions that came with the clock are a bit cryptic. The instructions below are based on my experience with the assembling the clock. Follow these instructions carefully. I have included little check boxes for you to use as you proceed.

- Practice Soldering – For your project to work properly every one of the 100 solder joints must be perfect. Practice until you are comfortable using the lead fee solder. Make sure your iron is set to the right temperature. The secret to lead free soldering is to make sure the joint is hot before you apply the solder. If you look really closely you will see the solder ring around the hole in the board change form solid to liquid. That means the joint is hot enough to apply the solder.
- Solder Carefully – practice soldering on the practice board first. Lead free solder is more difficult to work with than conventional solder. I would normally use conventional solder for a project like this, but we will use lead free solder because it is safer.
- Work carefully – it is very easy to make a mistake in the assembly process.
- Check your work – after each step carefully check your solder joints with a magnifying glass. Fix any problems by carefully reflowing the solder
- Don't Rush – if you rush through this project it will not work in the end.
- Work Neatly – try to place your parts on the board so that they are oriented in the same way. I soldered all my resistors so that they were oriented in the same direction. I place all my capacitors so that the printed value was facing the side of the board with the switches

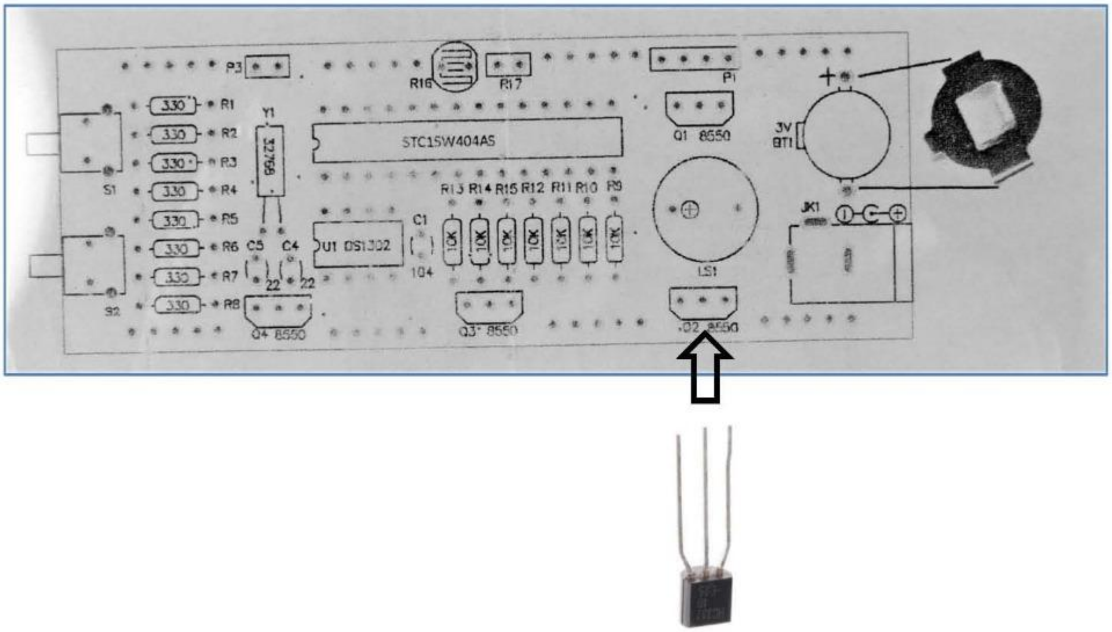
This project is unusual in that both sides of the circuit board need to be soldered. Once you have finished installing the small components you will solder in the large LEDs. Doing this will cover the backside of the board, so once they are in place you cannot resolder any of the connections you previously made. Therefore, it is critical at steps **17** and **18** that you check every solder joint on the back of the board. I will help you if you have trouble doing this.

Note: in my kit there were an extra 330Ω resistor, 10KΩ resitor, and 22 pf capacitor.

Assembly Instructions for the Circuit Board

1. ☐ - insert and solder <u>eight</u> 330Ω resistors (R1-R8) one at a time (Note: the resistor values might be different if your display is red or white). It is best to insert and solder one resistor, clip the leads and then move on to the next rather than insert all the resistors and then solder them. Check every solder joint after you finish and before moving on to the next step.

2. ☐ - insert, solder and clip <u>seven</u> 10KΩ resistors (R9-R15) one at a time. Check every joint before moving on.
3. ☐ - insert, solder and clip <u>four</u> 8550 transistor (Q1-Q4). Be very careful to align the flat side of the transistor with the flat side of the symbol on the circuit board. Push the transistor down until it is about a quarter of an inch above the board. HINT: transistors are notoriously sensitive to heat. Solder one terminal on each of the four transistors, then return to the first transistor and solder all the second terminals. Finally do all the third terminals. This way no transistor gets too hot.



4. ☐ - insert, solder and clip the crystal (Y1). This is a small silver cylinder with two leads. There is no direction to the crystal so it can go in either way. Insert it so that it is about a quarter inch above the board. Once you have soldered it in place you can bend it over so that it is flat against the board.
5. ☐ - insert, solder and clip <u>two</u> 22pf capacitors (C4-C5). Be careful to identify these capacitors by checking for the number 22 on the side of the capacitor. There is another capacitor that is almost the same size, but it says 104 on the side. This is for the next step. Be very careful to orient the capacitors so that they are aligned as shown on the circuit board.

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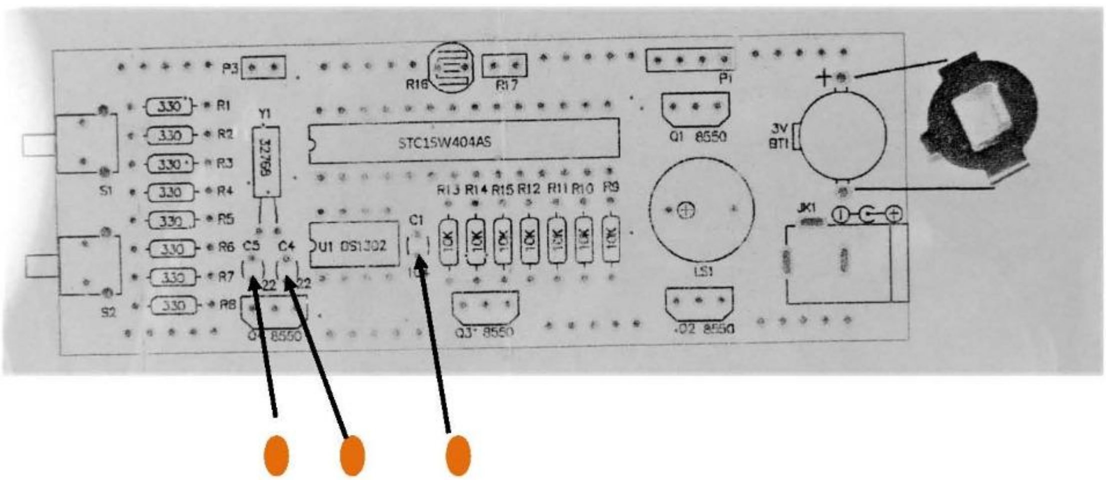
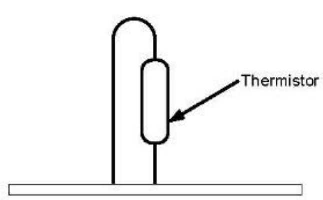
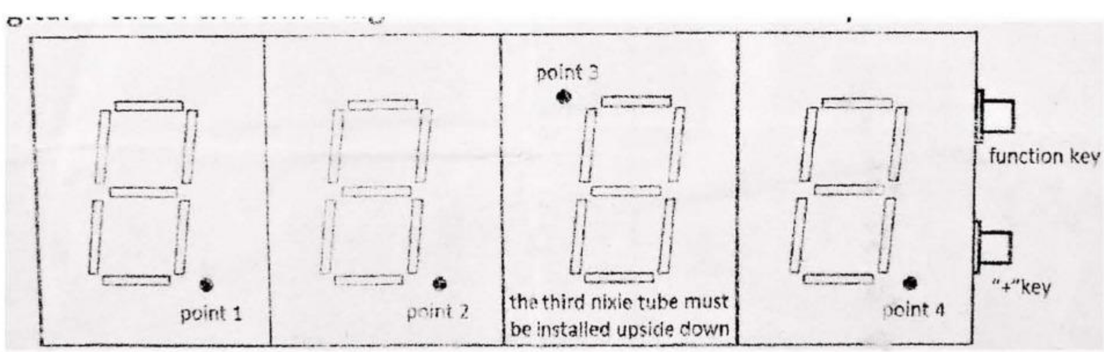


6. ☐ - Insert, solder and clip the 0.1uf capacitor (marked as 104 on the side).
7. ☐ - Insert and solder the small socket (U1). Notice that this socket has a notch on one end. This should correspond to the notch on the circuit board.
8. ☐ - Insert and solder the large socket (U2). Notice that this socket has a notch on one end. This should correspond to the notch on the circuit board. One way to install this part is to "tack solder" to pins that are diagonally opposite. Do this by putting a small dab of solder on your iron and touching it to the pin briefly. This will hold the socket in place so you can solder the other pins. Be sure to resolder the two pins you tack soldered earlier.
9. ☐ - Insert and solder switches (S1 and S2).
10. ☐ - Insert and solder power jack JK2.
11. ☐ - Insert and solder the light sensitive resistor (R16). This component should be flat against the board.
12. ☐ - Insert, solder and clip the thermistor (R17). This device looks like a little glass tube. Although it looks like a diode it is not. You insert it either way. The best way is to insert the device vertically because the holes are too close together for the thermistor to lay flat against the board.



13. ☐ - Insert, solder and clip the Buzzer (LS1). Note the orientation of the buzzer. There is a small plus sign on the bottom near one of the terminals. Be sure this terminal corresponds to the plus sign on the circuit board.
14. ☐ - Remove paper cover from buzzer. This protects the buzzer during the wash process at the factory.

15. ☐ - Insert and solder battery holder.
16. ☐ - Stop and take a deep breath!
17. ☐ - IMPORTANT!! – Now is the time to check every single solder joint top and bottom. You should see a clean blob of solder on the bottom and on the top side you should see a small bump of solder where the solder flowed through the hole. Correct every joint that does not look right. If you don't do it now you will not be able to after you solder in the LED numbers.
18. ☐ - IMPORTANT!! Inspect every joint again. This time look for any solder bridges. If you find a solder bridge you must clear it now either by reflowing the joints or using the dental tool to scrape away the solder.
19. ☐ - Using the IC inserter, insert the two ICs. The ICs have a dot or a notch on one end. Be sure this end is aligned with the notch on the socket and on the circuit board.
20. ☐ - using your multimeter check the continuity between the two pins of JK1. Your red probe should be on the center pin. Set your meter to the Ohms scale. The continuity should be high (like 6KΩ or more). If you have very low continuity you have a short in your board.
21. ☐ - plug your clock into the USB port of the computer. Press the two switches simultaneously. Hold them for about 10 seconds. Release the switches. After a few seconds you should hear several beeps. If you do it means your clock is working, even though it does not yet have the display. If it does not work we will see if we can find out what is wrong before we go on.
22. ☐ - IMPORTANT!! – Clip the high leads on the Jack (JK1) and on the two switches (S1, S2). If you do not do this now the LEDs will not lay flat against the board.
23. ☐ - Insert and solder first LED (DS1). Before you solder it in be sure that you have it installed so that the DOT on the LED is oriented as in the diagram below:



24. ☐ - Insert and solder the second LED (DS2). Be sure the DOT is oriented according to the picture above.
25. ☐ - Insert and solder the third LED (DS3). IMPORTANT: This LED is installed upside down so that the DOT is as illustrated. If you do not install this properly the digit will not work. See illustration above.
26. ☐ - Insert and solder the fourth LED (DS4). Note the DOT should be like the first two LEDs (See illustration above).
27. ☐ - Check every LED solder joint. Make sure that there is a good joint on the top and that some solder has flowed through the hole around each lead. Reflow any defective joints.

28. ☐ - using your multimeter check the continuity between the two pins of JK1. Your red probe should be on the center pin. Set your meter to the Ohms scale. The continuity should be high (like 6KΩ or more). If you have very low continuity you have a short in your board.
29. ☐ - plug your clock into the USB port of the computer. The LEDs should light up, but might be sort of random. NOTE: always place the clock on a non-conductive surface so that you do not short the pins. Also be careful when working at the plastic topped table because there is a tendency for that type of table top to hold a static charge that can damage the chips in your clock.
30. ☐ - Unplug your clock and worked insert the CR1220 battery into the battery holder. The plus side (+) must be up and the button side (-) must be down. If you put the battery in the wrong way you will short it out.
31. ☐ - Plug your clock back in to the USB port and see if it still works.
32. ☐ - If your clock works give yourself a big pat on the back. If it does not work I will help you attempt to fix it, although once it is assembled it will be hard to work on
33. ☐ - Follow the steps below to assemble the case for your clock.

Assembling the Case –

This is not easy because there are no instructions. The case fits together and is held in place by small screws and nuts. The screw goes through the hole in one part of the case and the nut goes in the center of the little cross shaped cut-outs. The holes for the buttons, plug and buzzer give you some idea of where the parts go. When I assembled my case I put the screws through the hole in one piece and immediately put the nut on the screw. Then I attached the appropriate piece and lined up the nut on the screw with the cut-out.

- The largest piece is the front where the digits will be displayed
- I put the long piece with the oval cut is the top. The other long thin piece is the bottom.
- The piece with two holes goes on the right side (as seen from the front) where the two buttons are.
- The piece with a single offset hole goes on the left side as seen from the front where the power plug enters.
- The dark film will have to be trimmed to the front between slot cut outs.
- I put the right side on last so that I could slip the circuit board in from the right side. But I was also able to put the top and bottom on after I had the rest assembled. Try different approaches. Here are the steps:

☐ - Peal the paper backing from all parts.
☐ - Assemble top to back and fix with screw and nut
☐ - Assemble bottom to back and fix with screw and nut
☐ - Assemble front and left side (power plug side) to previous assembly and fix with two screws and nuts (one from top to left side and the other from the front to left side).
☐ - Cut filter to size and slip into front of assembly.
☐ - Slip clock into case
☐ - Attach right side to assembly with two screws and nuts (one from top to right side and the other form front to right side).
☐ - Program your clock as below.

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Clock Operation

Your clock only displays 24 hour time. This is the military time system that everybody in the world uses except the United States. You might as well learn how to tell military time now. You clock has the following functions:

- Time
- Date
- Day of Week
- Alarm
- Hourly Chime
- Temperature
- Seconds "tick" of the colon between hours and minutes.

While the clock is operating it will display the time for 45 seconds out of every minute. Then it will display the temperature, followed by the Month and Day and finally the day of the week (0 is Sunday).

In the Time Display mode the clock will display time, temperature, date and day of the week. During each minute the clock changes the display as follows:

Seconds	Display
00:19	Current Time (HH:MM)
20:24	Temperature (degrees C)
25:29	Date (MM:DD)
30:34	Day of week as a number (–W-)
35:59	Current Time (HH:MM)

You can read the temperature, date and weekday at anytime by pressing the Plus button four times. The temperature, date and week day will be display in succession and you will return to the main time display.

If the alarm rings you can stop it by pressing the Function button.

The decimal point in the lower right shows whether the alarm is set (on) or not (off).

Set up of the Clock

Your clock has two buttons on the right side. The upper button is the Function button. The lower Button is the Plus button. The usage of the buttons depends upon what programming step you are at.

Start Up –

Plug you clock into a USB power source. The display will probably be scrambled.

- Press and Hold the Function and Plus buttons at the same time.
- Hold Function and Plus buttons until clock displays 7:59.
- Release Function and Plus buttons.
- Clock will show 8:00
- Buzzer will sound for about 10 times. When it is finished your clock is ready to program.

Programming –

Programming the time, alarm, date, weekday, chime and temperature calibration is controlled by the Function and Plus Button. When programming the time, alarm, and chimes the Function button moves between stages in the programming cycle and the Plus button changes values. When programming temperature, date and weekday the roles of the buttons are somewhat different as shown on the programming diagram.

Note: when programming the clock you will probably find that the buttons are a bit finicky. My guess is that they are not properly "debounced", which is a technique for preventing unstable behavior of buttons. Just be patient.

Programming Time, Alarm, and Chimes –

The main block at the top is the normal Time Display mode. The rounded rectangles are modes in the programming cycle. Lines with arrows indicate how the system moves from one step to the next based on which button (Func or Plus) is pressed.

From the Time Display follow the steps below (referring to the programming chart at the end.

Press Func button. The clock moves to the TIME:Hour mode. Pressing the Plus button will change the hour.

Press Func: The clock moves to the Time:Minute mode. Pressing the Plus button will change the minutes of the current time.

Press Func. The clock moves to the ALARM:Hour mode. Pressing the Plus button will change the alarm hour.

Pres Func: The clock moves to the Alarm:Minute mode. Pressing the Plus button will change the alarm minute.

Press Func: The clock moves to the ALARM:On/Off state. Pressing the Plus button turns the alarm on or off as indicated by the rightmost decimal point.

Press Func: The clock moves to the CHIME:Start mode. Pressing the Plus button will change the hour when the clock will start sounding the hourly chime.

Pres Func: The clock moves to the CHIME:End mode. Pressing the Plus button will change the hour when the clock will stop the hourly chime. Probably if you set the CHIME:Start and CHIME:End to the same value, like 00:00, the hourly chime will be turned off completely.

Press Func: The clock returns to the Time Display

Programming Temperature, Date and Weekday –

Starting from the Time Display mode push the Plus button. The clock moves to the TEMPERATRUE mode.

In TEMPERATURE mode you can push the Func button to match the displayed temperature to the current room temperature. This is basically a calibration step.

Press Plus: The clock moves to the DATE mode and displays the current date. You can either leave the date alone or press the Func button. If the date is Okay press the Plus button to set the week day. If the date is incorrect proceed as follows:

Press Func: The clock moves to DATE:Month mode and flashes the Month digits. Press Plus button to adjust the month.

Press Func: The clock moves to the DATE:Day mode and the day digits flash. Press Plus button to adjust the day.

Press Func: The clock moves to the WEEKDAY mode and displays the day of the week between two dashes. Press Func to adjust the Weekday. The week day number is arbitrary. Zero can represent Sunday or Monday as you desire.

Press Plus: Clock returns to Time Display.

Notes on the Schematic

With a little work you should be able to read the schematic. The first thing you might notice is that components have two labels. Consider the 10KΩ resistor in the upper left. It the 10K label obviously denotes the value in ohms. The other label, R9, is the name of the resistor and is used to relate the symbol in the schematic to the outline marks on the board. Engineers frequently use these sorts of labels so that they can talk about a component explicitly without using vague language, like "the 10K resistor next to that round black thing on the board". Usually the labeling scheme is:

C – Capacitor
R – Resistor
L – Inductor
Q – Transistor
J – Jack

- P – Plug
- S – Switch
- T – Transformer
- U – Large device, like an IC
- Y – Crystal or miscellaneous component

One convention used in complex schematics, like this one, is not to show every connection with a point to point line. Look at the resistor R9 in the top left. One side connects to the transistor, but the other side is not connected. However, there is a name, A1, on the line. This indicates that it connects with another wire labeled A1 someplace else on the schematic. If you look carefully you will see that this line connects to pin 17 of U2, the microcontroller. Similarly, the lines on the four display modules (DS1 – DS3) are labeled Z1 to Z8. Lines with the same name are connected together. This drawing convention saves space and makes the drawing easier to understand.

Component U2 is the large black chip. It has 28 pins. If you look at the data sheet for this device you will see where each pin is located. One end of the device has a notch and next to the notch is a dot. The pin next to the tiny dot is pin 1 and the other pin numbers are sequential down the long side, around the bottom and up the other side. You will notice that in the schematic on the side of U1 and U2 there are labels next to each pin. These are short names for the function of the pin and make the schematic easier to read without having to refer back to the data sheet.

The clock is run by a small programmable microcontroller (U2) which is an STC15W40AS. As sold this device is un-programmed and can perform any reasonable function. The buyer (the maker of our clock) then programs the part with the program for this particular clock. The microcontroller is the long thin integrated circuit.

The other integrated circuit (U1) is a real time clock chip. It keep track of time, date, alarm and so forth. The crystal (Y1) is a small oscillator that sets the base for time keeping. The crystal is made from a piezoelectric material, which is bends mechanically when electricity is applied. It is shaped like a tiny tuning fork and in conjunction with the two capacitors (C4 and C5) oscillates at a fixed frequency (about 32,000 Hz). The little 3Volt button battery keeps the clock chip running when the power is removed so that you do not have to reset it after every power outage. When power is removed the LEDs go out and the microcontroller stops, but the little U1 chip still keeps time. When you plug your clock back in it should still tell the correct time.

The clock display consists of four seven-segment LEDs. Each bar and dot in these displays is actually a separate LED just like the ones we use in class. The microprocessor lights up each segment in sequence, but does so very rapidly in a way that the display does not flicker. If you carefully shake your clock side to side you will see that the digits do not glow continuously. The 330Ω resistors are current limiting resistors such as we have discussed in class. The transistors (Q1-Q4) enable each LED digit in succession under control of the program. While a particular digit is enabled the microcontroller then enables each segment of that display sequentially as required to display the digit. This type of LED scanning is very common in displays.

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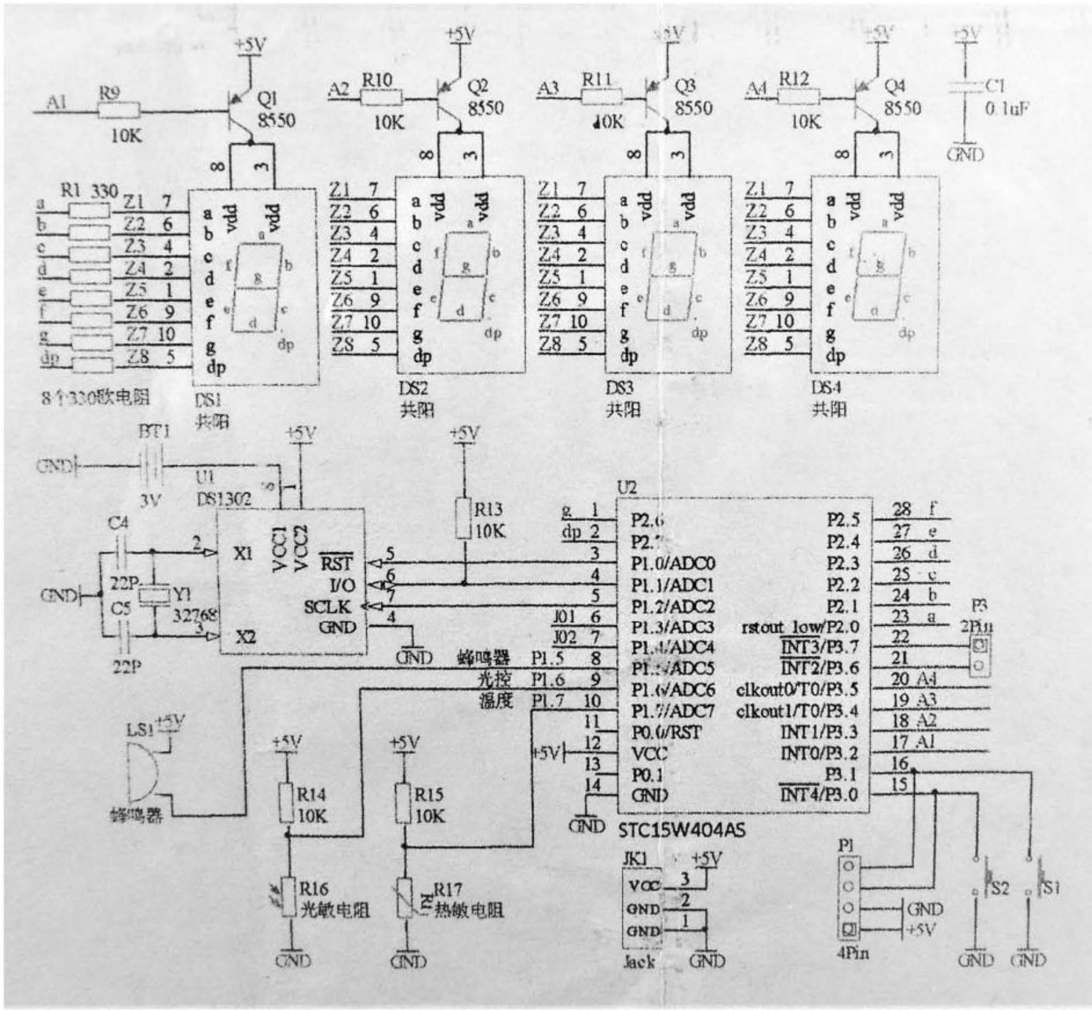
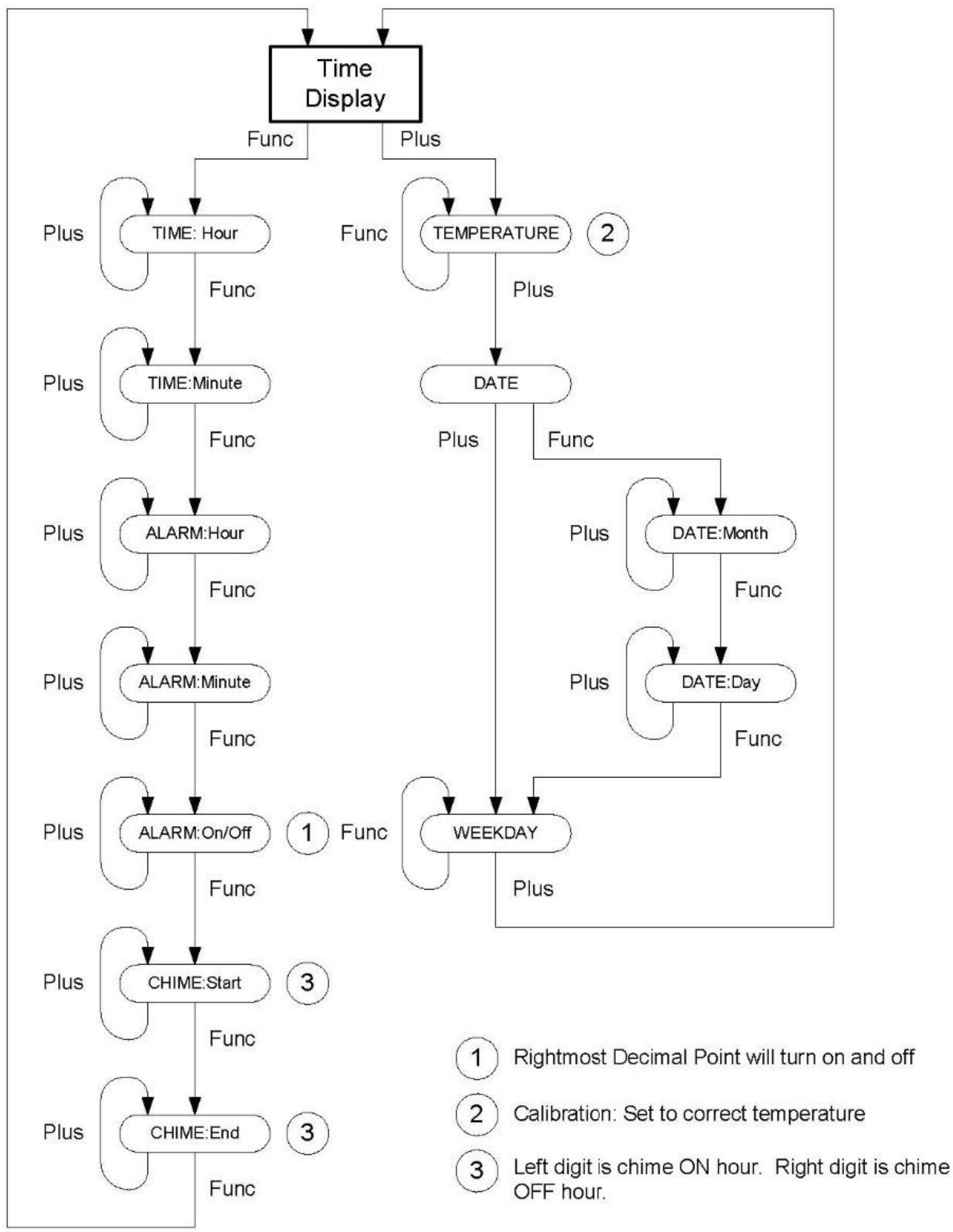


Schematic for Clock



Clock Programming