



MODEL CLK056

DIGITAL CLOCK

ASSEMBLY & OPERATION MANUAL



GEKCO Inc.
1565 SW Cypress Ln
McMinnville, OR 97128
(503) 472-4770

P/N 595-325 REV 181030

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CLK056

1. Introduction

The Digital Clock Model CLK056 was designed to fill the need for an accurate digital clock with the capabilities of two time zone displays in a compact format.

This clock has 6 digits for hours, minutes and seconds and the hours display can alternate between two time zones, i.e. Coordinated Universal Time (UTC) and local time.

The CLK056 is offered in kit form or fully assembled and tested. The kit is very easy to assemble with no surface mount parts.

This step by step manual will guide you through the process to complete the assembly and testing of the model CLK056 Digital Clock. The manual was designed so a total beginner in electronics can be successful but the more experienced builder can skip any unnecessary information. Also this design is fully open source for both the hardware and firmware. There are full schematics and pictorial diagrams of the hardware, also there are links and flowcharts of the firmware microcontroller code.

2. Operational Summary

The Model CLK056 has 6 digits of seven segment displays to display HOURS, MINUTES and SECONDS. The HOURS display can alternate between two time zones, which can be UTC and local time. This function can be turned off by a menu selection if desired.

- The six digit display provides Hours, Minutes and Seconds
- Dual time zone display, alternates between two time zones every 2 seconds, i.e. UTC and local
- The display LEDs are high contrast red, 0.56 inch character height
- Adjustable display brightness
- Local hours can be set for 12 or 24 hour mode
- Very accurate Real Time Clock (RTC) with battery backup
- Powered by a U.L. listed 5 VDC wall adapter
- Size: 4.16 x 2.35 x 1.46 inches (Width x Height x Depth)
- Weight: 0.30 pounds

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3. Parts and Unpacking

The kit is packaged in the order that the assembly is recommended. Each assembly block has it's associated parts bag. Only open a parts bag when called for during assembly to avoid misplacing parts.

3.1. Top Level Parts List

Remove the parts from the main bag and separate each individual parts bags.

<u>ITEM</u>	<u>QTY</u>	<u>PART NO.</u>	<u>DESCRIPTION</u>
1	1	DBR656-KIT	Clock Display Board PCA parts bag
2	1	CLK056M-KIT	Clock Main Board PCA parts bag
3	1	2217625	Real Time Clock (RTC) Module DS3231
4	1	CLK056HDW-KIT	Final Assembly Hardware
5	1	CLK0X6ENC-KIT	Enclosure Acrylic 6 Piece
6	1	54-660	AC to DC Power Supply Wall Adapter Single Output 5 Volt 1 Amp 5 Watt 2.1mm Conn

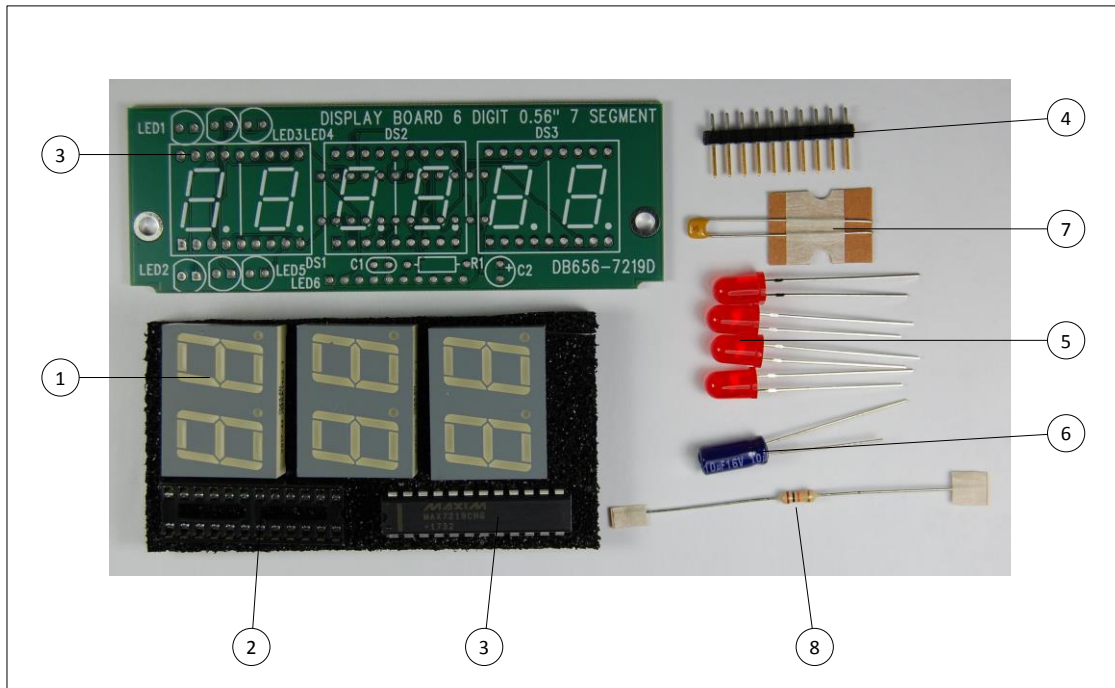


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3.2 Display Board Parts List

Clock 056 Display Board Printed Circuit Assembly (PCA) parts kit, P/N DBR656-KIT

<u>ITEM</u>	<u>QTY</u>	<u>REFDES</u>	<u>PART NO.</u>	<u>DESCRIPTION</u>
1	3	DS1,DS2,DS3	412-499	LED Display Module 7-Segment 2-Digit 0.56"
2	1	X1	434-3110	Socket IC Dip24-300
3	1	U1	442-3090	IC LED Display Driver MAX7219CNG
4	1	J1	131-1X10	Connector Header Single Row Male 10 pins
5	4	LED3,LED4, LED5,LED6	412-125	LED Red PCB Mount T1 3/4
6	1	C2	26-102	Cap elect alum radial lead 10uF/16v
7	1	C1	20-104	Cap mono Cer 50v radial lead
8	1	R1	6-1002-12	Res metal film 1/4w 1% 10k
9	1		81-180911D	PCB Display Board

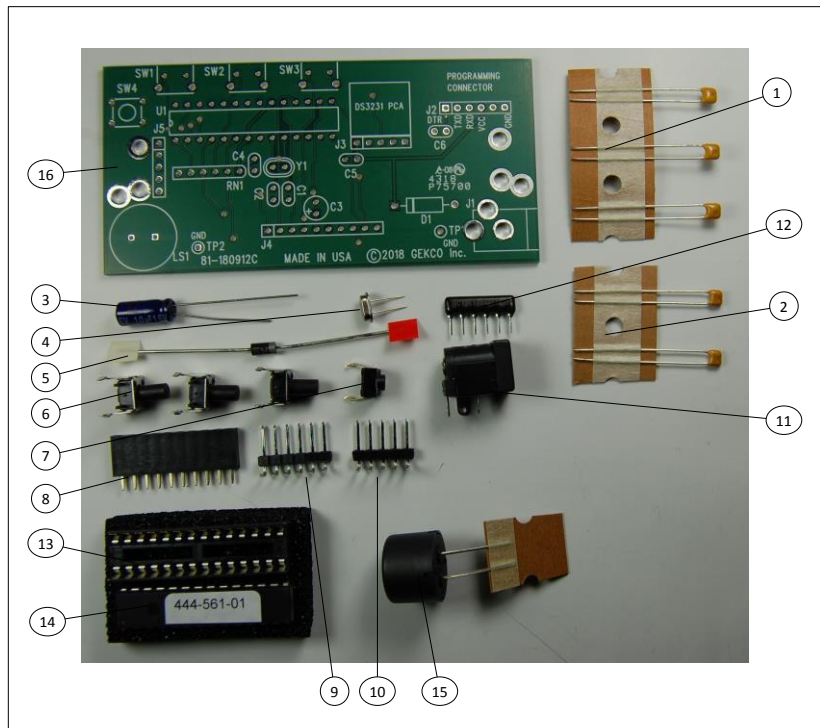


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3.3. Main Board Parts List

Clock 056 Main Board PCA parts kit, CLK056M-KIT

ITEM	QTY	REFDES	PART NO.	DESCRIPTION	VALUE
1	3	C4,C5,C6	20-104	Cap mono Cer 50v radial lead	0.1UF
2	2	C1,C2	21-220	Cap mono Cer COG radial lead	22pF 100v
3	1	C3	26-102	Cap elect alum radial lead	10uF/16v
4	1	Y1	404-160	Crystal HC49	16.00 MHz
5	1	D1	55-62	Diode schottky rectifier	1N5817-T
6	3	SW1,SW2,S W3	64-1839	Switch Momentary SPST	
7	1	SW4	64-1827	Switch Momentary 5mm H	
8	1	J4	131-1X10S	Conn Header Female Single Row 10 pins	
9	1	J2	131-1X06RA	Conn Header Right Angle	Male 1 row of 6 pins
10	1	J3	131-1X05RA	Connector Header Right Angle	Male 1 row of 5 pins
11	1	J1	134-002	Connector Power 2.1mm PCB Mount	
12	1	RN1	95-103	Res network 6 sip	10K 5 Res SIP Package
13	1	X1	434-311	Socket IC	Dip28-300
14	1	U1	444-104-01	IC Microcontroller	Programmed Part CLK056 V1.01
15	1	LS1	220-1420	Audio Piezo Transducer 30V	
16	1		81-180912C	Printed Circuit Board	Main Board

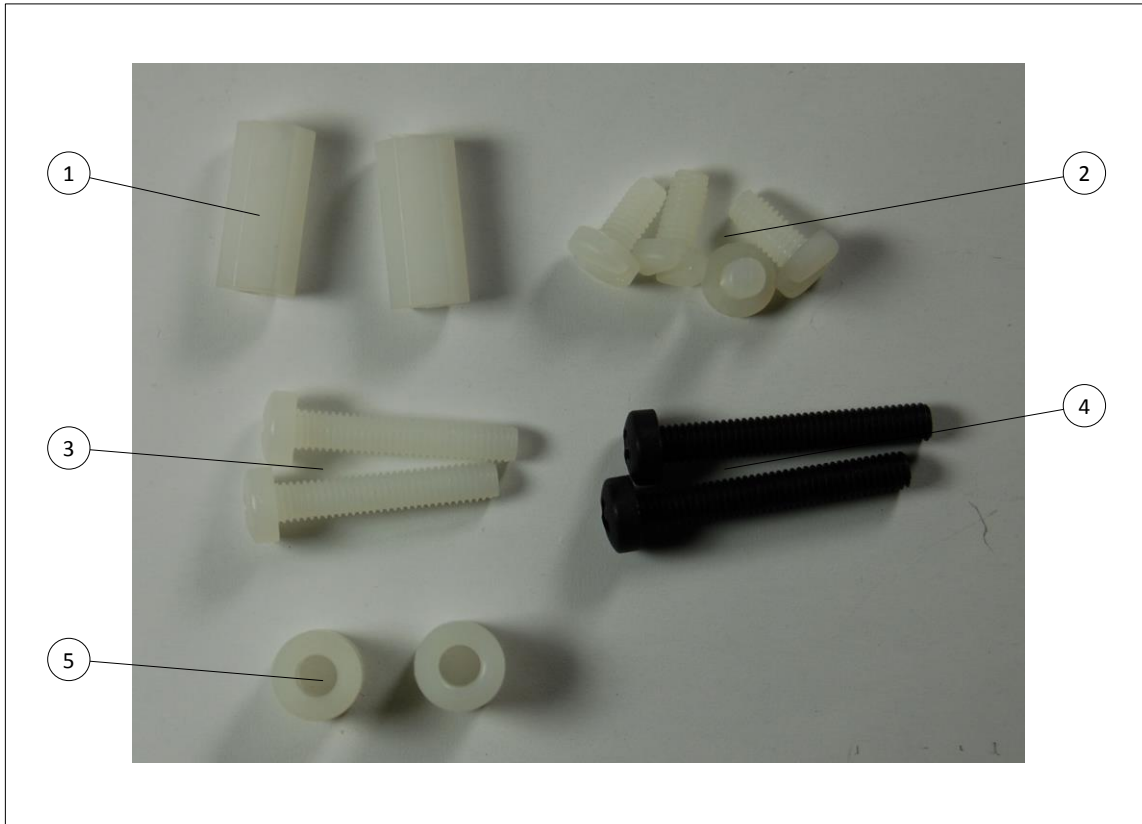


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3.4. Final Assembly Hardware Parts List

Clock 056 Final Assembly Hardware parts kit, P/N CLK056HDW-KIT

<u>ITEM</u>	<u>QTY</u>	<u>PART NO.</u>	<u>DESCRIPTION</u>
1	2	255-25511	Hardware Standoff Nylon M3 x 12 mm
2	4	255-29341	Hardware Screw Nylon M3 x 0.50 mm Thread, 6mm White (used for temporary assembly only)
3	2	255-29346	Hardware Screw Nylon M3 x 0.50 mm Thread, 16mm White
4	2	255-29347	Hardware Screw Nylon M3 x 0.50 mm Thread, 20mm Black
5	2	255-876	Hardware Spacer Round 0.25" Hole Size #4

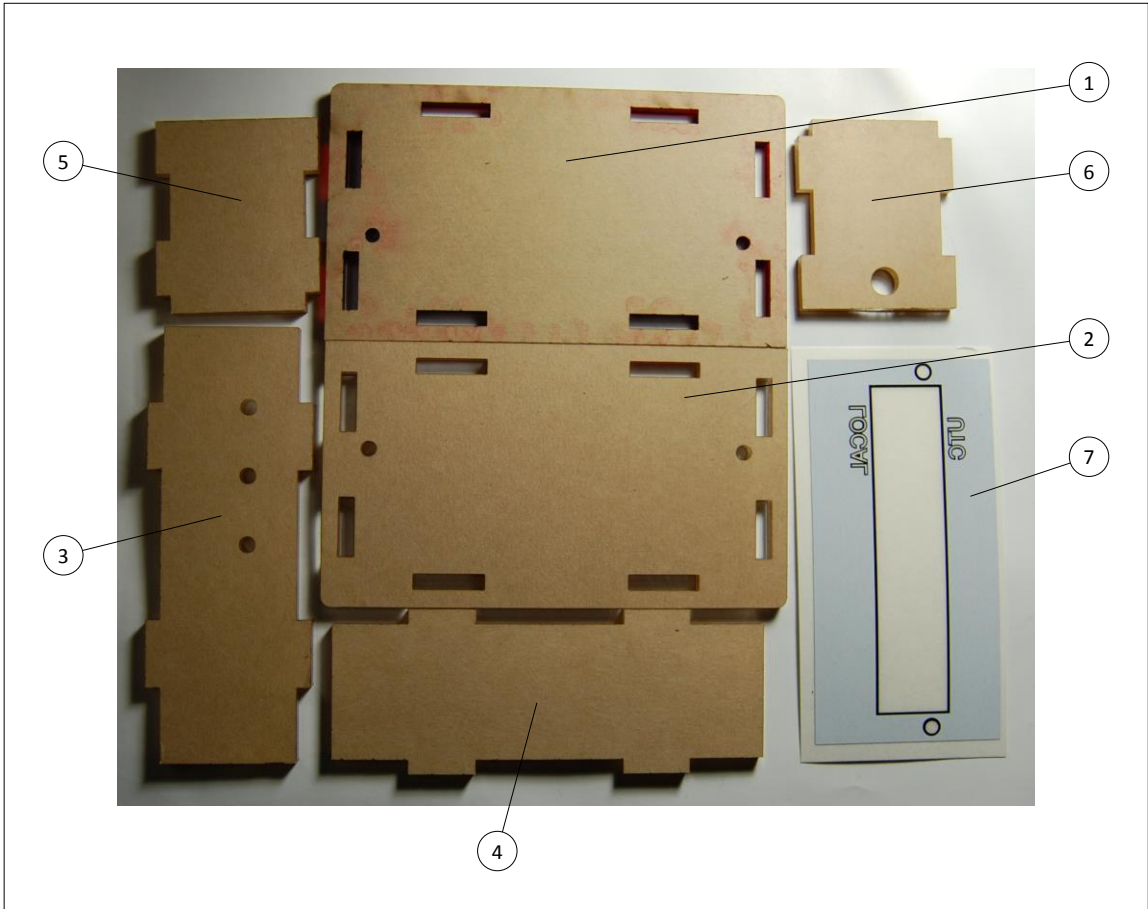


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3.5. Enclosure Parts List

Clock 056 Enclosure kit, P/N CLK0X6ENC-KIT

ITEM	QTY	PART NO.	DESCRIPTION
1	1	86-18111901	Front Panel Acrylic 3mm Transparent Red
2	1	86-18111902	Back Panel Acrylic 3mm Clear
3	1	86-18111903	Top Panel Acrylic 3mm Clear
4	1	86-18111904	Bottom Panel Acrylic 3mm Clear
5	1	86-18111905	Left Side Panel Acrylic 3mm Clear
6	1	86-18111906	Right Side Panel Acrylic 3mm Clear
7	1	86-18111907	Front Window Label



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4. Assembly Notes

4.1. TOOLS

You will need these tools to assemble your kit.

- Diagonal Cutters
- Needle Nose Pliers
- Flat Head Screwdriver
- Philips Screwdriver (for the enclosure only)
- Pencil Soldering Iron (22 to 25 WATTS)

4.2. ASSEMBLY

1. Follow the instructions carefully. Read the entire step before you perform each operation.
2. Refer to the Pictorial and Detail Illustrations for help in performing the assembly steps. The illustrations are arranged in the proper sequence, as called for in the assembly steps.
3. Pictorials show the overall operation for a group of assembly steps: Details generally illustrate a single step. When you are directed to refer to a certain Pictorial "for the following steps," continue using that Pictorial until you are referred to another Pictorial for another group of steps.
4. Position all parts as shown in the Pictorials.
5. Solder instructions are generally given only at the end of a series of similar steps. You may solder more often if you desire.
6. Each circuit part in an electronic kit has its own reference designator (R3, C8, etc.). Use these designators when you want to identify the same part in the various sections of the manual.
7. **SAFETY WARNING: Avoid eye injury when you cut off excessive lead lengths. Wear safety glasses or goggles and hold the leads so they cannot fly toward your eyes.**

4.3. SOLDERING

Soldering is one of the most important operations you will perform while assembling your kit. A good solder connection will form an electrical connection between two parts such as a component lead and a circuit board foil. A bad solder connection could prevent an otherwise well-assembled kit from operating properly.

It is easy to make a good solder connection if you follow a few simple rules:

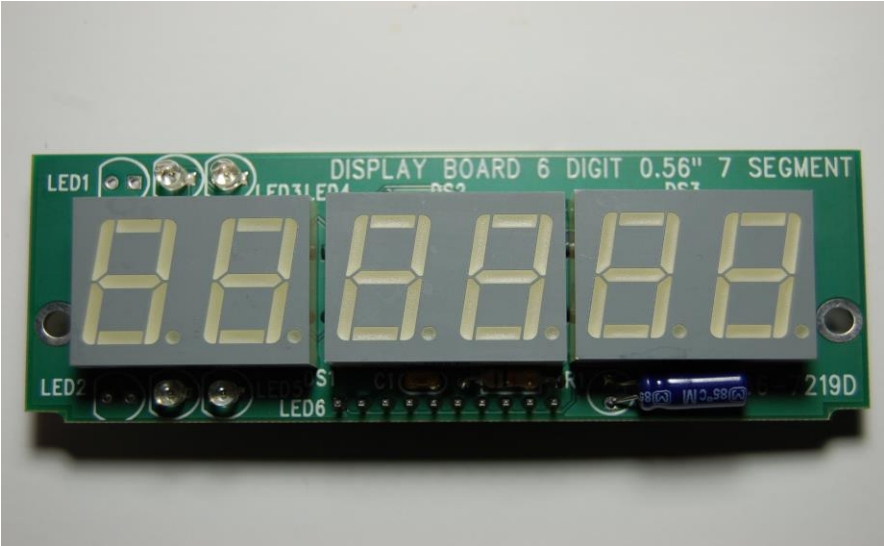
Use the right type of soldering iron. A 22 to 25-watt pencil soldering iron with a 1/8" or 3/16" chisel or pyramid tip works best.

Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth: then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good connections. When solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and re-tinned.

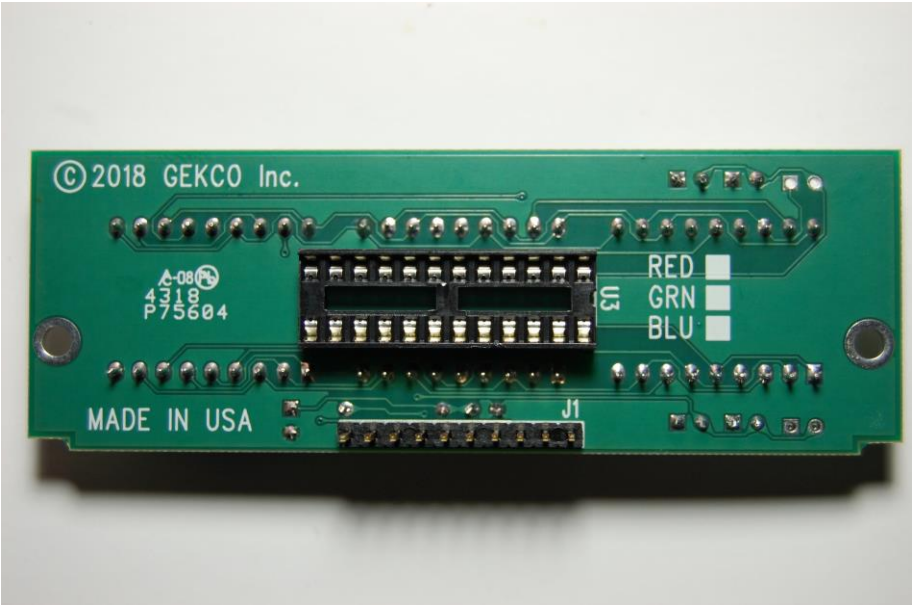
NOTE: What solder to use, leaded or lead free? The printed circuit boards in this kit are plated with lead free solder so if you choose to use lead free solder the complete assembly will be RoHS compliant. Regarding kits though, it is more difficult to solder with lead free material due to the higher melting temperature, so we recommend using a rosin core, radio-type solder (60/40) or (63/37) tin-lead content) for all of the soldering in this kit. If you decide to use leaded solder, be careful to wash your hands after soldering and never eat, drink or smoke, until you wash thoroughly and you are done soldering. Contain all materials that touched leaded solder in a special container dedicated for that purpose. This waste can be disposed of at electronic-recycling events or contact your waste management company

5. Step-By-Step Assembly

5.1. Display Circuit Board



• Figure 1: Display Board Top Side Completed Assembly



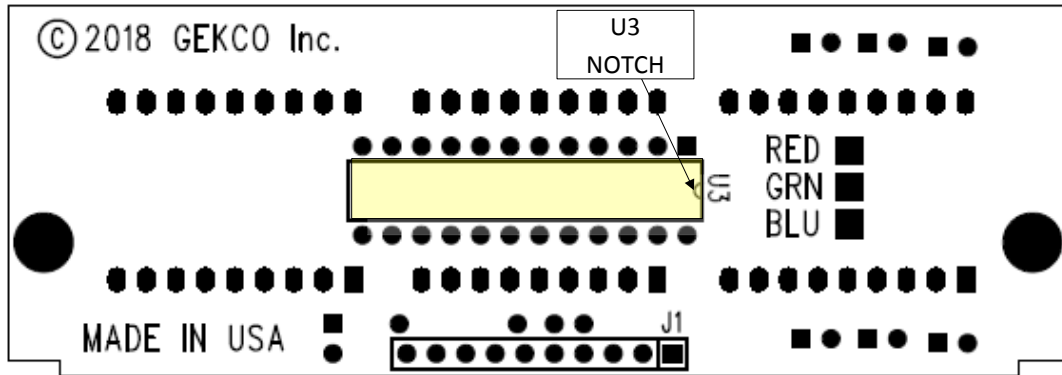
• Figure 2: Display Board Bottom Side Completed Assembly

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() Open the Display Board Printed Circuit Assembly (PCA) parts kit, P/N DBR656-KIT

Refer to Figure 3 for the following steps.

Position the Display Circuit Board with the bottom side facing up as shown



• Figure 3 Display Board Bottom Side

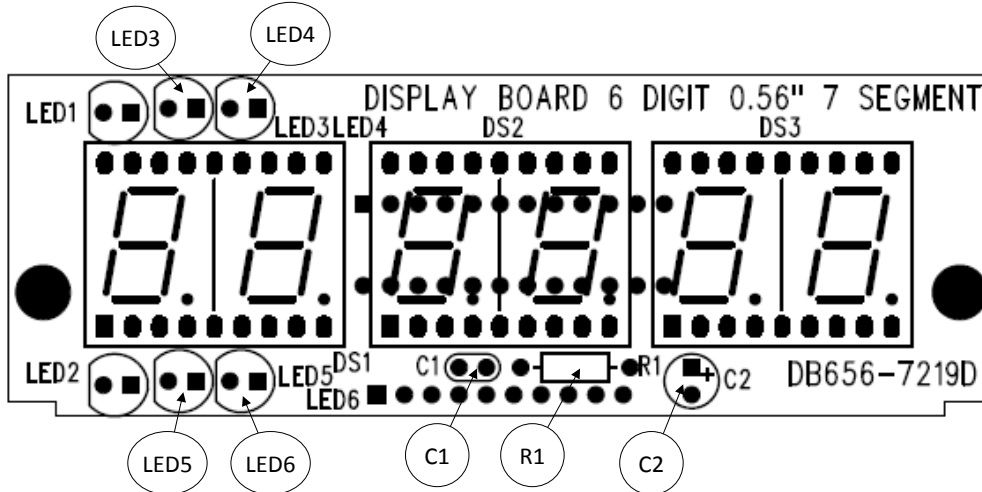
Locate the 24 pin IC socket for U3

Place the socket on the board with the notch on the socket aligned with the notch noted on the printed circuit board (PCB) silkscreen. Turn the board over and solder the corner pins and check to be sure the socket is firmly against the board and then solder the rest of the pins.

() X3: 24 pin DIP socket

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Position the Display Circuit Board with the component side facing up as shown below



• Figure 4: Display Board Top Side Assembly Pictorial

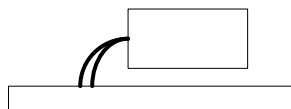
Install the decoupling capacitor.

() C1: 0.1 uF (104) radial-lead ceramic capacitor

() R1: 10 kΩ (brn-blk-org-silver) resistor

NOTE: Before you install an electrolytic capacitor, look at it and identify the leads. One lead will have either a negative (-) mark or a positive (+) mark near it on the side of the capacitor. The aluminum electrolytic capacitor has the marking for a negative lead which may look like an oblong bar, sometimes with a circle around it, inside an arrow. Be sure to install the positive lead in the positive-marked hole.

() C2: 10 uF radial-lead electrolytic aluminum capacitor (lay down the capacitor against the board so it does not interfere with the enclosure)



C2 SIDE VIEW

() Solder the leads to the foil and cut off the excess lead lengths.

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In the next step, make sure the LED display modules are oriented correctly. Match the decimal point on the display with the orientation shown on the PCB silkscreen. Solder the corner pins first and make sure the display is mounted flush with the board and oriented correctly and then solder the rest of the pins.

- () DS1: 7 segment LED display module
- () DS2: 7 segment LED display module
- () DS3: 7 segment LED display module

Make sure the LEDs are oriented correctly, there is a flat side on the LED housing or make sure the long lead (anode) is inserted in the square hole and the short lead (cathode) in the round hole.

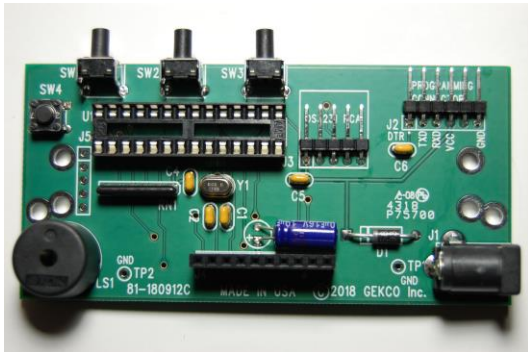
- () LED3: LED Red PCB Mount
- () LED4: LED Red PCB Mount
- () LED5: LED Red PCB Mount
- () LED6: LED Red PCB Mount

Note: LED1 and LED2 are not installed in this version of the display board.

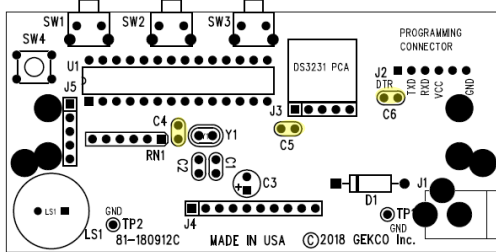
- () Solder the leads to the foil and cut off the excess lead lengths.

This completes the assembly of the Display Board. Connector J1 will be installed after the main board assembly is almost complete. Set aside for the final assembly later.

5.2 Main Circuit Board



• Figure 5: Main Board Completed Assembly

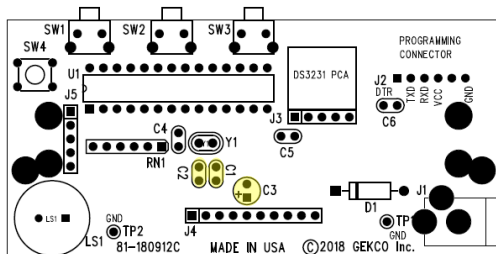


• Figure 6 Main Board Top View 1

() C4: 0.1 uF (104) radial-lead ceramic capacitor

() C5: 0.1 uF (104) radial-lead ceramic capacitor

() C6: 0.1 uF (104) radial-lead ceramic capacitor

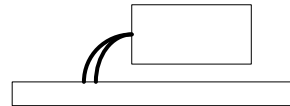


• Figure 7: Main Board Top View 2

() C1: 22 pF (22) radial-lead ceramic capacitor

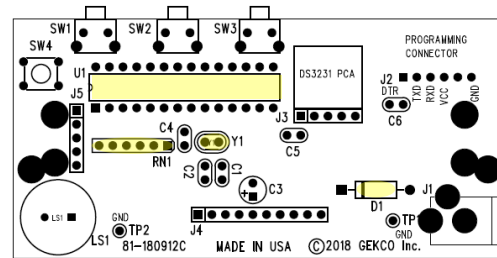
() C2: 22 pF (22) radial-lead ceramic capacitor

In the next step be sure to observe the correct polarity as noted before and lay the capacitor down against the board.



C3 SIDE VIEW

() C3: 10 uF radial-lead electrolytic aluminum capacitor



• Figure 8: Main Board Top View 3

() Y1: Crystal HC49 16 MHz

For the next step, be careful to position the end with the dot or line towards the “square pad” and tapered outline on the circuit board. After you solder the first pin make sure the pins are fully seated in their holes, solder the rest of the pins to the foil.

() RN1: 10 kΩ 103 resistor pack.

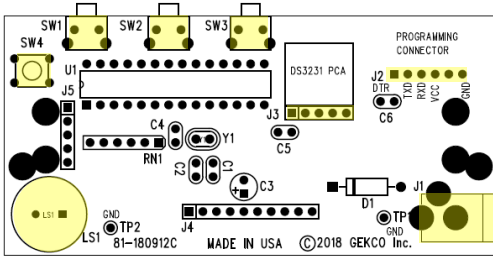
NOTE: When you install the diode, be sure to orient the diode correctly. Always match the band on the diode with the band mark on the circuit board. The circuit will not work properly if a diode is installed backwards.

() D1: 1N5817 schottky diode

When installing the IC socket next, be sure to align the notch on the socket with the notch on the PCB silkscreen.

() X1: 28 pin DIP socket

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• Figure 9: Main Board Top View 4

- () SW1: momentary right angle switch
- () SW2: momentary right angle switch
- () SW3: momentary right angle switch
- () SW4: momentary switch
- () J2: Connector Header Male 6 pin right angle mount
- () J3: Connector Header Male 5 pin right angle mount

In the next step, solder one pin and re-align the connector if necessary and then solder the rest of the pins. The connector needs to be aligned with the silkscreen outline.

- () J1: Connector Power 2.1 mm
- () LS1: Audio Piezo Speaker
- () Solder the leads to the foil and cut off the excess lead lengths.

The next step is to install the mating connectors between the display board (J1) and the main board (J4). You will be temporarily mounting the two boards together to make sure the mating connectors align properly.

Open the final assembly hardware bag and get the following parts:

Quantity 2 of:
M3 x 12 mm nylon standoffs

Quantity 4 of:
M3 x 6 mm nylon screws

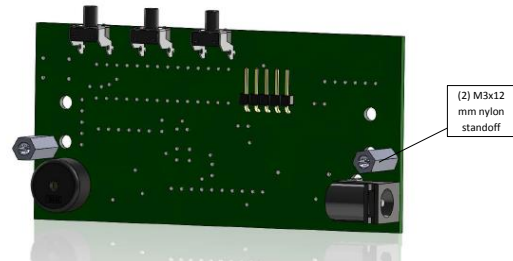
The display board assembled earlier.

The display board connector
J1: Connector header male 10 pin

The main board connector
J4: Connector Header Female 10 pin

Refer to figure 10 and 11 for the next steps

Mount two M3 x 12 mm nylon standoffs with two M3 x 6 mm nylon screws on the main board as shown.



• Figure 10: Main board with standoffs

Insert the 10 pin female connector into the main board at J4.

Identify the gold plated pins on the display board 10 pin male connector J1 and insert into or mate with J4 the 10 pin female connector.

Place the display board onto the two M3 x 12 mm nylon standoffs, with the 10 pin male connector J1 inserted into J1 on the display board and insert two M3 x 6 mm nylon screws as shown.



• Figure 11: Main and Display board Interface connector mounting

Solder the pins of the display board connector J1 on the display board and then do the same for the connector pins on the main board J4.

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Now you can disassemble the two boards together and set aside the two M3 x 12 mm nylon standoffs to be used later. The four M3 x 6 mm nylon screws will not be used, if you plan to use the acrylic enclosure, and can be discarded.

J5 is not installed in this version of the kit.

This completes the assembly of the Main board.

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit boards for the following problems.

- () Unsoldered connections
- () Poor solder connections
- () Solder bridges between foil patterns
- () Protruding leads which could touch together

Refer to the illustration where the parts were installed as you make the following visual checks.

- () Diodes for the proper type and positioning of the banded end
- () Electrolytic capacitors for the correct position of the positive (+) or a negative (-) marked ends

6. Initial Tests

Before installing the IC's perform the following tests.

Display Board

Using a multi-meter to measure resistance perform the following checks.

- () Verify that the resistance with the positive lead on C1 positive pin and negative lead on C1 negative pin, is greater than 2k ohms.

Main Board

- () Verify that the resistance with the positive lead on D1 cathode (the component end with the band) and negative lead on the ground pad TP1, is greater than 2k ohms.

IC INSTALLATION.

NOTE: You will install the following IC's on the main circuit board.

CAUTION: Integrated circuits (IC's) are complex electrical devices that perform many complicated operations in a circuit. These devices can be damaged during installation. Read all of the following information before you install the IC's.

Some of the IC's you will install in the following steps are MOS {metal oxide semiconductor} devices. Be sure they do not get damaged by static electricity. Once you remove the IC from the foam pad, **do not let go of it** or lay it down until it is in its socket. Install it as follows. Read all of the following steps before you pick up an IC.

1. Pick up the IC and touch the foam pad with both hands.
2. Hold the foam pad with one hand and remove the IC with the other hand.
3. Continue to hold the IC with the one hand and straighten any bent pins with the other hand.
4. The pins on the IC's may be bent out at an angle, and if this is the case, they will not line up with the holes in the IC socket or circuit board pads. Lay the IC down on its side as and very carefully roll it toward the pins to bend the lower pins into line. Then turn the IC over and bend the pins on the other side in the same manner. Do not try to install an IC without first bending the pins as described. To do so may damage the IC pins or the socket, causing an intermittent contact.

Install the IC on the display circuit board. Be sure to line up the dimple with the circuit board silkscreen

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() U1: MAX7219 IC

Install the IC on the main circuit board:

() U1: ATMEGA328P IC

This completes the assembly.

7. Final Tests

Using a multi-meter to measure resistance perform the following checks.

() Verify that the resistance with the positive lead on U5 pin 20 and negative lead on pin 10, is greater than 2k ohms.

() Connect the plug in transformer T1 to power connector PS1 and plug into a wall outlet and verify that the voltage with the positive lead on U5 pin 20 and negative lead on pin 10, is 5V.

8. In Case Of Difficulty

The “Visual Checks” that are provided below will help you locate any difficulties that might occur during the assembly and testing of your Digital Clock. Additional “ In Case of Difficulty” information is also provided in your Operation Manual.

In an extreme case where you are unable to resolve a difficulty, refer to the “Customer Service” information at the back of the Manual.

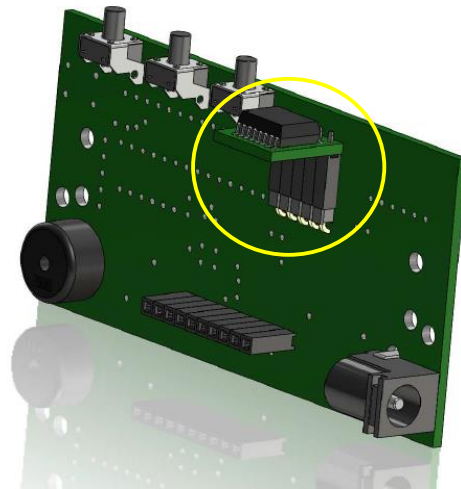
VISUAL CHECKS

1. The majority of kits that fail are due to poor solder connections. Therefore, you can eliminate many difficulties by carefully inspecting each connection to make sure it is soldered as described in the solder instructions section. Reheat any doubtful connections.
2. Check the circuit board to be sure there are no solder bridges between adjacent connections.

3. Check capacitor values carefully. Be sure the proper value part is installed at each capacitor location and that the negative (-) mark or a positive (+) mark is oriented correctly.
4. Check each resistor value carefully.
5. Be sure the correct diode is installed at each location, and that the banded end is positioned correctly.
6. Check the orientation and the correct part number of the Integrated Circuits. Use the pictorial diagrams as a reference.

9. Final PCA Assembly

() Locate the RTC module and install on the clock main board as shown.



• Figure 12 RTC Module Assembly

10. Final Assembly

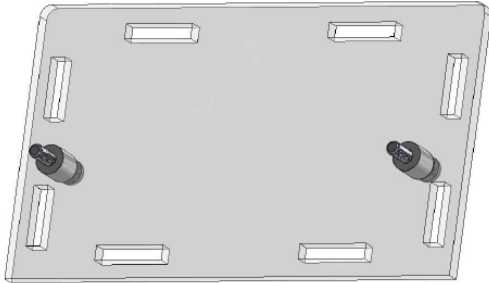
Skip these steps if the enclosure is not used.

() Unpack the 6 piece enclosure which includes a transparent red front piece, and clear back, top, bottom and side panels.

() Remove the paper backing on all the enclosure pieces.

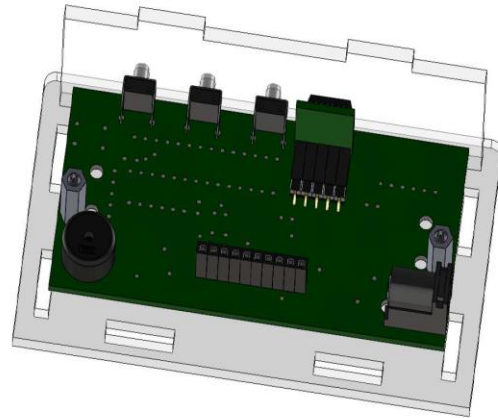
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() Locate the clear back panel and insert two white screws into their respective mounting holes and add two 1/4" spacers. Lay this assembly down on the work space with the screw threads facing up.

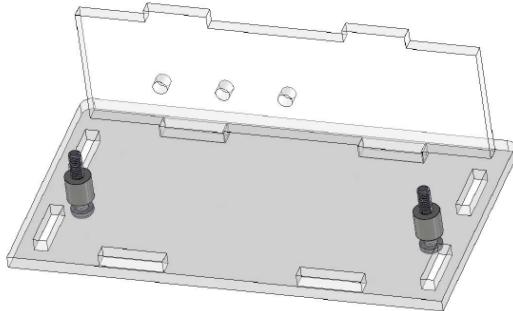


• Figure 13 Enclosure Back

() Insert the two M3 x 12mm hex standoffs and secure to the two rear screws.

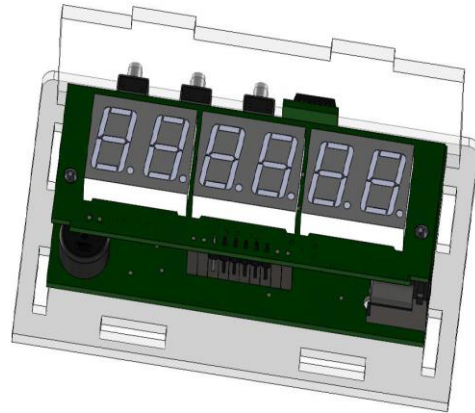


() Insert the top panel of the enclosure onto the main board assembly. Make sure the switches properly align with the top piece of the enclosure.

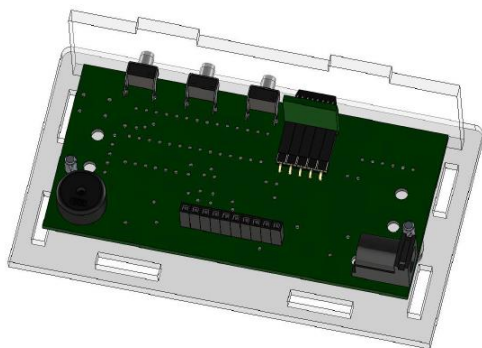


• Figure 14 Enclosure Back with Top

() Mate the display board to the main board and make sure the connector is mated properly.



() Add the main board assembly with the top panel on to the screws and spacers.

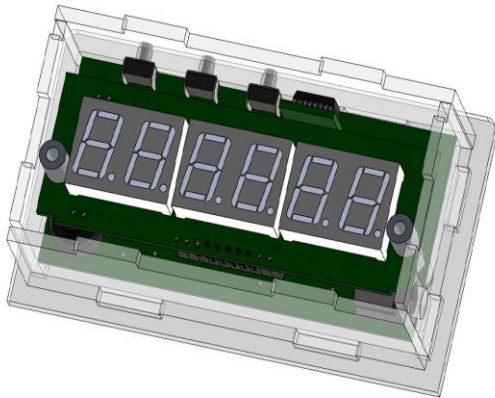


() Add the left panel.

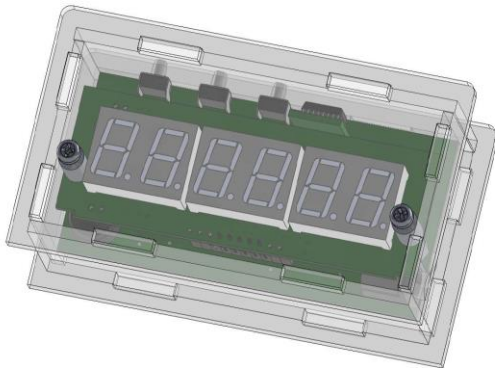
() Add the right panel and make sure the hole is aligned with the power connect J1.

() Add the bottom panel.

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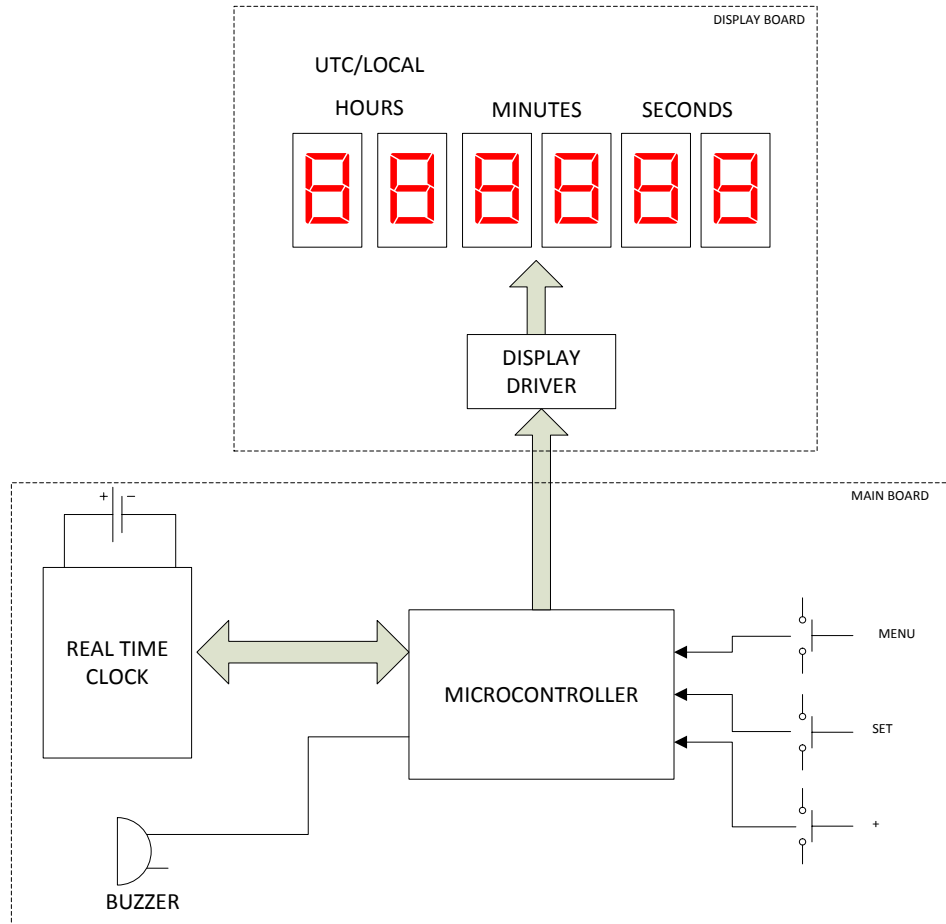
- () Install two spacers over the mounting holes
- () Add the front panel and make sure all pieces are aligned properly.
- () Add two black screws and loosely tighten to secure the enclosure.



Congratulations you have successfully completed the assembly of the unit and now you can enjoy using a clock that you have assembled yourself.

11. Theory of Operation

11.1. Block Diagram



The clock consists of two modules, the main board and the display board. The clock was designed this way to allow the same main board to use different display boards which could vary in size.

It may be helpful to review the block diagram and schematics while reading the circuit descriptions.

11.1. Main Board Circuit Description

The main circuit board has the microcontroller, real time clock (RTC), switch inputs and connectors for the display board, programming interface and the input power.

The microcontroller U3 is the heart of the clock. This design uses the popular Atmel ATMEGA328P. This is a very powerful microcontroller with 32Kbytes of flash memory, and 2Kbytes of SRAM as well as numerous other peripherals. See the ATMEGA328P data sheet for details.

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The crystal Y1 provides the clock for the microcontroller and C1 and C2 are required pad capacitors for the crystal to operate. The display board interface connectors are J4 and J5. J4 is the only one used in the model CLK056. This connector provides the standard serial peripheral interface (SPI) interface to the display board. The signal SS is asserted low when serial data is present on the MISO signal. The MISO signal is the serial data stream from the microcontroller to the MAX7219 on the display board. The signal SCK provides the clock timing for the interface. More details of the SPI interface can be found on the web.

Connector J3 provides the interface to the real time clock (RTC) module. The clock time accuracy and the time keeping function are provided by the RTC module, which has a Maxim DS3231 real time clock. This device uses a 3 wire, I2C interface to communicate with the microcontroller.

Connector J2 is the programming interface connector. This allows the firmware to be modified and the ability to reprogram the microcontroller. The CLK056 board looks just like a Arduino Uno and can use the popular Arduino IDE.

The path for the input power for the clock is provided by connector J1. The input voltage should be 5V +/- 5%. Diode D1 is a schottky diode which provides protection of the internal circuits if the polarity of the applied voltage is incorrect.

Resistor network RN1 provides the 10kohm pull up resistors for the switch inputs SW1 through SW4. SW1, SW2 and SW3 provide the clock setup capabilities and SW4 allows the user to reset the device.

The piezo electric buzzer LS1 provides an audible alert for the alarm function.

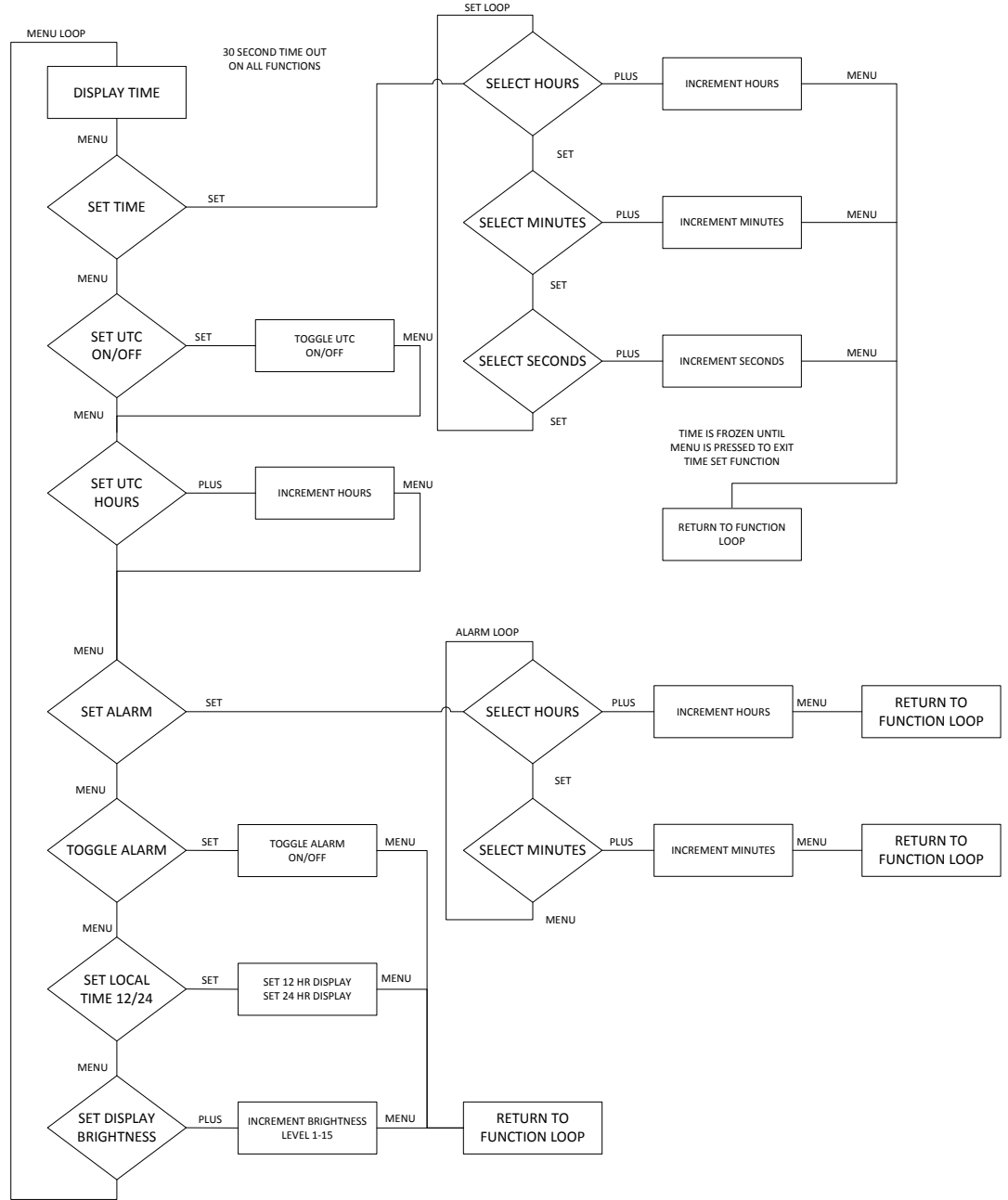
11.2. Display Board Circuit Description

The display board used in the model CLK056 utilizes the MAX7219 as the display driver and controller. This part provides a 4 wire interface to the main board to interface to the 6 digit display. The LED displays are multiplexed by the logic in the MAX7219. The microcontroller on the main board only needs to communicate with the display board when a change in the display is desired.

The seven segment common cathode LED display modules are from SunLED part number XDUR14C2. There are two digits per display module and each digit has separate interface pins. In our design, we have the segment sections wired in parallel and each digits common cathode is wired separately to the display controller. Resistor R1 sets the current drive for the LED displays.

12. Firmware

12.1. Flow Chart

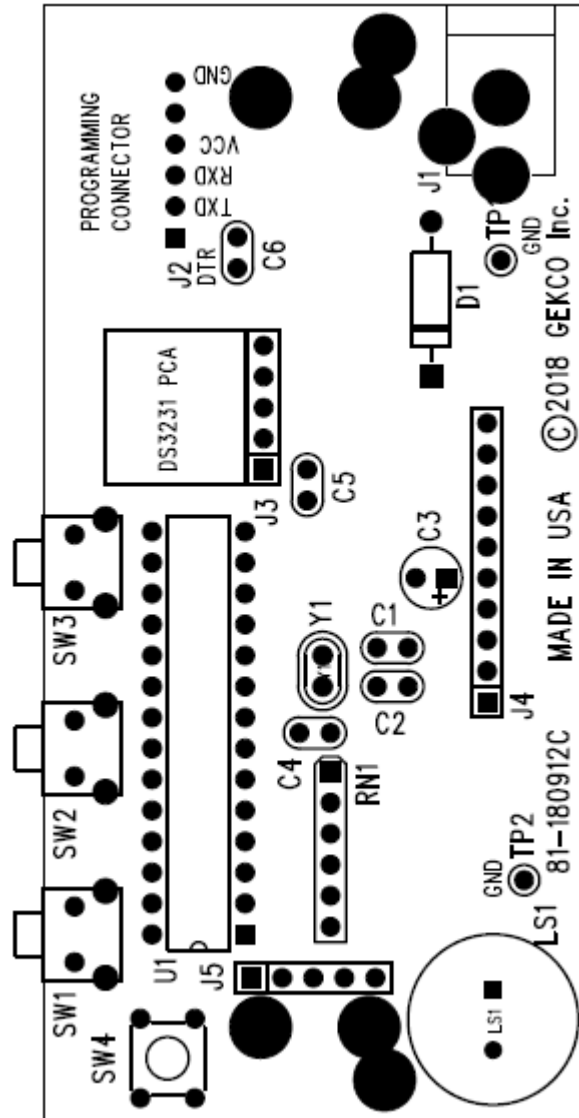


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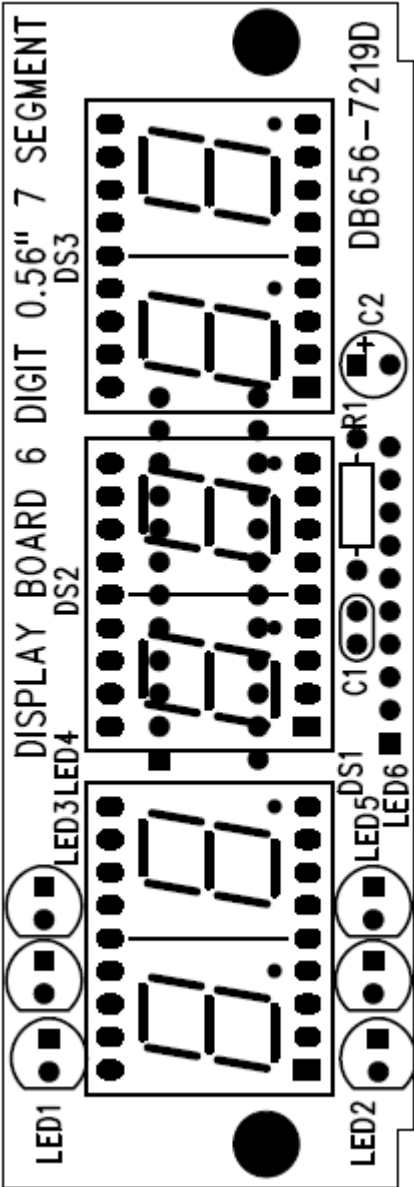
12.2. Firmware Design Description

13. PCA Pictorial Diagrams

13.1. Main Board

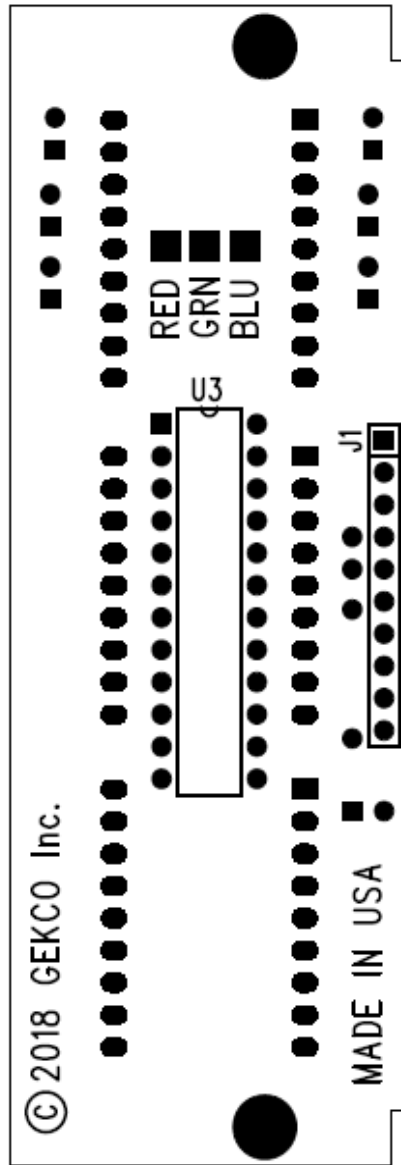


13.2 Display Board



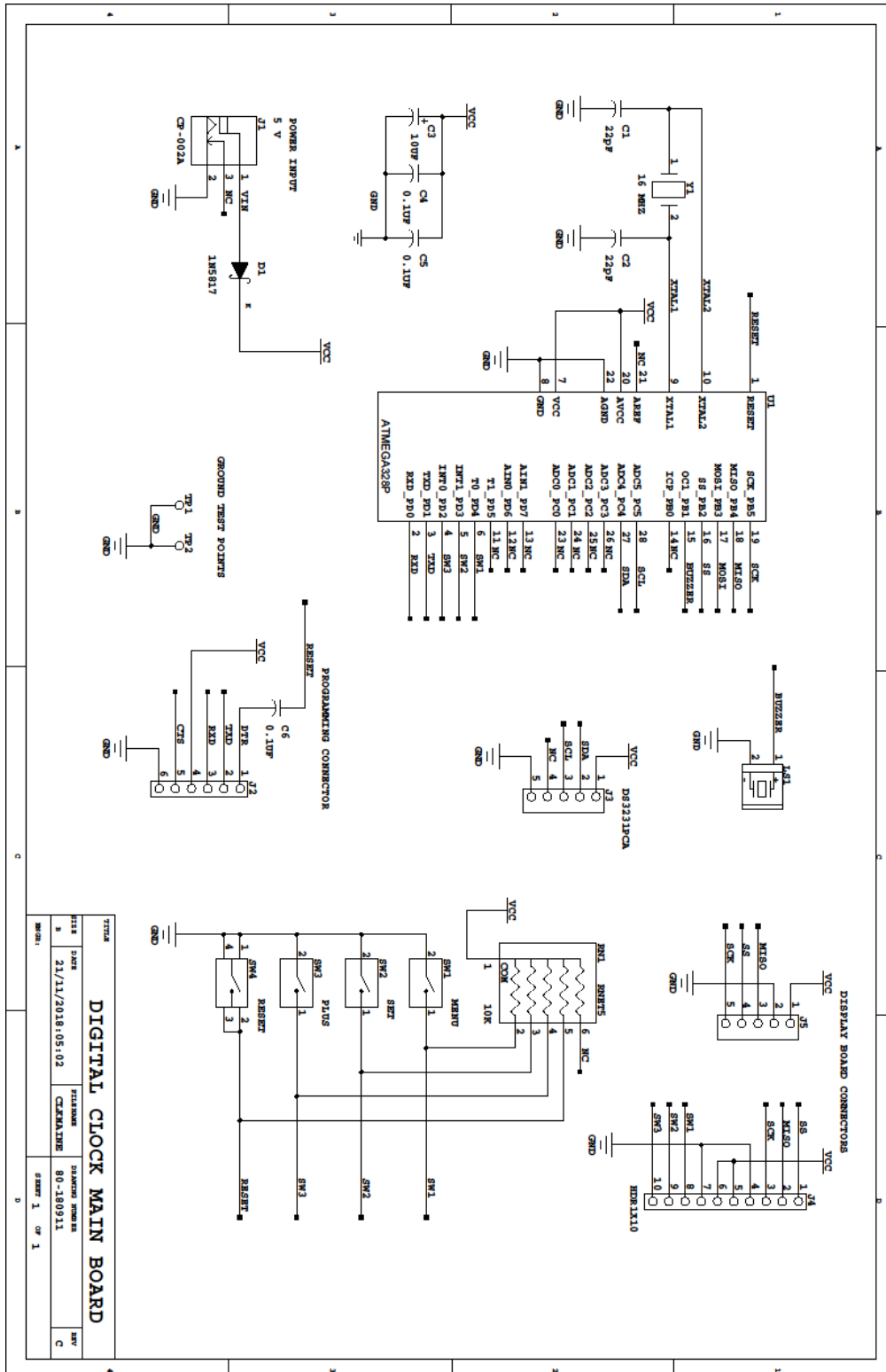
•Figure 15 Display Board Top Side

DIGITAL CLOCK MODEL CLK056



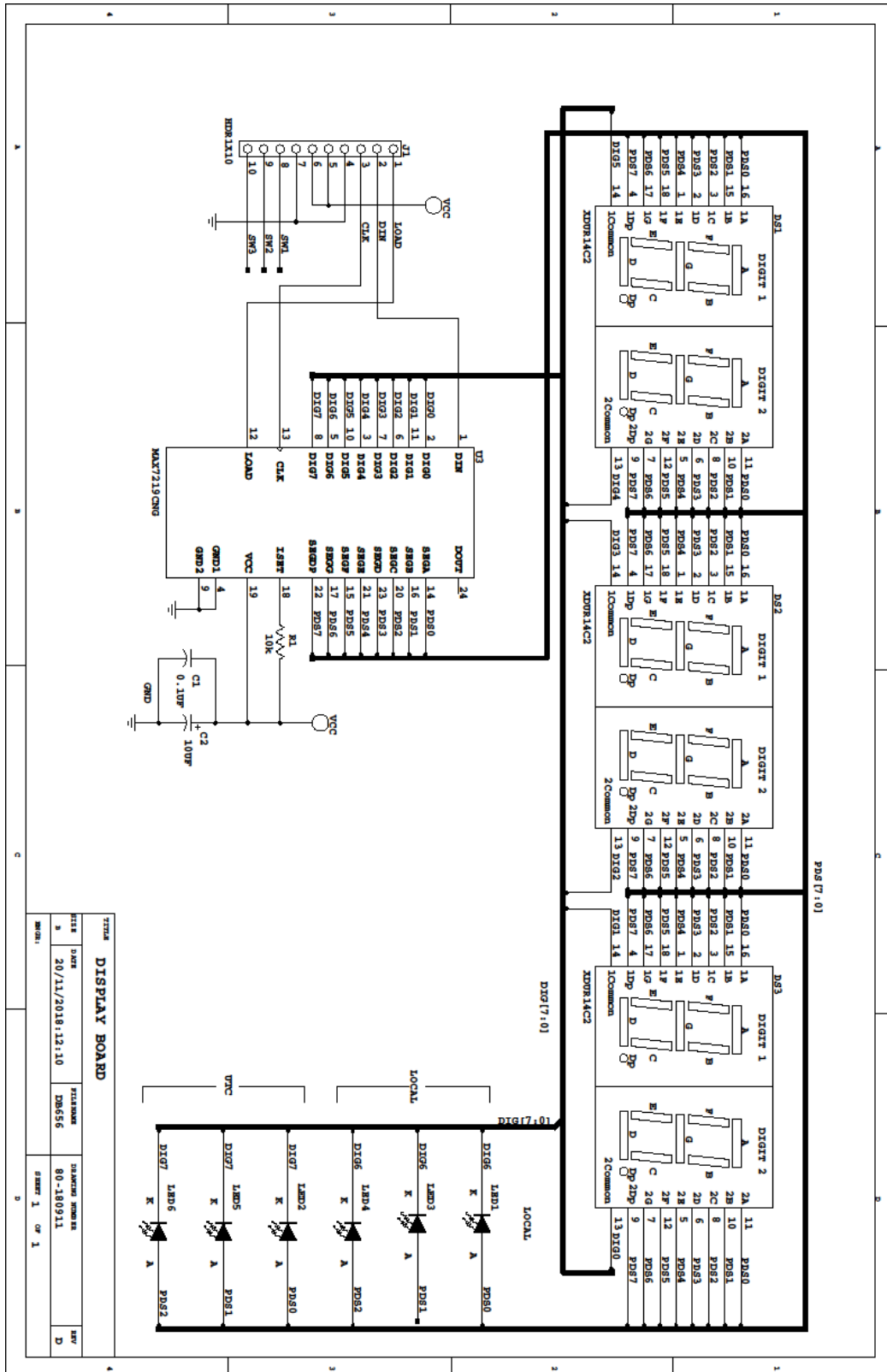
•Figure 16 Display Board Bottom Side

14. Schematic Main Board



DIGITAL CLOCK MODEL CLK056

15. Schematic Display Board



16. Document Revision History

1.0	30-Nov-18	Initial Release
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